STUDIES ON THE EFFECT OF REPEATED APPLICATION OF HUMAN AND CATTLE URINE ON SOIL PROPERTIES, GROWTH AND YIELD OF VEGETABLE CROPS

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in

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BENGALURU **JANUARY, 2012**

Affectionately

Dedicated to

My Beloved Parents

&

Farming Community

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY
UNIVERSITY OF AGRICULTURAL SCIENCES
BENGALURU

CERTIFICATE

This is to certify that the thesis entitled **"Studies on the effect of repeated application of human and cattle urine on soil properties, growth and yield of vegetable crops"** submitted by **Mr. YOGEESHAPPA, H., I.D. No. PAK 8060,** for the award of degree of **DOCTOR OF PHILOSOPHY** in **SOIL SCIENCE AND AGRICULTURAL CHEMISTRY** to the University of Agricultural Sciences, Bengaluru, is a record of research work done by him during the period of his study in this university under my guidance and supervision. This thesis has not previously formed the basis for the award of any other degree, diploma, associateship, fellowship or any other similar titles.

Bengaluru
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Bengaluru
January, 2012 ***(YOGEESHAPPA, H.)***

THESIS ABSTRACT

In order to find the ways and means of utilizing human urine and cattle urine as liquid fertilizer for crop production and to assess the effect on soil properties, growth and yield of vegetable crops, experiments were carried out under laboratory, field and green house conditions from 2009 to 2011. The urine from persons of different age group and diet and different categories of cattle was characterized and changes in chemical composition when incubated under open and closed conditions was mentioned. Field experiment was conducted in farmer's field with ashgourd, french bean, pole bean and pumpkin as test crops and 14 treatment combinations at Nagasandra village, Doddaballapur, Bangalore rural district to study the effect of repeated application of human urine and cattle urine on soil properties, growth and yield of vegetable crops. In a green house experiment effect of higher doses of human urine and cattle urine on growth and yield of tomato in red, laterite and black soils was studied. The fresh urine from persons of vegetarian and non-vegetarian diet and of different age groups and of different categories of cattle were acidic in reaction, had appreciable amount of soluble salts, primary and secondary and micronutrients. Urine from non-vegetarians had more nutritive value when compared to vegetarians. Upon incubation, nitrogen concentration decreased but there was no much variation in phosphorus and potassium concentration. The pH of urine samples of all category turned to alkaline reaction with time. In the field experiment, application of recommended dose of nitrogen through human urine in three split doses plus gypsum recorded higher yield (39.2, 14.2, 17.4 and 38.7 t ha^{-1}, for ashgourd, french bean, pole bean and pumpkin grown sequentially), growth and yield parameters, nutrients uptake, soil available nutrients, soil microbial population and B:C ratio as compared to other treatments. In the green house experiment, application of 2 times the recommended dose of N through human urine to red and laterite soils recorded higher tomato fruit yield (3.6 and 3.4 kg $plant^{-1}$, respectively), growth and yield parameters, quality components, nutrients uptake, soil available nutrients and soil microbial population as compared to other treatments. In black soil, all these components were found significantly higher in treatment receiving 2 times the recommended dose of N through chemical fertilizers as compared to other treatments.

Signature of the Student **Signature of the Major Advisor**

ಮಾನವ ಮತ್ತು ಹಸುವಿನ ಮೂತ್ರದ ಪುನರಾವರ್ತಿತ ಬಳಕೆಯಿಂದ ಮಣ್ಣಿನ ಗುಣಧರ್ಮಗಳು, ತರಕಾರಿ ಬೆಳೆಗಳ ಬೆಳವಣಿಗೆ ಮತ್ತು ಇಳುವರಿಯ ಮೇಲಾಗುವ ಪರಿಣಾಮಗಳ ಬಗ್ಗೆ ಅಧ್ಯಯನ

ಯೊಗೀಶಪ್ಪ, ಹೆಚ್.

ಪ್ರಬಂಧದ ಸಾರಾಂಶ

ವಿವಿದ ವಯಸ್ಸಿನ ಮತ್ತು ವಿಭಿನ್ನ ಆಹಾರ (ಸಸ್ಯಾಹಾರಿ ಮತ್ತು ಮಾಂಸಾಹಾರಿ) ಸೇವಿಸುವ ಮಾನವನ ಮೂತ್ರ ಮತ್ತು ವಿವಿದ ಬಗೆಯ ಜಾನುವರುಗಳ ಮೂತ್ರವನ್ನು ತೆರೆದ ಮತ್ತು ಮುಚ್ಚಿದ ವಾತವರಣದಲ್ಲಿ ಶೇಕರಿಸಿ ಮೂತ್ರದ ರಾಸಾಯನಿಕ ಗುಣಗಳನ್ನು ಪ್ರಯೊಗ ಶಾಲೆಯಲ್ಲಿ ಅಧ್ಯಯನ ಮಾಡಲಾಯಿತು. ಇದರ ಜೊತೆಗೆ ನಾಗಸಂದ್ರ ಹಳ್ಳಿಯ ರೈತನ ಜಮೀನಿನಲ್ಲಿ ಮಾನವ ಮತ್ತು ಸುವಿನ ಮೂತ್ರದ ಪುನರಾವರ್ತಿತ ಬಳಕೆಯಿಂದ ಬೂದಗುಂಬಳ, ತಿಂಗಳ ಹುರುಳಿ, ಹಬ್ಬುವ ಬೀನ್ಸ್ ಮತ್ತು ಸಿಹಿಕುಂಬಳ ಬೆಳೆಗಳ ಉತ್ಪಾದನೆ ಮತ್ತು ಮಣ್ಣಿನ ಮೇಲಾಗುವ ಪರಿಣಾಮದ ಬಗ್ಗೆ ಸಂಶೋಧನೆ ನಡೆಸಲಾಯಿತು, ಇದಲ್ಲದೆ ಹಸಿರು ಮನೆಯಲ್ಲಿ ಜಾಸ್ತಿ ಪ್ರಮಾಣದಲ್ಲಿ ಮಾನವ ಮತ್ತು ಹಸುವಿನ ಮೂತ್ರವನ್ನು ಕೆಂಪು, ಜಂಬಿಟ್ಟಿಗೆ ಮತ್ತು ಕಪ್ಪು ಮಣ್ಣಿನಲ್ಲಿ ಹಾಕಿದಾಗ ಮಣ್ಣಿನ ಗುಣಗಳು ಮತ್ತು ಟೊಮ್ಯಾಟೊ ಬೆಳೆಯ ಮೇಲಾಗುವ ಪರಿಣಾಮವನ್ನು ಅಧ್ಯಯನ ಮಾಡಲಾಯಿತು.

ತಾಜಾ ಮಾನವನ ಮತ್ತು ಜಾನುವಾರುಗಳ ಮೂತ್ರವು ಆಮ್ಲೀಯವಾಗಿದ್ದು, ಇವುಗಳಲ್ಲಿ ಉಪ್ಪಿನ ಅಂಶ ಗಮನಾರ್ಹವಾಗಿದ್ದು ಪ್ರಾಥಮಿಕ, ದ್ವಿತೀಯಕ ಮತ್ತು ಲಘುಪೋಷಕಾಂಶಗಳೂ ಸಾಕಷ್ಟು ಪ್ರಮಾಣದಲ್ಲಿವೆ. ಮೂತ್ರವನ್ನು ಶೇಖರಣೆ ಮಾಡಿದಾಗ ಸಾರಜನಕದ ಪ್ರಮಾಣವು ಕಡಿಮೆಯಾಗಿರುವುದು ಕಂಡುಬಂತು, ರಂಜಕ ಮತ್ತು ಪೊಟಾಷಿಯಂ ಅಂಶದಲ್ಲಿ ಹೆಚ್ಚಿನ ವ್ಯತ್ಯಾಸ ಕಂಡುಬಂದಿರುವುದಿಲ್ಲ ಆದರೆ ಎಲ್ಲಾ ರೀತಿಯ ಮೂತ್ರದ ಮಾದರಿಗಳ ರಸಸಾರವು ಕ್ಷಾರೀಯತೆಗೆ ತಿರುಗಿರುತ್ತದೆ.

ಕ್ಷೇತ್ರ ಪ್ರಯೊಗದಲ್ಲಿ, ಶಿಫಾರಸ್ಸು ಪ್ರಮಾಣದ ಸಾರಜನಕವನ್ನು ಮೂರು ಕಂತುಗಳಲ್ಲಿ ಮಾನವ ಮೂತ್ರದ ಮೂಲಕ ಪೂರೈಸುವುದರ ಜೊತೆಗೆ ಜಿಪ್ಸಂ ಹಾಕಿದಾಗ ಬೆಳೆಗಳ ಇಳುವರಿ (ಪ್ರತಿ ಹೆಕ್ಟೆರ್ ಗೆ 39.2, 14.2, 17.4 ಮತ್ತು 38.7 ಟನ್, ಕ್ರಮವಾಗಿ, ಬೂದಕುಂಬಳಕಾಯಿ, ತಿಂಗಳ ಹುರಳಿ, ಹಬ್ಬುವ ಹುರಳಿ ಮತ್ತು ಸಿಹಿಕುಂಬಳಕಾಯಿ) ಬೆಳವಣಿಗೆ ಮತ್ತು ಇಳುವರಿ ಪೂರಕಗುಣಗಳು, ಫೋಷಕಾಂಶಗಳ ಹೀರುವಿಕೆ, ಮಣ್ಣಿನ ಫಲವತ್ತತೆ, ಮಣ್ಣಿನಲ್ಲಿನ ಸೂಕ್ಷ್ಮಾಣು ಜೀವಿಗಳ ಸಂಖ್ಯೆ ಮತ್ತು ಆದಾಯ ಖರ್ಚಿನ ಅನುಪಾತ (4.71, 3.22, 4.14 ಮತ್ತು 3.70 ಕ್ರಮವಾಗಿ, ಬೂದಕುಂಬಳಕಾಯಿ, ತಿಂಗಳ ಹುರಳಿ, ಹಬ್ಬುವ ಹುರಳಿ ಮತ್ತು ಸಿಹಿಕುಂಬಳಕಾಯಿ) ದಲ್ಲಿ ಗಮನಾರ್ಹವಾಗಿ ಹೆಚ್ಚಾಗಿರುವುದು ಕಂಡುಬಂದಿದೆ.

ಹಸಿರುಮನೆ ಪ್ರಯೊಗದ ಸಂಶೋಧನಾ ಫಲಿತಾಂಶದಿಂದ ತಿಳಿದುಬಂದಿರುವುದೇನೆಂದರೆ ಬೆಳೆಯ ಇಳುವರಿ (ಪ್ರತಿ ಟೊಮಟೊ ಸಸ್ಯದಿಂದ 3.6 ಮತ್ತು 3.4 ಕಿ.ಲೊ. ಕ್ರಮವಾಗಿ, ಕೆಂಪು ಮತ್ತು ಜಂಬಿಟ್ಟಿಗೆ ಮಣ್ಣುಗಳಲ್ಲಿ), ಬೆಳವಣಿಗೆ ಮತ್ತು ಇಳುವರಿಯ ಪೂರಕಗಳು, ಗುಣಮಟ್ಟ, ಫೋಷಕಾಂಶಗಳ ಹೀರುವಿಕೆ, ಮಣ್ಣಿನ ಫಲವತ್ತತೆ, ಮಣ್ಣಿನಲ್ಲಿನ ಸೂಕ್ಷ್ಮಾಣು ಜೀವಿಗಳ ಸಂಖ್ಯೆ ಗಮನಾರ್ಹ ರೀತಿಯಲ್ಲಿ ಹೆಚ್ಚಾಗಿರುವುದು ಕೆಂಪು ಮತ್ತು ಲ್ಯಾಟೆರೈಟ್ ಮಣ್ಣಿನಲ್ಲಿ ಶಿಫಾರಸ್ಸಿಗಿಂತ ಎರಡು ಪಟ್ಟು ಹೆಚ್ಚು ಸಾರಜನಕವನ್ನು ಮಾನವ ಮೂತ್ರದ ಮೂಲಕ ಕೊಡುವುದರಿಂದ ಕಂಡುಬಂದಿರುತ್ತದೆ. ಆದರೆ ಕಪ್ಪು ಮಣ್ಣಿನಲ್ಲಿ ಶಿಫಾರಸ್ಸಿಗಿಂತ ಎರಡು ಪಟ್ಟು ಹೆಚ್ಚು ಸಾರಜನಕವನ್ನು ರಾಸಾಯನಿಕ ಗೊಬ್ಬರಗಳ ಮೂಲಕ ಕೊಡುವುದರಿಂದ ಎಲ್ಲಾ ಅಂಶಗಳೂ ಗಮನಾರ್ಹ ರೀತಿಯಲ್ಲಿ ಹೆಚ್ಚಾಗಿರುವುದು ಕಂಡುಬಂದಿದೆ.

2012

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qÁ|| ¹. J. ²æÃ¤ªÁ¸ÀªÀÄÆwð ªÀÄÄÄRå ¸À®ºÉUÁgÀgÀÄ

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LIST OF ABBREVIATIONS

@	at the rate	DAT	Das after transplanting
^0C	Degree celcious	Dec	December
-	Minus	DTPA-Mn	DTPA extractable Manganese
%	Per cent	DTPA-Zn	DTPA extractable zinc
+	plus	dS m^{-1}	deci Siemen per meter
i.e.	That is	DTPA-Cu	DTPA extractable Copper
Apr	April	DTPA-Fe	DTPA extractable Iron
Aug	August	EC	Electrical conductivity
Avail.	Available	et al.	Co workers
BOD	Biological Oxygen Demand	etc.	Etcetera (so on)
^{0}Brix	Degree brix	Fe	Iron
C. D.	Critical Difference	Feb	February
Ca	Calcium	Fig.	Figure
cc	cubic centimeter	g	gram
Cd	Cadmium	g $fruit^{-1}$	gram per fruit
CEC	Cation Exchange Capacity	g L^{-1}	Gram per Litre
CFU	Colony Forming Units	g $plant^{-1}$	gram per plant
Cl	Chlorine	g^{-1}	per gram
cm	centimeter	ha^{-1}	Per hectare
cm^3	cubic centimeter	ha^{-1} $crop^{-1}$	per hectare per crop
cmol (p^+) kg^{-1}	centimole proton per kilogram	HF	*Holstein friesian*
COD	Chemical Oxygen Demand	IIHR	Indian Institute of Horticulture Research
Cu	Copper	Jan	January
cv.	Cultivar	Jul	July
DAS	Das after sowing	Jun	June

K	Potassium	OC	Organic carbon
K_2O	Potassium	Oct	October
kg	kilogram	P	Phosphorus
kg ha^{-1}	kilogram per hectare	P_2O_5	Phosphorus
LAI	Leaf Area Index	Pb	Lead
m	Meter	ppm	Part(s) per million
m^2	square meter	Pvt.	Private
m^3	cubic meter	q ha^{-1}	quintal per hectare
MAI	Month after incubation	RCBD	Randomized Complete Block Design
m^3 ha^{-1}	cubic meter per hectare	RDF	Recommended dose of fertilizer
MAP	Months After Planting	RDN	Recommended dose of nitrogen
Mar	March	Rs.	Rupees
meq L^{-1}	milli equivalent per litre	S	Sulphur
Mg	Magnesium	S.Em±	Standard error of mean
mg kg^{-1}	milligram per kilogram	Sep	September
mg L^{-1}	milligram per litre	SO_4	Sulphate
mm	millimeter	t	tonnes
Mn	Manganese	t ha^{-1}	tonnes per hectare
N	Nitrogen	TSS	Total Soluble Solids
N NH_4OAC	Neutral Normal Ammonium Acetate	Univ.	University
Na	Sodium	Viz.	Namely
NH_4	ammonium	WTO	World Health Organisation
Ni	Nickel	yr	year
NO_3	Nitrate	Zn	Zinc
Nov	November		

INTRODUCTION

I INTRODUCTION

Human urine is a natural resource available in every household. Human urine contains almost all the plant nutrient elements in appreciable quantity. Each individual produces 1 to 1.5 L of urine per day, the chemical composition of which depends on feeding habits, the amount of water consumed, physical activities, body size, and environmental factors. In general, human urine contains very few enteric microorganisms. The nutrient contents in human urine qualities it as a good liquid fertilizer for plants.

Human urine is known to contain appreciable quantity of plant nutrient elements (especially Nitrogen), which may be readily absorbed and assimilated by crops if used properly. There is lot of hesitation amongst people in handling this nutrient rich waste due to lack of knowledge and by consuming the produce grown by using anthropogenic liquid waste one may suffer from various deadly diseases which may not be a reality. Now we are in the midst of the problems in terms of shortage of good quality water, shortage of fertilizers and also problem of proper methods of waste disposal. Hence a study of this kind is very much appropriate and necessary to address such problems being faced by mankind. The scientists in the field of agriculture are therefore deeply concerned about the use of human and cattle urine for agricultural purposes. Proper utilization of anthropogenic liquid waste may improve the soil quality, soil health and crop growth and yield.

Urine is produced after filtration of the blood in the kidneys, and therefore, it contains compounds with low molecular weight, since proteins are not filtered. About 75 to 90 per cent of N is excreted as urea, the remaining in the form of either ammonium or creatinine. Urea is rapidly degraded by urease to ammonium and water, which may elevate pH values up to 9, this can also reduce the bacterial population, although ammonia evaporation is also higher at higher pH values. In urine or artificial fertilizers, nitrogen is in the form of urea or ammonium i.e., 90 to 100 per cent of urine N is in the form of either urea or ammonium, as has been verified in fertilization experiments. The P and K present in urine are almost in an inorganic form 95–100%. These ions are directly available to plants.

Urine is used by the body as a balancing medium for liquids and salts and the amount of urine excreted varies from person to person (Jonsson *et al.*, 2004). Excessive sweating results in concentrated urine, while consumption of large amounts of liquid dilutes the urine. Feachem *et al*. (1983) reported that the urine generation rate for most adults is between 1.0 and 1.3 kg per person per day. Vinneras *et al.* (2006) suggested a design value for urine generation to be 1.5 kg per person per day based on measurements in Sweden. Winblad *et al.* (2004) reported 1.1 to 1.4 kg per person per day.

The nutrients in urine are in the forms which are readily available to plants. The nitrogen is in the form of urea which readily degrades to ammonium and nitrate forms and phosphorous, potassium and sulphates are in ionic forms. This makes urine a unique biogenic fertiliser.

In the present context of urbanization and industrialization, large volumes of wastes are being generated and are posing problems of disposal. Over one billion people still lack access to safe drinking water, and two-fifth of the world’s population does not have access to improved sanitation. More than three million people die every year from water-related diseases. Most of the urban centers all over the world are facing problems of disposal of municipal wastewater as it is rich in nutrient elements and may lead to eutrophication in addition to generation of putrifiable gases. Among these, anthropogenic liquid waste may aggravate these problems as it is rich in plant nutrient.

Ecological sanitation is a term not well defined. In ecosan system, anthropogenic liquid waste from households is considered a resource and not a waste. Urine diverting ecosan toilet consists of a superstructure similar to that of most toilets, the urine and faeces are separated at source using the urine-diverting toilet. The Urine diverting Ecosan toilet fulfil the dual objective of water conservation and also environmental sustainability. If installed indoors, this toilet can help in water conservation as minimum water is used.

Diverting nutrient-rich urine to land instead of water bodies can reduce pollution of such water bodies and hence reduces the occurrence of algal blooms. (Winblad *et al*., 2004).

The strategy for production of vegetables in the present context must be by increasing the productivity of land under cultivation, reduced costs of production and higher input use efficiency with no harm to the soil, ground water, environment and product quality. Soil-plant-environment system should be free from economic exploitation and overuse and misuse of the inputs. No doubt, the use of mineral fertilizers and pesticides was a boon in the past, but their non-judicious use is being considered a bane in the present scenario, causing for a shift towards organic farming which has its own limitations. It is now time to reanalyse the production advantage to the cost of nature destruction, where impairment of soil physical, chemical and biological properties are the key problems associated with indiscriminate and over use of synthetic fertilizers and pesticides. The poor soil respiration rate and complete vanishing of natural decomposer communities from agro-ecosystems further threatens land sustainability and food security around the world. Similarly, the escalation in the cost of chemical fertilizers, particularly N, P and K coupled with related ecological concerns has drawn the attention of scientific and farming community from chemical alone agriculture to integrated nutrient management strategy which utilizes human urine and cattle urine as subsidiary sources or alternatives to chemical fertilizers.

The greatest challenge facing mankind in the world in the twenty first century is to produce the basic necessities of food, fodder, fiber, fuel and other raw materials from 0.14 ha or less land per capita. The nutrient turn over in soil plant continuum concept is considerably high under intensive cropping, neither the chemical fertilizers nor the basic or biological sources alone can achieve production sustainability. Long term studies indicated that the balanced use of only NPK fertilizers could not maintain high yield levels because of emergence of other macro and micro- nutrient deficiencies and deterioration in soil physical eco-system. As a consequence of this and other constraints there seems to be no option but to fully exploit alternative sources of plant nutrients. The judicious use of naturally available resources like human urine (anthropogenic liquid waste) and cattle urine help in maintaining yield stability through correction of marginal deficiencies of macro and micro-nutrients, enhancing efficiency of applied nutrients and providing favourable soil chemical and physical conditions and reducing the environmental pollution.

Vegetables are so common in human diet that a meal without a vegetable is supposed to be an incomplete diet in any part of the world. Vegetables provide proteins, carbohydrates, minerals, vitamins and roughages which constitute the essentials of a balanced diet. In the opinion of nutrition experts 295 g of different vegetables need to be included for a balanced diet.

Taking all these factors into consideration, the study entitled with "studies on the effect of repeated application of human urine and cattle urine on soil properties, growth and yield of vegetable crops" was taken up with the following objectives.

1) To characterise human urine and cattle urine.
2) To study the changes in nutrient composition of human and cattle urine stored under open and closed condition.
3) To study the effect of application of human and cattle urine on soil properties.
4) To study the effect of application of human and cattle urine on growth and yield of vegetable crops and
5) To work out the economics of use of human and cattle urine in crop production.

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

Human excreta both faeces and urine have traditionally been used for crop fertilisation in many countries. The recycling of urine and faeces was introduced in the 12^{th} Century and in China human and animal excreta have been composted and used since thousands of years. The systematic implementation of reuse and recycling of nutrients and water as hygienically safe, closed loop and holistic alternative to conventional sanitation solutions. Ecosan systems enable the recovery of nutrients from anthropogenic liquid waste for the benefit of farmers and help to preserve soil fertility, assure food security for future generations, and minimize environmental pollution. The relevant literature pertaining to nutritive value of human and cattle urine and their influence on soil properties and growth and yield of crops is presented in this chapter under the following headings.

2.1 Characterization of human and cattle urine

2.2 Effect of incubation of human urine and cattle urine on chemical and biological properties.

2.3 Effect of human and cattle urine on growth, yield and quality of crops.

2.4 Effect of human and cattle urine on soil properties and available nutrient status of soil.

2.5 Effect of human and cattle urine on microbial population in soil.

2.6 Effect of application of amendments on soil properties.

2.7 Rate of application of human and cattle urine as nutrients source to crops.

2.8 Growth, yield and quality of different vegetable crops affected by application of human and cattle urine.

2.9 Dry matter accumulation and nutrients uptake by crops

2.10 Economics of use of human and cattle urine on crop production.

2.1 Characterization of human and cattle urine

An adult man excretes about approximately 550 kg of anthropogenic liquid waste in a year which contains about 4 kg nitrogen. The nitrogen was found mainly in the form of urea (80 per cent), ammonia (7 per cent), nitrate (6 per cent) and the remaining is in the form of shorter peptides and free amino acids (Lentner *et al.*, 1981)**.**

Physiological measurements indicated that the amount of plant nutrients excreted via urine per person and yearly (2.5-4.3 kg nitrogen, 0.7-1.0 kg phosphorus and 0.9-1.0 kg potassium) are larger than the amounts excreted via faeces (0.5-0.7 kg nitrogen, 0.3-0.5 kg phosphorus and 0.1-0.2 kg potassium). Thus, separation of urine means that 60-90% of the plant nutrients N, P and K ingested can be retrieved in solution (Guyton, 1986)

Anthropogenic liquid waste is a complex solution, containing nutrients as in diluted forms. Sodium chloride (NaCl) and urea [$CO(NH_2)_2$] are the main components, although anthropogenic liquid waste also contains phosphorus (P), potassium (K), calcium (Ca) and sulphate (SO_4^{2-}). Phosphorus is present as phosphate ions (H_2PO_4 or HPO_4^{2-}) and potassium as K^+. Most of the total nitrogen (around 80 per cent) present in fresh anthropogenic liquid waste, exists in urea form [$CO(NH_2)_2$] (Altman and Dittmer, 1994).

Kirchmann and Pettersson (1995) conducted pot experiment with ^{15}N labelled human urine and observed higher gaseous losses and lower crop uptake (barley) of urine N than that of labelled ammonium nitrate. Phosphorus present in urine was utilized at a higher rate than soluble phosphate, showing that urine P is available to crops as soluble P fertilizers.

The nitrogen content in anthropogenic liquid waste (but not faeces) seems to vary with the intake of protein. The fact that anthropogenic liquid waste mixed with water is a good fertilizer and that a person urinates almost half cubic meter annually, gives a reason to look at human excreta from a new perspective (Jacks *et al.*, 1997).

The concentration of heavy metals in anthropogenic liquid waste are very low, it contained 3.2 mg cadmium/kg phosphorus (Jonsson *et al.,* 1997). This can be compared to mineral fertilizers containing 26 mg Cd/kg of P and sludge from Swedish sewage treatment plants containing an average of 55 mg Cd/kg of P (Swedish, EPA, 1997).

The urea degradation increases the pH value of urine from its normally slightly acidic state (pH ±6 when excreted) to a value of approximately 9. The phosphorus in urine is in the form of phosphate, while the potassium is in the form of ions. Many chemical fertilizers contain nitrogen in the form of ammonium, phosphorus in the form of phosphate and potassium is in the form of ions. Thus fertilising effect of urine ought to be comparable to the application of the same amount of the plant nutrients in the form of chemical fertilisers (Jonsson, 1997)

Markwell *et al.* (1998) studied the effects of cations and anions on urine pH in cats and he fed 32 types of canned food to cats in order to predict urine pH. The dietary cations, anions, and amino acid that affected urine pH were calcium, sodium, potassium, phosphorus, methionine, and chloride. Their equation accounted for 36% of the variation seen in their observed urine pH values. When applying their equation to the 60 wet foods used in the present study, the equation only accounted for 12% of the variation seen in the pH values.

An adult may produce 400 litres of anthropogenic liquid waste per year containing 4.0 kg nitrogen, 0.4 kg phosphorus and 0.9 kg potassium. A considerable portion of NH_3 in the anthropogenic liquid waste solution is lost due to agitation during transport or application as fertilizer (Hellstrom and Johansson, 1999).

In municipal wastewater, anthropogenic liquid waste is the dominating source for the major plant nutrients viz., nitrogen, phosphorus and potassium and hold 5 to 90 per cent of these essential elements (Larsen and Gujer, 1996)

The anthropogenic liquid waste stands for a minor proportion of the heavy metals found in the household wastewater (Vinneras, 2002). Many of the heavy metals analyzed in earlier studies, have been below the detection limit, while other metals may occur in detectable amounts. If for instance copper pipes are used within the ALW pipe system, concentration of copper may be significantly higher than otherwise.

Carlander *et al.* (2001) did a field experiment at Stockholm on the fertilizing value of source separated anthropogenic liquid waste. This four-year-old project compared the fertilizing effect of anthropogenic liquid waste to the effects of industrial fertilizer. Anthropogenic liquid waste is a complete fertilizer with nutrient ratios of N:P:K is 11:1:2.5. The crop yields from fields fertilized with anthropogenic liquid waste were identical to mineral fertilizer, both for fertilizing before sowing (basal) and during the crop (top dressing).

The nutrient concentration of the excreted urine depends on the amount of nutrients, and on the amount of liquid, which on an average for adults can be in the range of 0.8-1.5 litres per person per day and for children about half of that amount (Lentner *et al.*, 1981). Based upon this and other measurements, the proposed Swedish default value is 1.5 litres per person per day (550 litres per person per year) (Vinneras, 2001), while Gao *et al.* (2002) reported 1.6 litres per person per day (580 litres/person, year). Urine is used by the body as a balancing medium for liquids and salts and the amount of urine therefore varies with time, person and circumstances. For example, excessive sweating results in concentrated urine, while consumption of large amounts of liquid dilutes the urine. Thus, to determine the application rate of urine as a fertilizer, the calculation should preferably be based upon the number of persons and days that it has been collected from, as this gives a better indication of the nutrient content than the volume.

Schouwz *et al.* (2002) reported the following metal contents per person and day in human excreta in Southern Thailand: 9-16 mg zinc (Zn), 1.4-1.5 mg copper (Cu), 0.3 mg nickel (Ni), 0.02-0.03 mg Cd, 0.07-0.14 mg lead (Pb), 0.01 mg mercury (Hg) and 0.8-1.1 mg boron (B). The metal content and mass flows in faeces are usually reported to be far higher than in urine. He also reported that an excreted nutrient in anthropogenic liquid waste was about 80-90 per cent nitrogen, 50-65 per cent phosphorus and 50-80 per cent potassium.

The estimations assume that the loss between the food supplied and the food actually consumed, the food waste generated is of the same relative size in the different countries. This assumption is verified by Chinese data. The total excretion reported by Gao *et al.* (2002) for China was 4.4 kg of N and 0.5 kg of P. These values considering how difficult it is to do measurements representative of the excretion of a large population.

The total excretion has also been partitioned between urine and faeces and for this Swedish data have been used. In Sweden, approximately 88% of the excreta N and 67% of the excreta P are found in the urine and the rest in the faeces. The partitioning of nutrients between urine and faeces depends upon how digestible the diet is, as digested nutrients enter the metabolism and are excreted with the urine, while undigested fractions are excreted with the faeces. Thus, for countries where the diet is less digestible than in Sweden, the urine will contain somewhat less than 88% of the excreta N and 67 per cent of the excreta P. Gao *et al.* (2002) indicated that the urine contains approximately 70 per cent of the excreta N and 25 to 60 per cent of P. To decrease the uncertainty on the nutrients, especially P, are partitioned, more measurements are needed on the composition of excreta in countries with less digestible diets.

The plant nutrients present in anthropogenic liquid waste have been traditionally used for fertilization in many countries. In Japan, the recycling of anthropogenic liquid waste was introduced in the 12th century and in China human and animal excreta have been composted for thousands of years. Anthropogenic liquid waste is the fraction that contains the major part of the nutrients in domestic wastewater, approximately 80 per cent of nitrogen, 55 per cent of phosphorus and 60 per cent of potassium. At the same time it constitutes less than 1 per cent of the total wastewater volume. Thus, it is possible to collect relatively concentrated fertilizer by separating anthropogenic liquid waste from the wastewater (Schonning, 2003).

Anthropogenic liquid waste is quick acting wastewater rich in nitrogen and other nutrient elements. It contains largest proportion of nitrogen (70 to 90 per cent), phosphorus (45 to 80 per cent), and potassium (75 to 95 per cent). The actual proportions measured depend upon the digestibility of the diet and on successful diversion of all anthropogenic liquid waste (Vinneras and Johnson, 2003).

Plants take up nutrients in ionic form and the nutrients in anthropogenic liquid waste are easily available to plants, since they are in ionic form or rapidly degraded to this form. Most of the nitrogen in anthropogenic liquid waste is excreted as urea, which is easily degraded to ammonium, during collection and storage (Vinneras *et al.*, 2003).

An adult may produce 500 litres of anthropogenic liquid waste per year containing 500 g of nitrogen, 180g of phosphorus and 370 g of potassium (Shayo, 2003).

Palmquist and Jonsson (2003) stated that the flows and consumptions of wastewater fractions, field measurements were performed on the Gebers wastewater system (80 residents), which source separates the flow into four fractions of anthropogenic liquid waste, dry collected faeces, grey water and solid degradable waste. The flows were 1.77, 0.22, 110 and 0.18 kg per person and day respectively. The chemical composition of the following compounds (TS, COD, N-total, P-total, K, S, Ag, B, Bi, Cd, Co, Cr, Cu, Mn, Ni, Pb and Zn) was reported as 14, 7.44, 7.66, 0.5, 1.64, 0.46, 0.0003, 0.969, less than 0.00005, 0.08, 0.00025, 4.2, 17.2, 0.0015,4.2,4.2 and 107 mg/L, respectively. A ratio of hazardous elements verses nutrients was calculated to evaluate the potential for nutrient recycling. The lower the quotient, better the quality of the fertilizer. Obtained ratios of 12 non-essential elements to phosphorus and nitrogen were lower in ALW than in all of the other fractions.

Magee *et al.* (2004) studied the contribution of dietary protein and inorganic sulfur to total urinary sulfate in humans and found that urinary sulfate from protein sources had a strong correlation with urinary nitrogen (r^2=0.86). Inorganic sulfur was the difference between total sulfate in urine minus the sulfate derived from protein sources. The estimated contribution of inorganic sulfur to total urinary sulfate in humans ranged from 20 to 30 per cent.

The contents of heavy metals and other contaminating substances such as pesticide residues are generally low or very low in excreta, and depend on the amounts present in consumed products. The urine is filtered from the blood by the kidneys. It contains substances that have entered the metabolism and therefore the levels of heavy metals in urine are very low (Jonsson *et al.*, 1997 and 1999, Johansson *et al.*, 2001, Vinneras *et al*., 2006 and Palmquist and Jonsson, 2004). The content of these substances is higher in the faeces compared with the urine. The major reason for this is that faeces consist mainly of non-metabolized material combined with some metabolized material. The main proportion of the micronutrients and other heavy metals passes through the intestine unaffected (Frausto da Silva and Williams, 1997). Even so, the concentrations of contaminating substances in faeces are usually lower than in chemical fertilizers (e.g. cadmium) and farmyard manure (eg. chromium and lead).

The annual urine production varied from 2592 to 1936 liters and dung production from 5000 kg to 7000 kg in bullocks and in cows respectively with an average composition of 1% N and 1.35 per cent K_2O in urine and 0.40 per cent N, 0.20 per cent P_2O_5 and 0.10 per cent K_2O (Yawalkar *et al*., 2002). During the process of nutrient recycling by means of the excretions, appreciable losses of some elements like nitrogen occurred (Klein De *et al*., 2003 and Van Groenigen *et al*., 2005).

A large proportion of the hormones produced by our bodies and the pharmaceuticals that we consume are excreted with the urine, but it is reasonable to believe that the risk for negative effects on the quantity or quality of crops is negligible. All mammals produce hormones and, during the course of evolution, these have long been excreted in terrestrial environments. Thus, the vegetation and soil microbes are adapted to, and can degrade, these hormones. Furthermore, the amount of hormones in manure from domestic animals is far larger than the amount found in human urine. Thus, even though theoretical estimations based on tests with fish have indicated a risk of ecotoxicity from oestradiol when applying urine, both fertilizer experiments and evolutionary history strongly indicate that there is no real risk (Ambjerg-Nielsen *et al.*, 2003).

By far the majority of all pharmaceutical substances are derived from nature, even if many are synthetically produced, and they are thus found and degraded in natural environments with a diverse microbial activity. This has been verified in ordinary wastewater treatment plants, where the degradation of pharmaceutical substances improved when the retention time was prolonged from a number of hours to a number of days. Urine and faecal fertilizers are mixed into the active topsoil, which has a microbial community just as diverse and active as that in wastewater treatment plants, and the substances are retained for months in the topsoil. This means that there is plenty of time for the microbes to degrade any pharmaceutical substances and that risks associated with them are small.

Jonsson *et al.* (2004) observed that the amount of plant nutrients excreted through anthropogenic liquid waste per person per year was measured to be 4.5 to 4.6 kg nitrogen, 0.4 to 0.5 kg phosphorus and 1.3 to 1.4 kg potassium.

Vinneras *et al.* (2006) analysed the nutrient content in anthropogenic liquid waste and found that annual excretion rate per person per year in Sweden was about 4000 g nitrogen, 365 g phosphorus and 1000 g potassium.

Urine contains the largest proportion of plant nutrients found in the household waste and wastewater fractions. The amount of plant nutrients excreted via urine per person and year has been measured as 4.3 kg N, 0.4-1.0 kg P and 0.9-1.0 kg K (Lentner *et al.*, 1981; Vinneras *et al.*, 2006).

Caroline Schonning *et al.* (2007) showed that 12-months storage before use was sufficient for the inactivation of most pathogens to acceptable levels. When working or spending time in the garden the annual risk of infection by Ascaris was still slightly above 10^{-4} in these scenarios, although the incidence rate for Ascaris is very low in the population in question. Measures to further reduce the hygienic risks include longer storage, or treatment of the faeces. The results can easily be extended to other regions with different incidence rates.

Laboratory scale tests for magnesium ammonium phosphate (MAP) precipitation following urea hydrolysis of human urine were conducted using orthogonal experiment design. The effects of initial pH, temperature and the volumetric ratios of stale urine to fresh urine, on urea hydrolysis in urine were studied to determine the final hydrolysis time to recover most nitrogen from separated human urine by MAP. With a volumetric ratio of stale to fresh urine >10% and at temperature ≥ 20°C, urea hydrolysis could be completed in two days (Liu Zhigang *et al.*, 2008).

The reliable identification of compounds such as illegal growth promoters in cattle is generally based on expensive gas chromatography mass-spectrophotometric analysis in urine, a method that does not allow on a large-scale screening. The use of simple, semi-quantitative electrochemical biosensors may provide a means of screening for the presence of compounds such as illegal growth promoters. Before such sensors can be utilised, it is necessary to understand which factors influence the response of an electrochemical sensor in bovine urine. The concentration range of protein (0.01–0.04 %), uric acid (0.5–0.65 mM), xanthine (0.02–0.12 mM) and ascorbic acid (0.1–0.95 mM) in 26 individual urine samples were determined. Using *p*-aminophenol (*p*-AP) as a model system, the electrochemical response increased by 5% in the presence of 6.0 mM uric acid, by 10% on the addition of 0.2 mM xanthine and by 22 % in the presence of 1.0mM ascorbic acid. Exposed urine to air and light for 75 min and eliminated interference from ascorbic acid. Addition of Cu^{2+} (10µM) reduced the time required to 34 min. Binding of species such as growth promoters to proteins may be disrupted by the addition of 8-anilino-1-naphthalene sulphonic acid (ANS) to the urine samples. Addition of 10µM ANS did not affect the limit of detection of *p*-AP. The pH of fresh bovine urine samples was monitored over the period 7 to 192 h after collection and ranged from 8.00 to 8.77. The pH of lyophilised urine samples ranged from 8.24 to 9.60. Amperometry was the most sensitive method among a range of electrochemical techniques in the detection of *p*-AP with a limit of detection (LOD) in urine of 1.0 gmL^{-1} (10 µM) on a glassy carbon electrode (Mamun Jamal, *et al.*, 2005).

Jonsson *et al.* (2004) and Vinneras *et al.* (2006) made measurements on the nutrient content of urine, and found the annual excretion rate per person in Sweden to be about 4000 g N, 330-365 g P and 1000 g K. Together, the nutrients in urine and faeces in Sweden add up to some 4500-4600 g N, 500-550 g P and 1400 g K per person per year. Based on FAO data on food supply, Jonsson and Vinneras (2004) estimated the quantity of nutrients in Ugandan excreta to be 2500 g N and 400 g P per person per year.

Jensen *et al.* (2009) studied that regardless of the starting pH, which varied from 9.4 to 11.6, a >99 per cent die-off of *Ascaris suum* eggs was obtained after 105 to 117 days of storage for all lime concentrations and 97 per cent of eggs were nonviable after 88 days of storage. The most critical parameter found to determine the die-off process was the amount of ammonia (urine) in the excreta which indicates that longer storage periods are needed for parasite egg die-off if urine is separated from the excreta. They concluded an inactivating >99% of all *Ascaris suum* eggs in human excreta during a storage period of only three months the commonly used Double Vault Composting (DVC) latrine, in which urine is not separated, could therefore potentially provide a hygienic acceptable fertilizer.

The total nitrogen (N) concentration in the urine of 12 to 18 month old female sheep, cattle and deer grazing a common pasture was measured in the morning, noon and evening for three consecutive days on two separate occasions in spring, and on a single occasion sampling in autumn. Mean (and range) of urine N concentrations for single urinations were 7.9, 4.4 and 4.1 g N kg^{-1}fresh urine for sheep, cattle and deer, respectively. Wide ranges in urine N concentration were found within days, between days and between animals within the same species. Differences in urine N concentration between the three different species in any one measurement occasion were significant but inconsistent between measurement occasions (Hoogendoorn, 2010).

2.2 Effect of incubation of human and cattle urine on chemical and biological properties

In fresh urine the greater part of the nitrogen appears in organic form as urea $[CO(NH_2)]_2$. Urea hydrolyses rapidly into ammonia (NH_3). Loss of nitrogen as NH_3 and toxicity to plants can occur during urine management and application as fertilizer (Blouin, 1979). Urea hydrolysis is catalyzed by the *urease*, an enzyme, which many microorganisms possess.

Stored human urine had pH values of 8.9 and was composed of eight main ionic species (> 0.1 meq L^{-1}), the cations Na^+, K^+, NH_4^+, Ca^{2+} and the anions, Cl^-, SO_4^{2-}, PO_4^{3-} and HCO_3^-. Nitrogen was mainly (> 90 per cent) present as ammoniacal N, with ammonium bicarbonate being the dominant compound. Urea decomposed during storage. Heavy metal concentrations in urine samples were low compared with other organic fertilizers, but copper, mercury, nickel and zinc were 10-500 times higher in urine than in precipitation and surface waters. In a pot experiment with ^{15}N labelled human urine, higher gaseous losses and lower crop uptake (barley) of urine N than of labelled ammonium nitrate were found. Phosphorus present in urine was utilized at a higher rate than soluble phosphate, showing that urine P is at least as available to crops as soluble P fertilizers (Kirchmann and Pettersson, 1995). And he stated that the plant availability of the nutrients in source-separated urine is high. The concentrations of different heavy metals in human urine are very low (Jonsson *et al.*, 1997). However, as anthropogenic plant nutrients are 'natural' products, their ingredients vary as a result of eating habits, health conditions and terms of collection and storage. Besides the mentioned nutrients, the composition of fresh urine is very complex, usually containing salt, carbonic acid, tannin, resorcinol, orthocresol, guanide, indole, polyamine, benzoate, uric acid, insulin, various hormones, and other substances. Large quantities of pharmaceutical agents or their metabolites are also found in human excreta.

Escher *et al.* (2002) showed that the toxic effect of a mix of pharmaceuticals, each without any specific mode of toxicity (baseline toxicity), can be estimated by adding up the toxic effects of the individual substances. As mentioned, during storage, compositions may change but are difficult to predict as pH, temperature or light can all influence decomposition processes. There is an obvious difference between the nitrogen content of fresh urine and of urine stored for atleast six months. While fresh matter (pH 7) contains approximately 9 g l^{-1} of N (Larsen and Gujer, 1996), less than half of the concentration is found in stored source-separated urine (pH 9). It is not quite clear whether dilution occurs as a result of mixing with flushing water during collection or if chemical processes during storage lead to change in the total nitrogen content. This would mean a gaseous loss of nitrogen into the atmosphere or the fixation of nitrogen due to precipitation in pipes or tanks. However, the observation has also been made for urine collected in waterless urinals or dry toilets (Mnkeni *et al.*, 2005).

In opposition, Jonsson *et al.* (2000) stated that the NH_3 loss is below 1 % in human urine collection systems with closed tanks. During storage, the urea contained in urine is converted to ammonium (or ammonia) and carbon dioxide. As a result, stored urine contains approximately 95 % of its N in the form of NH_4^+, while nitrogen in fresh urine is bound in the form of urea ($CO(NH_2)_2$). Stored human urine is therefore closely related to mineral ammonium fertilisers (e.g. ammonium sulphate) in its basic chemical characteristics. Mineral ammonium fertilisers are rarely used in agriculture as they lead to acidification. Ammonium provides a slower N source than nitrate which, in contrast, raises the pH value. In commercial agriculture in Europe, N fertilisers containing both ammonium and nitrate (e.g.: Calcium Ammonium Nitrate, CAN) are predominant, as their influence on the pH-value is negligible. Furthermore, the mixture of fast available nitrogen (nitrate) and a slower releasing source (ammonia) is positive as it provides N for plants at sufficient amounts over longer periods of time. Added to this is the fact that urine is a liquid and can infiltrate into the soil quickly, which gives it an advantage over granulated mineral fertilisers, which require additional water to dissolve.

Pure urine is microbiologically fairly clean when passed by a healthy person. There is, however, a risk of contamination of the urine by faecal material. Heavy metal contents are much lower in urine than in solid waste but higher than in rain and surface water. The N fertiliser use efficiency of urine is lower than that of ammonium nitrate due the larger gaseous N losses from urine (Kirchmann and Pettersson, 1995).

Anthropogenic liquid waste when collected in ordinary jerricans or large plastic tanks can be stored for long time and used for fertilization. The ventilation of the collection system should be kept at minimum to prevent losses of nitrogen in the form of ammonia and to prevent odour problems (Haneaus *et al.*, 1996). They also stated that anthropogenic liquid waste is subject to chemical hydrolysis and biological decomposition during storage condition.

$$CO(NH_2)_2 + 3H_2O \longrightarrow 2NH_4 + HCO_3 + OH^-$$

The ammonium is in equilibrium reaction with dissolved ammonia

$$NH_4 + OH \longrightarrow NH_3 \text{ (gas)}$$

The pKa-value for the equilibrium is 9.3 at 25 ^{0}C.

Dissolved ammonia is in equilibrium with gaseous ammonia:

$$NH_3 \text{ (aq)} \longrightarrow NH_3 \text{ (gas)}$$

The decomposition of urea will lead to an increase in the concentration of ammonia and an increase in pH in the anthropogenic liquid waste. Ammonia is directly available for the biota and thus key component in the nitrogen cycle.

Stored human urine normally has a high pH (8.6–9.2), which increases the risk of ammonia losses during storage and after spreading. Ammonia emissions are both a resource problem and an environmental problem (Lofgren *et al.,* 1998). The high pH in human urine may have a positive effect in killing infectious bacteria and viruses (Hoglund *et al.,* 2000).

Hellstrom *et al.* (1999) reported that one time dosage or addition of 60 m.eq sulphuric acid or acetic acid per liter of undiluted anthropogenic liquid waste at the beginning of the storage period could inhibit the decomposition of urea during more than hundred days of storage.

The aim of stabilization technique is to reduce or stop urea hydrolysis and nitrogen losses as ammonia during storage and handling of urine. Hellstrom (1999) conducted experiments to decrease the high pH by nitrifying a part of the ammonia to nitrate, but complete nitrification was not achieved. He also stated that by addition of acid to urine, the hydrolysis could be prevented. About 50 % of total ammonia in urine could be stabilized by biological nitrification in biofilms (Udert *et al.*, 2003).

Anthropogenic liquid waste separation toilet has been proposed as a means of achieving maximum recovery and circulation of nutrients not contaminated by hazardous compounds such as heavy metals. Some people view that use of anthropogenic liquid waste (ALW) is problematic with regard to management, storage and transportation. By freezing ALW the nutrients can be concentrated to 25 per cent of the original volume. The freezing and melting method is suitable and made it to capture 80 per cent of the nutrients in 25 per cent of the volume. This can be an important step towards improving anthropogenic liquid waste management with regard to storage and transportation. For the concentration method a 6 m^3 tank is sufficient for collecting ALW for 400 people (Lind *et al.*, 2001).

However, the biggest problem today is the last step before closing the loop, the reuse of anthropogenic nutrients on arable land. Few farmers in Sweden or elsewhere are involved in this crucial step today for different reasons. Transport and storage are key issues, as well as spreading techniques for urine. This issue is quite big in countries outside the cold climate region or with poorer economical resources like in the developing world. Lack of clear regulation regarding urine spreading for hygienic reasons makes the uncertainties even more problematic. Swedish recommendations are just guidelines and its interpretation may lead to confusions or subjective assumptions (Wallin, 2002).

Oldenburg *et al.* (2003) concluded that no nitrogen losses did occur in the anthropogenic liquid waste storage, either in normal or in acid storage conditions. Caroyln Akilith (2005) conducted an experiment to study the extent of nitrogen retention in anthropogenic liquid waste and test the effect of selected additives on the storage of urine in a closed container. The results revealed that sulfuric acid showed substantial decrease in the hydrolysis of urea (1.785 mg to 2.295 mg). It was found that anthraquinone bearing plants and mixtures decreased urea hydrolysis resulting in 12 per cent minimal volatilization.

Xanthoulis *et al.* (2003) observed long-term solutions to the general problem of waste water reuse in accordance with specific needs and environmental conditions in Mediterranean countries. Low cost technologies for wastewater treatment are investigated. Free water system with and without recycling, mixing olive oil wastewater with municipal wastewater or fresh water, achieve good results especially for BOD removal. The maturation and seasonal storage of wastewater shows the positive results of decontamination rate. Source separating toilets reduce the risk of nitrogen pollution.

It is important that the whole system for collection, storage and handling of human urine is to minimize nutrient losses. The experiences from handling and storage of animal manure showed that nitrogen losses can be as high as 30 – 77 % (Misselbrook *et al.*, 2004 and Parkinson *et al.*, 2004), and phosphorus losses around 4 to 30 per cent (Kirchmann, 1998 and Parkinson *et al.*, 2004).

The decomposition of urea will lead to an increase in the concentration of ammonium-ammonia and an increase in pH in urine (from 6 to 9.5) and ammonia will evaporate in contact with air. Ammonia evaporation in the field is dependent also on the soil mineralogical composition, its cation exchange capacity (CEC), soil pH, other salts present, and the weather conditions, time of spreading, etc. Ammonia evaporation up to 25 hours after urine spreading with different application techniques was studied in a clay soil under cold climate conditions in Sweden. Immediate incorporation of urine in topsoil could minimize the ammonia loss to around 5% (Rodhe *et al.*, 2004).

At the pH interval common for fresh urine (pH=5.6-6.8) phosphorus exists as HPO_4^- (pKa=7.71 at 25^oC). Stored human urine has an elevated pH (around 9) and the phosphorus is in HPO_4^- form (pKa = 12.36 at 25^oC). Phosphorus in urine is directly available to plants, and phosphorus loss during urine management is not high (Jonsson *et al.*, 2004). Macronutrients such as K and S in the urine occurs as free ions (K^+ and SO_4^{2-}), which are directly available to plants (Jonsson *et al.*, 2004).

Experience from handling urine in stock-farming in Sweden has shown that the losses of nitrogen during storage could be minimized by having a low temperature, a low pH-value and avoiding aeration above the liquid surface in storage tanks. However, high pH, high temperature, concentrated form of urine (high N concentration) and long storage periods are favourable for hygienic reasons (Hoglund, 2001). Pilot studies on storage conditions (Haneaus *et al.*, 1996) have shown that dilution of urine seems to promote the conversion of urea to ammonia. During spreading of urine as fertilizer to plants a dilution ratio of 3:1 to10:1 has been recommended (Jonsson *et al.*, 2004). However, dilution is also one of the main reasons why pathogens can survive in urine (Hoglund, 2001).

Tilley *et al.* (2008) studied in laboratory experiments using synthetic urine the effect of temperature, faecal contamination, dilution and headspace on urine to be used as a feedstock for struvite recovery were examined. The effects of adding different quantities of magnesium on the amount of phosphorus that could be removed from solution was also examined. An average of 62% of phosphorus could be removed in the form of struvite when magnesium was added to the urine solution after ureolysis had forced the precipitation of calcium and magnesium minerals. Dilution and the presence of faecal urease were found to affect the rate of ureolysis but not the purity of the struvite recovered. These results indicate that, by simply storing urine until it achieves a pH of 8 or greater, struvite can be recovered from source-separated urine with only a magnesium addition.

Ascaris suum egg inactivation exhibited a lag phase, was observed by Ghiglietti *et al.* (1997) and Nordin *et al.* (2009a). The inactivation of *Ascaris suum* eggs at fluctuating temperature (average 24 ºC) reached the no viability level at day 40 in the laboratory study. At constant temperatures of 34 ºC and 24 ºC for the undiluted urine (pH, 9-9.1), the time to reach the no viability level for *Ascaris suum* was 7 and 73 days respectively (Nordin *et al.* 2009a). The cans with wall exposure in the field study had the same average temperature (24 ºC) as those with sun exposure but had smaller amplitude, about 4.7 ºC instead of 7.5 ºC, and the viability at the end of the study was 4% at the wall compared with 1% in the sun. In the cans stored in the room, which had both lower average temperature of 22 ºC and lower amplitude (1.2 ºC), the 40% viability at day 42 was considerably higher than for the sun-exposed cans.

Jorn *et al.* (2010) reported the urine was collected in two 2 m^3 tanks using dry urinals in the men's restroom of the university cafeteria and transported monthly to two 10 m^3 storage tanks at the experimental site. The urine was stirred and analysed for nutrient content prior to use. Nutrient content in human urine to the extent of 4.4, 0.1, 1.4 g kg^{-1} N P K was observed.

The time of treatment for urine in small systems can be considerably shortened by storage of the urine containers in solar radiation. The higher the peak temperatures and the larger the amplitudes reached, the more efficient the inactivation. By using solar heat it is possible to significantly decrease the storage time for safe reuse of collected human urine (Semenov *et al.*, 2007).

2.3 Effect of human and cattle urine on growth yield and quality of crops

Farming is generally recognised as a major source of atmospheric ammonia, contributing 50 % of the global NH_3 emissions (Schlesinger and Hartley, 1992) and over 70 % in areas with intensive livestock farming, such as Europe (Buijsman *et al.*, 1987). Furthermore, the efficiency of NH_4^+ in surface-applied animal slurry as a source of nitrogen (N) to crops can be variable, due to volatilisation of ammonia (Jarvis and Pain, 1990).

According to Wolgast (1993), the annual quantity of human excreta from one person corresponds to the amount of fertiliser needed to produce 250 kg of cereals, which is also the amount of cereals that one person needs to consume per year.

The proportion of useful plant nutrients in urine will vary a little. According to Wolgast (1993) one litre of urine contains 11 g nitrogen, 0.8 g. phosphorus and 2 g potassium. That is a ratio of NPK of about 11:1:2. If 500 litres of urine are produced by each person per year, that amounts to equivalent of 5.6 kg nitrogen, 0.4 kg phosphorus and 1.0 kg potassium. The actual amounts of these minerals will vary from one person to another and also from country to country depending on the nutritional diet. The more protein consumed, the more nitrogen is excreted. Thus in dealing with urine as a potential supplier of plant nutrients, one must accept that it has a very high, but variable level of nitrogen (and also common salt). The ratio of the main plant nutrients (NPK) is approximately 11:1:2, which is not ideal for growing most plants, especially in the early stages of their growth.

The fertilizing effect of source separated anthropogenic liquid waste to cereals was investigated in two pot experiments, a three year field experiment and a one-year field demonstration in Sweden. These investigations showed that source separated anthropogenic liquid waste was well balanced complete fertilizer and its nutrients were readily available to plants. The nitrogen effect was found to be close (90 per cent) to that of ammonium nitrate fertilizer. It varied between 70 per cent and 100 per cent for different years. The phosphorus effect was equal to that of chemical fertilizer. In the experiments, the ammonia emission after spreading varied between less than 1 and 10 per cent. It averaged around 5 per cent. No toxic effects were observed in this experiment (Kirchmann and Pettersson, 1995).

One person produces approximately 500 litres of urine annually. The urine fraction contains 98% of nitrogen, 65% of phosphorus and 80% of potassium excreted by a human. Most of the nitrogen in human urine is in a form suitable for plants, for example ammonia nitrogen (Kirchmann and Pettersson, 1995 and Claesson and Steinbeck, 1996). The nitrogen content in stored human urine depends on the flushing capacity of the toilet water since flushing cause dilution (Jonsson, 1997). Diluted with water (5–10 per cent dilution), clean urine is a suitable source of nitrogen fertiliser for lawn and ornamental plants. Urine can also be used as additive nutrient in yard composts, but its use as fertiliser for edible plants should be investigated.

Since most of the nitrogen is lost immediately after urine has been spread, it is recommended that it should be composted deep in the field (Jonsson *et al.* 1999). For hygienic reasons, urine should be stored in a sealed vessel for six months before spreading.

With separating toilets, the urine is not usually collected and used as fertiliser in the garden, but instead led into grey water and absorbed into the ground through a septic tank or sand filter. With regard to nutrient recycling, more attention should be paid to the utilisation of urine as fertiliser as it contains more nutrients than faeces. For the farmer, the spreading of urine in the field makes sense only if the benefit exceeds the costs and the use causes no harm to the environment or health. The financial value of urine is based on the fertilising effect of its nutrients which are suitable for plants, the use of artificial fertilisation can be reduced. Nevertheless, even if the spreading of urine in the field is technically possible and financially profitable, it can still be hindered by public opinion and prejudice. The labour and machinery costs of urine transportation can easily exceed the value of the nutrients. Furthermore, spreading the urine at the wrong time or unevenly on the field can cause considerable crop failures (Malkki, 1999).

In Sweden, the utilisation of human urine in grain cultivation has been researched. In 1997, an application of human urine, containing 100 kg of total nitrogen per hectare, yielded 68 per cent of the harvest of plots fertilised with the same amount of nitrogen in mineral fertilisers. In 1998, yields from plots fertilised with human urine were at the same level as yields from plots fertilised with an equal amount of nitrogen in mineral fertilisers. (Steineck *et al.*1999)

Guadarrama *et al.* (2001) found that the anthropogenic liquid waste used as fertilizer was the best in cultivation of lettuce plant, owing to the availability of its nutrient, which at the same time, combined with soil humidity and became an optimal environment for the micro fauna and the mineralization process. The daily excretion of urea by an adult varies between 11.8 and 23.8 g per day and the ratio urea- N: total –N is about 0.8 (Fittschen and Hahn, 1998).

Hellstrom (1999) observed that application of human liquid waste significantly increased the yield of winter wheat over the control and artificial fertilizer treatment. Nutrients in anthropogenic liquid waste are easily available to the plants because they are in ionic forms and rapidly degradable in nature. The nutrients in anthropogenic liquid waste are water-soluble and are easily available to the plants for uptake and are easily transported into plant parts.

Elmsquist *et al.* (1998) studied the response of barley to anthropogenic liquid waste and effluent from digestion of food refuses as a nutrient source. They observed that application of ALW to supply 100 kg of N/ha yielded 2600 kg barley/ha and the same amount of mineral fertilizer yielded 3780 kg of grain /ha. The difference between the two sources is 32 per cent less when compared to mineral fertilizer and the difference was very small and acceptable.

Imke and Hermann (1998) reported that the concentration of plant nutrients in human urine was compared with those of liquid cattle excretion as traditional organic fertilizer. Nearly all investigated chemical parameters showed great differences. Cations and anions could not be balanced. During storage, the urea in both human urine and cattle urine was quickly converted to ammonium. During 41 days, storage of human urine with passive gas transfer did not lead to significantly higher nitrogen losses than closed storage. Cattle urine reached highly significantly better results than human urine in a germination test with summer barley and in most of the cases highly significantly or significantly worse results in a germination test with cress. The results indicate that the effects of liquid cattle excretion on plant growth are not the same as those of human urine.

Adamsson (2000) conducted a green house experiment in Sweden to study the potential use of anthropogenic liquid waste in culturing of micro algae in tomato. He stated that yield was increased (1.3 kg of tomato/8 plants) when compared to control (0.9 kg of tomato/8 plants). He concluded that it is possible to use anthropogenic liquid waste in an aquaculture approach and recycle of nutrients by using a constructed food chain.

Human urine collected in separating systems can be used directly as a liquid fertilizer (Kirshmann and Pettersen, 1995 and Jonsson *et al.*, 2000). The fertilizer value of pure urine is similar to NPK 18:2:5 (Linden, 1997) and for urine mixture (urine mixed with flush water) with NPKS ratio of 15:1:3:1 (Palmquist and Jonsen 2003). Guidelines for agricultural use of urine and for grain production using urine are available (Tidaker, 2003 and Vinneras *et al.*, 2003). Loss of nitrogen through ammonia evaporation during storage and spreading can be reduced from well above 20 per cent to below 10 % with better management and agricultural practice in Sweden (Johansson, 2000, Jonsson *et al.*, 2000 and Richert Stintzing *et al.*, 2001).

The high pH of stored urine (~ 9) promotes NH_3 volatilisation. The N loss in the form of NH_3 from animal urine during storage in uncovered tanks can be about 40 % of the total N content, with covered storage, the loss can be reduced by 90 per cent (Karlsson, 1996). or even more (Iversen, 1947). In human urine collection systems with closed tanks, the NH_3 loss is below 1 % (Jonsson *et al.*, 2000). However, ammonia emissions cannot totally be prevented when applying urine on fields.

Hoglund (2001) stated that anthropogenic liquid waste was a complete fertilizer with high concentration of plant available nutrients. Crops like maize, rice, millet, sorghum and wheat, Vegetables like chard, turnip, carrot and fruit crops like banana, orange, tea and coffee show a good response and yield.

The current recommendations for treatment of urine for safe plant nutrient recycling according to WHO (2006) are: 1) Storage at 4 ^{0}C for 1 month for urine to be used on food and fodder crops that are processed before human and/animal consumption; 2) storage at 4 ^{0}C for 6 months for urine to be used on food crops that are processed before consumption and on all fodder crops except grassland for fodder, 3) storage at 20 ^{0}C for 1 month for urine to be used on food crops that are processed and 4) storage at 20^{0}C for 6 months for urine for use on all crops. Other safety barriers for the urine include a close-to-ground application technique, which minimises the formation of aerosols, and incorporation into the soil after spreading, thereby not only minimising the exposure but also decreasing ammonia loss through evaporation (Hoglund *et al.*, 2002).

The nutrient balance of human urine is appropriate for cereal production. The food we need and metabolize is in balance with the 'wastes' we excrete as nutrients during a year and this is enough to produce the next years food (roughly calculated in kg grain). Nitrogen is mainly in the form of urea, phosphorus as phosphates and potassium as K^+ ion, and micronutrients are also present in balanced form in human urine. Moreover, human urine is free from cadmium and other heavy metals (Palmquist and Jonsen, 2003) and in a healthy person urine is sterile, when leaving the body.

In a field trial in Sweden, different application strategies for urine as a fertilizer on leeks were tested (Bath, 2003). Fertilizing with urine gave a three-fold yield increase. Neither yield nor nutrient uptake was significantly affected by whether the same total amount of urine was applied in two doses or whether it was divided into smaller doses applied every 14 days. The N efficiency (i.e. N yield – (N yield in unfertilized plots)/added N), when using human urine was high, ranging from 47% to 66%. This is on the same level as when mineral fertilizers are used. N efficiency for most other organic fertilizers, e.g. compost, is normally between 5 and 30%.

The source-separated human urine can be used for the vegetable plants particularly broad bean, black gram and Green Pea. There was still unutilised NPK found in the media solution. With the applied dilution, effluent still contains traces of NPK. Therefore, further dilution of source-separated human urine can be applied for total nutrient recovery. In future studies, actual nutrient uptake by vegetable plants from source separated human urine and chemical fertilizers in soil media with different dilution or loading rate in the same condition can be investigated in terms of bio-mass growth. The system is based on reuse of valuable nutrients, giving rise to a sustainable treatment process with vegetable plants. It can reduce the dependence on chemical fertilizers, which will save foreign currency needed to import the fertilizers in the developing countries (Kedar Man Prajapati and Deepak Raj Gajurel, 2003).

In field trials on organic farms during 1997-1999, human urine was tested as a fertilizer on spring and winter wheat (Lundstrom and Linden, 2001). For winter wheat, applications were made in spring in the growing crop. A comparison with dried chicken manure and meat + bone meal was made. Human urine corresponding to 40, 80 and 120 kg N/ha increased the grain yields of winter wheat by, on average 750, 1500 and 2000 kg/ha, respectively. Dried chicken manure gave yield increases of, on average, about 600, 1100 and 1500 kg/ha, respectively. Dried meat + bone meal gave the smallest yield increase of about 400, 800 and 1200 kg/ha, respectively. On an average for all the three N fertilization levels, the increase in the winter wheat yields was 18 kg grain per kg N for human urine, 14 kg for dried chicken manure and 10 kg for meat + bone meal. These data showed that the plant availability of N in urine is higher than in chicken manure and meat + bone meal, which is to be expected since chicken manure and meat + bone meal all have a higher fraction of organically bound N. For spring wheat, yield increases and N utilization were lower, probably due to high levels of plant-available N in the soil at the start of the cultivation period.

Urine has been tested as a fertilizer on greenhouse-grown lettuce in Mexico (Guadarrama *et al*., 2001). There were treatments comparing urine with compost, a urine-compost mixture and no fertilizer at all. The application rate was 150 kg of total N per hectare in all treatments, except for the unfertilized one. Urine gave the best yield of lettuce, due to its high availability of N. Similar results are reported for other vegetable crops.

Urine was tested as a fertiliser on barley in Swedish field experiments from 1997 to 1999 (Johansson *et al.,* 2001., Richert-Stintzing *et al.*, 2001 and Rodhe *et al.*, 2004). If the amount of nitrogen remaining after ammonia losses is taken into account when applying the urine, yields were about 80 – 90 % of those that resulted from the application of mineral fertiliser. Between 20 and 200 kg of N from human urine were applied in field experiments. A further finding was made: Human urine and mineral fertiliser differ in terms of nitrogen utilisation. In 1997, crops fertilised with human urine containing 98 kg of nitrogen per ha absorbed 44 % of the nitrogen input. The corresponding figure for mineral nitrogen in the same year was 61 %. The figures for 1999 were 70 % and 83 %, respectively. This indicates that crops absorb less of the nitrogen in human urine than they absorb from artificial fertiliser, and the rest remains in the soil or is emitted into the atmosphere. This nitrogen surplus is either released into the air or water by denitrification or leaching, or it is stored in the organic material of the soil.

The fate of ^{15}N-labeled cattle (*Bos taurus*) urine (52 g N m^{-2}) applied to a 0.4-1.0 m^2 surface area on three dates between May and October to three different pasture soils, was studied using m-2 lysimeters. Over a period of two years, the sward recovered most of the^{15}N, but the amount recovered decreased with application date (62 % in spring to 17% in fall). However, N uptake by rye grass (*Lolium perenne* L.) in Year 2 showed that some nitrogen came from the previous year’s urine application. The largest leaching losses of urine N resulted from the late application date. These losses mainly occurred during the first winter despite the small amount of water drainage. Soil type largely determined ^{15}N losses. The granitic Brunisol was the most freely draining and had the greatest leaching (up to 35% recovery of urinary N).

In contrast, leaching in the silty loam Neoluvisol remained under 4% of 15 N applied. The calcosol appeared to be susceptible to all kinds of N losses with intermediate unaccounted- N pool and leaching fractions and lesser utilization of urinary N by grass.

Immobilization in soil organic matter, roots and litter, and stubble pools were not markedly influenced by the date of application or soil type. They amounted to 25 to 33, 2, and 2 % of N applied as urine, respectively. In these climatic conditions with moderate drainage, leaching of water poor in quality for nitrate only occurred for late season grazing or on the granitic Brunisol, which was very vulnerable to leaching (Decau *et al.*, 2003).

Simons and Clemens (2004) applied acidified urine with pH 4, untreated urine with pH 8, as well as mineral fertiliser to *Lolium multiflorum* and *Trifolium sp.* in a greenhouse experiment. The plots treated with urine showed higher N removals compared to the mineral fertiliser plots. The authors suggested that urine N may substitute N from conventional mineral fertiliser. It was furthermore recommended to apply urine with slurry to increase the N content of the fertiliser. The urine used in the experiment contained relatively low contents of nitrogen (1.6 kg m-3 total N). Barley and rye were also treated with urine 'as mineral fertiliser' in field trials. Again, the urine in some treatments was acidified in order to reduce ammonia emissions and microbial contamination. The results from field trials showed that the fertilising effect of urine was higher than that of mineral fertiliser in the production of barley. There was no difference in yields between plots fertilised with acidified urine and untreated urine.

Rodhe *et al.* (2004) measured gaseous emissions of ammonia after application of urine on clay soil in Sweden. They found that following a spring application with trailing hoses and harrowing after four hours, the nitrogen loss as ammonia, averaged over three years, was 5 % of the applied N, irrespective of the application rate. The largest loss (10 % of the applied N) was measured after application of 60 tonnes of urine per hectare in spring. Hardly any NH_3 loss occurred after incorporation with a harrow, with the exception of the highest application rate. Loss of NH_3 was very low, close to 1 % of the applied N, when the urine was incorporated directly into the soil in spring by band application with trailing shoes. Virtually no emissions were detected when the urine was applied to the growing crop, neither by trailing hoses nor by trailing shoes.

Urine has been tested as a fertilizer on amaranthus in Mexico (Clark, 2003). Results showed that a combination of urine and poultry manure gave the highest yield of 2,350 kg/ha. Chicken manure alone gave a yield of 1,900 kg/ha. Human urine alone gave a yield of 1,500 kg/ha and the unfertilized control gave a yield of 875 kg/ha. The amount of N applied was 150 kg N/ha for the three treatments. Soil sampling showed no differences between treatments regarding physical or chemical characteristics. Urine has been tested as a fertilizer on Swiss chard in Ethiopia (Sundin, 1999).

Martin Aluja and Jaime Pinero (2004) evaluated the attractiveness of three aqueous dilutions of human urine (HU 50, 25, and 12.5%) to adults of pestiferous and nonpestiferous *Anastrepha* species (Diptera: Tephritidae) in small guava, grape fruit, mango, and sapodilla orchards with glass McPhail traps. As control treatments used a commercially available hydrolyzed protein bait (Captor Plus®) and tap water. In the guava orchard, the three urine dilutions were as effective as hydrolyzed protein in attracting *A. fraterculus.* Also, when 25 and 50% urine were used, 93 and 96%, respectively, of the adults captured were females. In the grapefruit orchard, protein baited traps captured significantly more *A. ludens* than urine-baited traps. In the mango orchard, both *A. oblique* and *A. serpentine* were more attracted to hydrolyzed protein than to any other bait treatment. In the sapodilla orchard, traps baited with 50% urine surpassed all other treatments in the capture of *A. serpentine* and *A. obliqua*. The findings indicate that human urine performs as well or better than hydrolyzed protein in certain types of orchards. They also support the notion that there is no “universal” *Anastrepha* bait. They conclude that human urine is a viable, low-tech alternative *Anastrepha* bait for subsistence or low income, small-scale fruit growers in rural Latin America.

Peter Morgan (2004) conducted experiment to study the effect of anthropogenic liquid waste application on spinach plant. The results revealed that application of 3:1 diluted urine at 0.5 litres, twice a week showed good response and yield of spinach leaves. The total yield of spinach was higher in ALW treatment (2522gm) and water treated spinach yield was 741gm after 28 days of growth. He observed that application of anthropogenic liquid waste led to a 3.4 fold increase in harvest after 28days, compared to water fed plants. And also studied the response of maize to different levels of anthropogenic liquid waste application and concluded that one litre of ALW recorded maximum cob yield and cob weight of maize (243.11 gm) when compared to control (82.4 gm /cob).

Jonsson *et al.* (2004) conducted an experiment to study the effect of anthropogenic liquid waste application on the productivity of potato. The experiments were conducted in Khokan region on potato, which included 20 sub-plots each of size 1 m^2. They stated that the yield remains the same. The productivity (15.85 t/ha) was significantly high with chemical fertilizer use than with the application of ALW (11.74 t/ha). Though the productivity was less due to application of anthropogenic liquid waste, it was still within the national average yield of potato (11t/ha).

Guzha (2004) observed that application of 3:1 diluted anthropogenic liquid waste was adequate. The succeeding two crops of maize were positively responding to the anthropogenic liquid waste application. He concluded that regular application of diluted anthropogenic liquid waste on fruit trees also showed positive response.

Mnkeni Pearson (2008) used diluted fresh urine from male students of the Ford Hare University in South Africa to fertilise spinach and cabbage grown in 10-litre pots. Increased dosages of urine resulted in increased yields. The experiment did not include a comparison of yields from other (e.g. mineral) fertilisers.

Aragundy (2005) investigated the use of urine on a household level in Ecuador. She reported a “good growth” of fast-growing vegetables after treatment with stored urine. The experimental set-up did not allow comparisons between mineral fertiliser and urine. The “good taste” of urine-fertilised spinaches is also mentioned in the report. However, no empirical investigation was carried out concerning this.

Heinonen-Tanski *et al.* (2006) fertilised cucumber with urine from a kindergarten, a café, and from private households, collected in separation toilets in Finland. The nitrogen content of the stored urine varied between 2.4 and 3.1 g per litre. The experiment included a mineral fertiliser treatment. However, it is not reported which kind of mineral fertiliser was used. The authors found the same or a slightly better fertilising effect if urine was used instead of ‘standard’ mineral fertiliser. They further stated “the results show clearly that recently formed urine could serve as a valuable fertiliser for cucumbers, and these vegetables could be eaten without cooking or used for fermentation.”

Pradhan *et al.* (2007) used human urine as a fertilizer in cabbage cultivation and compared with industrial fertilizer and nonfertilizer treatments. Urine achieved equal fertilizer value to industrial fertilizer when both were used at a dose of 180 kg N/ha. Growth, biomass, and levels of chloride were slightly higher in urine-fertilized cabbage than with industrial-fertilized cabbage but clearly differed from nonfertilized. Insect damage was lower in urine-fertilized than in industrial-fertilized plots but more extensive than in nonfertilized plots. Microbiological quality of urine-fertilized cabbage and sauerkraut made from the cabbage was similar to that in the other fertilized cabbages. Furthermore, the level of glucosinolates and the taste of sauerkrauts were similar in cabbages from all three fertilization treatments. The results showed that human urine could be used as a fertilizer for cabbage and does not pose any significant hygienic threats or leave any distinctive flavor in food products.

Helvi Heinonen-Tanski *et al.* (2007) obtained human urine from separating toilets was tested as a fertilizer for cultivation of outdoor cucumber (*Cucumis sativus* L.) in a Nordic climate. The urine used contained high amounts of nitrogen with some phosphorus and potassium, but numbers of enteric microorganisms were low even though urine had not been preserved before sampling. The cucumber yield after urine fertilisation was similar or slightly better than the yield obtained from control rows fertilized with commercial mineral fertilizer. None of the cucumbers contained any enteric microorganisms (coliforms, enterococci, coliphages and clostridia). In the taste assessment, 11 out of 20 persons could recognize which cucumber of three cucumbers was different but they did not prefer one over the other cucumber samples, since all of them were assessed as equally good.

Jean Emmanuel Ndzana and Ralf Otterpohl (2009) reported on fertilization of bamboo plantations with urine derived from the Source Control Sanitation, the so called

Ecological Sanitation (Ecosan), urine had demonstrated its potential as a valuable resource for agriculture. Basically urine is a pathogen-free mixture. In terms of nutrient elements nitrogen (N), phosphorus (P) and potassium (K) in wastewater streams, urine alone represents 87 per cent (N), 50 per cent (P) and 54 per cent (K), making it the major component of nutrient rich wastewater. Urine is in use for fertilizing a variety of crops ranging from vegetables to fruit trees. Usually application of urine on soil only happens on a discontinuous basis; that means a couple of applications per year. This study is a pioneer one investigating the reuse of urine on bamboo plantations as fertilizer on a year-round basis. The optimum nutrient loading rate based on nitrogen feeding is researched. The nutrient uptake of the bamboo species used Phyllostachys viridiglaucescens (P. *viridiglaucescens*) is analysed. The effect of continuous feeding with urine on the biomass production was discussed. The experiment was conducted on a lab-scale plant under measured and controlled parameters. The year-round reuse of urine can be a method of choice for urine reuse where the storage of urine is not feasible.

Sridevi *et al.* (2009) revealed that highest bunch yield (30.0 t ha^{-1}) of banana was recorded in the treatment which received RDN through human urine (after 30 days of planting) + gypsum applied to soil when compared to absolute control, recommended dose of fertilizers, recommended dose of nitrogen through human urine with and without gypsum and fertilizer applied to soil and different combinations of human urine and fertilizers. Significant increase in the nitrogen, phosphorus and potassium content in plant samples was observed. The highest total soluble solids (25.85 per cent), reducing sugars (20.93 per cent) and total sugars (23.87 per cent) were recorded in banana fruit grown using human urine.

Surendra *et al.* (2009) reported that the urine fertilized plants produced equal amounts of tomato fruits as mineral fertilized plants and 4.2 times more fruits than non fertilized plants. The levels of lycopene were similar in tomato fruits from all fertilization treatments, but the amount of soluble sugars was lower and Cl^- was higher in urine + ash fertilized tomato fruits. The β-carotene content was greater and the NO_3^- content was lower in urine fertilized tomato fruits. The results suggest that urine with or without wood ash can be used as a substitute for mineral fertilizer to increase the yields of tomato without posing any microbial or chemical risks.

2.4 Effect of human and cattle urine on soil properties and available nutrient status of soil

Andr Bationo (1997) studied to examine the changes over time in soil pH and mineral nitrogen (N) concentrations at the micro sites of cattle and sheep urine patches in comparison to those occurring in fertilizer urea placement zones. The urine and fertilizer solution containing each 400 mg N (800 kg N ha^{-1}) were spread onto individual plots covering a surface area of 4-cm radius. The treatments included a control, which consisted of distillate water. Soil samples from three replicate plots were taken in 4-cm increments to a depth of 16 cm and distance of 16 cm on a grid pattern at days 1, 7, 21, 49, 90, 120, and 150 after application. Significant pH and mineral N gradients developed in the vicinity of the fertilizer and urine placement zones declining towards the periphery and the deeper soil layers. The pH at the centre of the urine zone remained above 7.5 throughout the 150 days of the study period. After the initial increase, the soil pH below the fertilizer placement sites declined to the control level by day 90. Concentrations of ammonium (NH_4) + nitrate (NO_3) also increased markedly in the immediate soil layers of the urine and urea placement zones, and then decreased over time probably due to N losses by volatilization and leaching. Concentrations of mineral N at the periphery of the placement site were similar for all treatments throughout the study period, indicating very little lateral N diffusion. These results provided evidence that animal urine causes significant variabilities in soil chemical composition, even in short distance from the deposition zones. The high soil solution pH in the vicinity of the urine patches alleviate the potential of aluminum (Al) toxicity while increasing the phosphorus (P) availability to crop plants.

Powell *et al*. (1998) showed that sheep urine applied to a sandy siliceous soil in the Republic of Nigeria increased the soil pH, availability of phosphorus and ammonium levels drastically in the upper layer of 10-15 cm of soil especially during the first week following application. However, losses of applied nitrogen in the form of urine via volatilization were in the order of 30-50%.

Since cattle shed effluent is a mixture of cow dung, urine and water, it is rich in N and C. Thus, cattle shed effluent and /or urea can further increase N loading to grazed pastures and may be significant sources of non-point NO^{-}_{3} leaching (Di and Cameron, 2002).

Vinneras *et al.* (2003) found that the plant nutrients in both anthropogenic liquid waste and faeces emanate from arable fields and thus should be recycled as fertilizers to support sustainability and to retain the fertility of the fields. If anthropogenic liquid waste has been collected and stored, it becomes a quick acting fertilizer rich in nitrogen and with a composition of nutrients that well matches the needs of many crops. The amount of anthropogenic liquid waste to be used should be based on the amount of nitrogen that is recommended when fertilizing with urea based fertilizers. If no better knowledge exists, an estimate of the nitrogen concentration in anthropogenic liquid waste of 3-7 g L^{-1} can be used. Fertilization with anthropogenic liquid waste can be done once in the cultivation period, or repeatedly. Normally the effect of repeated application of anthropogenic liquid waste on yield is small if the total dosage remains the same with the conventional flood irrigation system.

Marilene Aban (2005) made organic fertilizer formulation using ALW and studied the effect on soil properties. He observed that there was a decrease in phosphorus and potassium contents in soil after harvest but nitrogen content increased. It is inferred that greater absorption of nitrogen was possible in ALW plus chicken manure, fish trash, rice hull ash and biosol. This could be due to the fibrous rooting system of the crops and the chicken manure might contain nitrogen that is in the readily available form. An anthropogenic liquid waste contains urease and it enhances decomposition of nitrogen in different manures and it creates some biological processes.

Stout (2003) investigated how the urine volume affects how much NO_3 is leached from a urine deposition in the climatic conditions of the northeast USA, a field study using large drainage lysimeters to measure NO_3-N leaching loss from synthetic urine applied in spring and summer with an orchard grass (*Dactyls glomerata* L., c.v. ‘Pennlate’) as test crop. The study site was located in central Pennsylvania on a Hagerstown silty loam soil (fine, mixed, mesic Typic Hapludalf). It was found that increasing urine volume increased the amount of urine N leached but had no significant effect on the apparent percent of urine N leached. The apparent percent of urine N leached was 25 per cent averaged over all treatment times and volumes and was 21 per cent for spring and summer applied urine and 32 per cent for fall applied urine.

The urine is especially rich in nitrogen and in the higher range of 3-7 g N/l given as indicative values by Jonsson *et al.* (2004). It can also be noted that sodium concentration is much higher than magnesium and calcium. In irrigation water where the concentrated ion of sodium salts is high relative to other types of salt, a sodic soil may develop, which is characterized by a poor soil structure: they have a low infiltration rate, they are poorly aerated and difficult to cultivate (FAO, 1985). Even though the salt concentration is quite high in urine, the total salt quantity applied per year is not high when compared to irrigation water. However salinity is complex and further research on urine use and salinity would be welcome to avoid long term problems.

Mussie *et al*. (2006) explained that application of dairy wastes from 5 years increased soil C, N, nitrate, available P and K. Majumdar *et al*. (2006) mentioned that after cow urine addition, NH_3 volatilization was very high on the 3^{rd} hour itself and the highest NH_3 emission from cow urine (50ml and 100ml, respectively) was during initial 21 days. Total NH_3-N emissions were 11 and 6 % in cow urine and 5-8 % in buffalo’s urine out of total nitrogen added through respective urine samples. High temperature, good moisture and prevalent alkaline conditions helped to enhance the emissions.

Marcinkowski and Pietrzak (2006) pointed out the ammonical nitrogen losses from dung (spread on stubble field with 140 kg N ha^{-1} and covered with soil for 24 h) were approximately 13.2 kg NH_3-N ha^{-1} but losses from solid manure applied at 120 and 150 kg N ha^{-1} but covered with soil for 72 h were two and even three times higher (24.9

and 41.5 kg N- NH_3ha^{-1}). High ammonia losses (24.2-49.5% of initial total content of N) were noticed when cattle urine was spread on grasslands in doses of 58-140 kg N ha^{-1}. Luo *et al*. (2007) reported that application of cow urine to soil increased N_2O fluxes above those from the control site for up to 6 weeks.

Tidaker *et al.* (2007) demonstrated that an agricultural system using human urine has several environmental benefits if the system is well designed. Emissions of nitrogen and phosphorus to water were lower in the urine-spreading scenario than in the reference scenario. A minor decrease in greenhouse gases was also apparent. Due to emissions of NH_3 during storage and spreading of the urine, the contribution to acidification increased in the urine spreading scenario. Applying an agricultural perspective when assessing a urine-separating system gave valuable information on how agricultural production using human urine could be designed. Effects influencing the yield, e.g. soil compaction and wheel traffic in a growing crop from spreading operations, could thereby be included. An optimal fertilizing strategy concerning application time, technique and substitution of mineral fertilizer was demonstrated to be important for reducing the environmental load and avoiding soil compaction. The approach also highlighted potential conflicts regarding nutrient utilization.

Stintzing *et al.* (2007) reported that urine and faeces supplement each other as fertilizers, urine is rich in nitrogen that is quickly available, while faeces is rich in phosphorus, potassium and organics and its nutrients are not that readily available. The chemical contamination of urine and faeces is minimal and the levels of heavy metals are very low. Pharmaceutical residues are excreted via urine and faeces. However, the soil-root barrier is very efficient and therefore the risk with these substances is probably far smaller than that associated with insecticides, fungicides and herbicides applied to crops. As these fertilizers contain all the elements removed from the field by the crop, their use decreases both the need of soil analyses and the risk for soil depletion. Reuse of urine and faeces as fertilizers essentially eliminates the risk that their nutrients pollute the environment and it enables sustainable crop production.

2.5 Effect of human urine and cattle urine on microbial population

Laanbroek and Gerards (1991) and Mc Andrew and Malhi (1992) observed an enhanced microbial activity in soil surface after application of organic wastes. Lovell and Jarvis (1996) reported that CO_2 production increased within one day of the urine application indicating an immediate and significant increase in biomass metabolic activity. They also have shown that urine treatment had higher rate of N_2O emission than the control.

Whitehead and Raistrick (1993) demonstrated that when urine and dung were stored with additional water as slurry, the hydrolysis of urea-N proceeded as rapidly as with urine alone. Mineralization of the dung organic matter occurred more rapidly than with dung stored alone. They also reported that the concentration of ammonium N in the liquid portion of the slurry after 3 weeks ranged from 3.5 g L^{-1} at 5^0C to 3.8 g L^{-1} at 35^0C. They also found a rapid development of urease-producing bacteria after 7 days of excretion.

Haynes and Williams (1999) concluded that the stock camping activity of grazing animals resulted in an increase in both the fertility and biological activity in soils from camp areas. Majumdar *et al.* (2006) stated that urine supplied essential nutrients to help in increasing the microbial population making them respire more.

Lovell and Jarvis (1996) stated that in clay loam soil, wetting with water or urine increased soil microbial biomass C and N contents by about 20% but there was no specific effect of urine. Urine, however, caused an increase in soil respiration of >50% and the average increase was greater for cow's urine (30.8 mg CO_2 m^{-2} min^{-1}) than for an artificial urine (20.1 mg CO_2 m^{-2} min^{-1}). Emissions of nitric and nitrous oxides following urine application were substantial (on an average 0.36 μg NO-N and 29 μg N_2O-N m^{-2} min^{-1}) but short lived (<40 days). The high levels of ammonium found in the urine treated soils (>200 mg NH_4^+-N kg^{-1}) were nitrified to nitrate over a period of 42 days. Qualitative changes in the soil microbial biomass were evidently not related to biomass size.

Hoglund *et al.* (2000) reported that variations in concentrations occur at different levels within urine tanks and to evaluate possible consequences thereof, urine samples were collected from four collection tanks and one storage tank of different urine separating sewerage systems. Plant nutrients and metals were found to concentrate in the sediment at the bottom of the tanks. Also, densities of indicator bacteria were higher in the bottom layer, probably due to adsorption to sedimented particles. The differences in concentration at different levels became more apparent during storage of the urine mixture. After four months of storage, concentrations of the investigated indicator bacteria, except clostridia, were below detection limits at all levels. Considering the variability in nutrient concentration, samples from the middle level correspond well to the average composition in the tanks and can be used to calculate urine application rates. When estimating hygienic risks with the reuse of human urine the concentration variability also needs to be considered.

Compost tea (cow dung + cow urine + water) containing high amounts of microbes was found to have complemented the activity of the native microbes and favoured decomposition of organic matter at a faster rate resulting in better transformation of nutrients and their availability to crops (Pathak and Ram, 2002).

The spreading of manure or fertiliser might influence chemical as well as biological soil properties. Adding plant nutrients to an agricultural ecosystem has an effect both on crops and on the organic soil shares. The soil is considered to be the farmer productive base (Diepenbrock *et al.,* 2005). Soil fertility is defined as the contribution of soil to the potential yield at a specific location in an agro-ecosystem (Kundler, 1989). It further describes the natural and sustainable ability of a soil to enable plant growth and secure high crop yields on a long-term basis (Scheffer and Schachtschabel, 1992). Over longer periods, management practices can influence and change soil fertility (Baeumer, 1992). The chemical, physical and biological properties of a soil are defined by site-specific conditions and management practices. Pankhurst *et al.* (1997) pointed out that addition of 'organic waste', as well as agricultural management practices, can affect soil biota. Changes in microbial activities and the composition of soil microbial communities can in turn influence soil fertility and plant growth by increasing nutrient availability and turnover, disease incidence or disease suppression.

Before applying organic residual materials to soil, it is essential to ensure that these materials do not pose any danger to humans, animals, or to the environment. Organic amendments to soil are of little value if these are injurious to the crop, to the soil microbial populations, or if these amendments are not transformed to humus materials in the soil environment. Thus, it is essential to ensure the absence of undesired organic and inorganic substances (Clapp *et al.*, 2005). However, despite being of organic origin, the carbon content of stored human urine is low. Unlike most of the other 'organic wastes' (plant or animal residues, manure, sewage sludge or municipal solid waste), its nitrogen fraction is largely not organically bound. This means a significant rise of the soil humus content as a direct result of the addition of organic carbon is not to be expected. Nevertheless, the humus content of soils might be influenced by increased plant growth and decomposition after spreading of urine, as it contains plant nutrients.

Amira Hassan Abdullah Al-Abdalall (2010) studied the effect of urine and camel milk in the inhibition of biological effects of mycotoxins produced by nine isolates of *Aspergillus flavus* and one isolate of *Aspergillus niger* isolated from pulse seeds. Where these toxins lost their ability to inhibit *Bacillus subtilus* growth, milk could not. Also, the study records the effect of camel urine on mycelial growth of some root rot fungi isolated from seeds of pulses like *Rhizoctonia solani, Fusarium moliniform, Aschocayta* sp., *Pythium aphanidermatum.* Studies also included some storage fungi (*Aspergillus* sp) isolated from coffee beans. Results proved that camel urine at low concentrations has no significant inhibitory effect on fungal growth, while inhibition can be obviously recorded after using high concentrations.

Aguiler*a et al.* (2010) observed that the incorporation of increasing dose of LCM (Liquid Cow Manure) modified the soil chemical properties. High dose of LCM application resulted in increased pH and EC values, nutrients and DOC (Dissolved Organic Carbon) content. The highest amendment dose presented a significant difference as compared to the other treatments throughout the 60 days incubation period. The respiration activity of the amended soils increased with the increasing dose of LCM. The $C\text{-}CO_2$ evolution rate constant showed that amended soils presented a higher $C\text{-}CO_2$ evolution levels on 1 incubation day. The amended soils which were incubated for more than 10 days presented a constant rate of respiration. The soil enzymatic activities indicated that LCM incorporation caused an increase in the FDA (fluorescein diacetate) hydrolysis and the β-glucosidase of amended soils. Although there was an initial inhibition in the FDA hydrolysis, in this study it was found that the incorporation of increasing dose of LCM modified the chemical and biological properties of the soil and that there was a correlation between the chemical properties of the soils amended and the biological activity, mainly C-CO_2 evolution.

Sadaf Javaria and Qasim Khana (2010) studied the use of organic fertilizer together with chemical fertilizers, compared to the addition of organic fertilizers alone, has a higher positive effect on microbial biomass. The INM changes the chemical and biological properties of soils, it improves the soil organic C, total N, phosphorus (P), and potassium (K) status and microbial biomass (C and N), and soil organic matter (OM) content and long-term soil productivity in the tropics where soil OM content is low. Soil biomass was increased by INM as these amendments supply readily decomposable organic matter in addition to increasing root biomass and root exudates due to better crop growth.

2.6 Effect of application of amendments on soil properties

Najar and Gupta (1996) reported that gypsum application decreased the pH, EC, exchangeable Na, ESP, CO_3 and HCO_3 contents and increased the organic matter, exchangeable Ca^{2+} and K^+ contents of sodic soil.

Ilyas *et al.* (1997) reported that in a field experiment conducted at Jodhpur (Rajasthan) on alkali soils, treatments receiving crop rotation with gypsum application significantly decreased the pH, EC, SAR and chlorides in the top 20 cm soil.

Solaimalai *et al.* (2001) reported that application of pressmud improved the soil fertility, nutrient uptake and yield in sodic soil. Application of gypsum in combination with pressmud resulted in better pH reduction than pressmud alone.

Rathod *et al.* (2003) reported about the efficiency of gypsum in reclaiming sodic Vertisol when used in association with FYM followed by irrigation with alkali water.

They concluded that integration of gypsum and FYM with NPK reduced the deleterious effect of alkaline water applied to sodic Vertisols and there was decrease in sodicity of soil.

Hargopal Singh and Bajwa (2003) studied the effect of gypsum and sodic water irrigation on the precipitation of Ca and removal of Na from a sodic soil reclaimed with different levels of gypsum (33, 67 and 100 per cent of the total gypsum requirement of the soil) and growth of rice was investigated in a greenhouse experiment. Precipitation of Ca and carbonates and soil Na saturation increased with increase in sodicity of irrigation water. Application of gypsum for initial sodic soil reclamation or at each irrigation (G_{ei}) during growth of rice and wheat increased the removal of Na from the soil and decreased exchangeable sodium percentage (ESP) and pH.

Chun *et al.* (2007) conducted a column experiment using organic matter (rice straw) and chemical amendments (H_2SO_4, $CaSO_4$, and $FeSO_4$), to evaluate the physical and chemical properties of the sodic soil influenced by the changes in hydraulic conductivity, penetrability of soil surface, pH, electrical conductivity, CO_3^{2-}, HCO_3^-, Ca^{2+}, Na^+, sodium adsorption ratio (SAR). Among the chemical amendments, H_2SO_4 and $FeSO_4$ were more effective than $CaSO_4$ to restore HC, electrical conductivity, Na^+, and SAR. Organic matter decreased the concentrations of CO_3^{2-}, HCO_3^-, and Na^+ in soil solution and increased the total volume of the leachate.

2.7 Rates of application of nutrients to crops

Treatments, consisting of combinations of three levels of N (100, 200 and 400 kg ha^{-1}), P_2O_5 (50, 100 and 200 kg ha^{-1}) and K_2O (50, 100 and 200 kg ha^{-1}) studied by Bagal *et al.* (I989a). Protein, sugar, ascorbic acid and mineral contents were significantly increased by increasing the rates of N, P and K application. Of the treatment combinations, 200 kg N, 100 kg P_2O_5 and 100 K_2O kg ha^{-1} produced the best quality fruits. Combination of N with K resulted in better quality tomatoes than the combinations of N with P.

Bagal *et al.* (1989b) reported that application of increasing rates of N, P and K fertilizers significantly increased the yield, juice content and juice TSS. The percentage moisture and nitrate contents were not affected by fertilizer treatment. Acidity increased with increasing fertilizer application, upto rates of 200 kg N, 100 kg P_2O_5 and 100 kg K_2O ha^{-1} after which there were no further increases. Increasing rates of K resulted in an increase in lycopene content, where as P had opposite effect. Combined N, P and K application resulted in the highest lycopene contents. The optimum fertilizer combination was 200 kg N, 100 kg P_2O_5 and 100 kg K_2O ha^{-1} which gave the highest yield (309 q ha^{-1}) and good quality fruits.

Yield and fruit weight were the highest at 1.0 evapotranspiration (ETM), but most quality components (^{0}Brix, acidity, colour and TSS %) were best at 0.7 ETM. N fertilizer treatments had less significant effects on yield and quality (Brauthome *et al.,* 1994). In a trial conducted by Lacatus *et al.* (1994) in Romania, processing tomatoes were supplied with N (as ammonium nitrate) at 100, 200 or 300 kg ha^{-1}, P_2O_5 (as concentrated super phosphate) at 75 or 150 kg ha^{-1}, K_2O (potassium sulphate) at 75 or 150 kg ha^{-1} and half fermented FYM at 20,40 60 t ha^{-1}. The best quality for processing was obtained with N, P and K rates of 300, 150 and 75 kg ha^{-1}, respectively with 20 t FYM ha^{-1}.

Although increasing rates of applied N to tomato crop had no effect on average fruit weight, they significantly increased fruit numbers. Application of 240 kg N ha^{-1} was excessive and significantly reduced the yield compared with 120 or 180 kg N ha^{-1}. The highest yield obtained with 180 kg N ha^{-1} was 38 t ha^{-1} (Adjanohoun *et al.,* 1996). Further with 100, 200, 400 or 800 kg N and 150, 300, 600 or 1200 kg K_2O ha^{-1}, it was calculated that the highest commercial yield (157.6 t ha^{-1}) was obtained with 359 kg K_2O + 200 kg N ha^{-1}. Nitrogen rates above this resulted in a decrease in fruit production (Silva *et al.,* 1997). Abdul Baki *et al.* (1997) compared four rates of N fertilizer (0, 56, 112 and 168 kg ha^{-1}) as water soluble NH_4NO_3 in 14 equal splits through trickle irrigation system. Tomato yield increased in response to applied N in both mulches (plastic and hairy vetch mulch) in all three years, optimum N rates of 90 and 190 kg ha^{-1} in hairy vetch and black polyethylene mulch, respectively, were predicted by a linear plateau model, and 124 and 295 kg ha^{-1} by quadratic plateau model. The linear plateau model is recommended because it would allow less N to become available for runoff and leaching. Podsiado and Karczmarczyk (2001) studied the influence of supplemental irrigation and NPK fertilizer doses and from their study they revealed that the leaves of plants grown on watered and well fertilized plots did show increased photosynthetic activity, which was demonstrated by a larger leaf surface, CO_2 assimilation and transpiration, and also a larger content of photosynthetic pigments.

A field experiment conducted by Ashok Kumar *et al.* (2001) revealed that fertigation level of 100% recommended rate (150 kg N + 40 kg P_2O_5 +50 kg K_2O ha^{-1}) was at par with 50% RF + 10 t FYM ha^{-1} and produced the highest marketable tomato yield. Balliu and Ibro (2002) reported the effect of different potassium fertilizer levels on yield and fruit quality. Nitrogen (8 m mol l^{-1}) and phosphorus were kept in a constant range while potassium ranged at the ratios of 1.0: 0.4: 1.2, 1.0: 0.4:2.4 and 1.0: 0.4: 4.8 N: P_2O_5: K_2O. There were no significant differences in the tomato crop yield. However, there were significant differences in the ascorbic acid content of the ripe fruits in relation to potassium level applied.

Hongxia *et al.* (2003) showed that under the same amount of N, the highest increment in yield (52.7 %) and the cost benefit ratio (1:3.9) were obtained with $N:P_2O_5:K_2O$ at 1:1:1.5. Fertigation with $N:P_2O_5:K_2O$ at 1:1:1 and 1:1:2 also increased the yield (36.4 and 47.3%, respectively) and gave high cost benefit ratios (1:3.4 and 1:3.3, respectively).

2.8 Growth, yield and quality of different vegetable crops as affected by the application of human and cattle urine

An experiment was conducted during winter season, to study the response of French bean to nitrogen levels (0, 30, 60, 90 and 120kg/ha) and four irrigation regime based on IW:CPE (1.2,1.0,0.8 and 0.6). Irrigation scheduling at an IW:CPE ratio accounting to six irrigations gave significantly highest yield. Nitrogen @120 kg/ha increased the grain yield, number of pods/plant and test weight (Dahatonde *et al.*, 1992).

Singh and Singh (1992) reported that French bean (*Phaseolus Vulgaris* L.) responded well to the application of phosphorus (60 kg P/ha), increased green pod yield with increased dose of phosphorus.

Christou *et al.* (1992) carried out the experiment with the tomato variety Justar (E6203). In samples of tomato fruits from each experiment, at harvest time, the concentration of N, P, K, Ca and Mg was measured. Differences in the concentration of mineral nutrients in the fruits, among the sites were found, with the highest differences noticed in P. The concentration of the five nutrients, ranged between 2.36 and 3.70 % for N, 0.29 and 0.65 % for P, 3.22 and 5.33 % for K, 0.12 and 0.21 % for Ca, and 0.15 and 0.29 % for Mg. The effect of water supply level on the mineral composition of the fruits was significant in some cases. Increasing amounts of water resulted in decreased concentration of N, Mg, or K in the fruit, while it resulted in increased concentration of P and Ca in other cases. On the other hand, the increase in nitrogen supply, resulted in an increased concentration of N in the fruits, in four out of six sites while the same trend was noticed in the other two sites. Also increased rates of N supply resulted in a decrease in P or an increase in Ca concentration in the fruit. Differences in soil condition as nutrient availability, pH, organic matter content or soil structure, as well as the climatic conditions resulted in variation in response to the same treatments.

Singh (2000), observed that French bean cv. 'Arka Komal' recorded maximum plant height (50.9cm) at 75kg/ha and minimum in 50kg/ha (49.6cm), while there was reduction in plant height with the application of nitrogen at 100kg/ha (52.4cm), and 125kg/ha (52.2cm) .

A study was conducted in Faizabad, U.P to find out the optimum and economical dose of nitrogen and phosphorus for better growth and seed yield of French bean. Plant height, number of branches and length of pod increased with successive increase in the doses of nitrogen as well as phosphorus. Application of 120kg N/ha produced significantly higher number of pods/plant, weight of seeds/plant, number of seeds/pod and seed yield whereas 160kg N/ha significantly reduced the seed yield. The maximum values on the above yield attributes were recorded with 60kg P_2O_5/ha. The combination of 120kgN+60kg P_2O_5/ha along with 60kg K_2O/ha gave maximum yield and net returns. (Tewari and Singh, 2000).

The roots of plants grown with fertigation tended to be confined to the dripped soil region, thus reducing soil chemical stress and increasing calcium uptake driven by water flux (Nakano *et al.,* 2001). The highest yield of tomato was obtained when fertigation was done twice a week compared to once a week (Fernandes *et al.*, 2002).

An experiment was conducted during Rabi season to study the effect of nutrient management treatments on growth and yield of French bean. Results showed that 100% recommended dose of fertilizers (90 kgN and 60kg P/ha) recorded significantly more plant height, functional leaves, leaf area per plant, number braches per plant, and grain yield/ha. Results further indicated that, 100% recommended nitrogen was at par with the application of 75% recommended nitrogen along with 25% nitrogen through FYM or vermicompost as well as 75% recommended nitrogen along with 25% nitrogen through FYM or vermicompost and biofertilizers gave better results.(Band *et al*., 2002).

Aiyelaagbe and Kintomo (2002) in the 1994 and 1995 cropping seasons, fluted pumpkin (*Telfairia occidentalis* Hook. F) was intercropped with banana or grown alone. The fluted pumpkin, whether intercropped or grown alone, received 30 to 120 kg N ha^{-1} in the first cropping season and 80 to 320 kg N ha^{-1} in the following season. Fluted pumpkin plants grown alone or which did not receive N served as controls. The objective of the study was to determine the N requirement of fluted pumpkin when grown alone or as an intercrop. Intercropping significantly decreased vine yield and number of fruits set in the 1994 cropping season, but it did not significantly influenced number of fruits set in the 1995 cropping season. In both cropping seasons, intercropping had no significant effect on fruit yield. In the 1994 cropping season, linear trends were significant for the response of vine yield to N fertilization. In the 1995 cropping season, quadratic trends were significant for the response of fruit set and fruit yield to N fertilization. There was no interaction between cropping systems and N fertilization.

Xiuming Hao *et al.* (2003) reported that the high Ca (300 mg L^{-1}) improved tomato fruit yield, and reduced incidence of BER (blossom endrot) and fruit russeting in a fall tomato crop, while it reduced firmness of pericarp tissue. The positive effects of yield improvement and reduction in BER and russeting should outweigh the negative impact on fruit soluble solids and firmness, because the latter two are not major quality concerns in fall production. Therefore, higher Ca concentrations are recommended, at least for fall tomato production. Low Mg (20 ppm) caused leaf chlorosis in middle leaves and tended to reduce fruit yield in late fruit production. High Mg increased fruit BER incidence, mainly at 150 mgL^{-1} Ca, but it did not offer any yield advantage in the early production period. However, 80 mg L^{-1} Mg improved root growth, leaf size and fruit firmness in late production at 300 mg L^{-1} Ca. Fruit yield was the highest at 300/50–80 mg L^{-1} Ca/Mg. Fruit russeting was the lowest at 300/50 mg L^{-1} Ca/Mg in the middle fruit production. Therefore, for a fall greenhouse tomato crop, the optimum Ca/Mg management strategy seems to be starting at 300/50 mg L^{-1} Ca/Mg and gradually increasing Mg to 80 mg L^{-1} towards the end of the season to improve plant growth and fruit firmness.

Krishna and Allolli (2008) observed that the productivity of tomato was significantly enhanced (30.99 t/ha) when it was grown in alleys supplemented with lopppings and FYM + 25% of recommended dose of fertilizer (RDF). On the contrary, the productivity of tomato followed decline (21.27 t/ha) trend when it was raised as sole crop deprived of loppings but supplemented with VAM + 25% RDF. Similar trend was also noticed with respect to qualitative (total soluble solids, 6.62%; acidity, 0.96%; lycopene content, 8.21 mg/100 g of juice) aspect of tomato fruits, when it was grown as a alley crop supplemented with loppings and FYM + 25 per cent RDF.

Helvi Heinonen-Tanski *et. al*. (2007) obtained human urine from separating toilets and was tested as a fertiliser for cultivation of outdoor cucumber (*Cucumis sativus* L.) in a Nordic climate. The urine used contained high amounts of nitrogen with some phosphorus and potassium, but number of enteric microorganisms were low even though urine had not been preserved before sampling. The cucumber yield after urine fertilisation was similar or slightly better than the yield obtained from control rows fertilised with commercial mineral fertiliser. None of the cucumbers contained any enteric microorganisms (coliforms, enterococci, coliphages and clostridia). In the taste assessment, 11 out of 20 persons could recognize which cucumber of three cucumbers was different but they did not prefer one over the other cucumber samples, since all of them were assessed as equally good.

Salikutty Joseph and Bavrah Balan (2008) worked out the biological efficiency indices LER(Land equivalent ratio), LEC(Land equivalent coefficient), ATER (Area time equivalent ratio), aggressivity and RCC (Relative crowding coefficient) for the system in both planting systems. LER and ATER for all the treatments were above one and this indicated that intercropping in ash gourd is biologically efficient. The LEC value was highest for ash gourd + amaranthus (T_4) and ashgourd + bush cowpea (T_3) combination. Negative aggressivity values for treatments containing three crop combinations indicated that the intercrops could be more aggressive, but there is no yield reduction in the base crop, ashgourd.

Basavarajeshwari *et al.* (2008) revealed that the application of boric acid @ 100ppm resulted in maximum number of primary branches (18.30), yield per plant (2.07kg) and fruit yield (30.50 t/ha). Followed by best treatment was the mixture of micronutrients (Bo, Zn, Mn and Fe @ 100ppm and Mo @ 50ppm) recording fruit yield of 27.98 t/ha and differed significantly from the control as well as other treatments. The maximum benefit cost ratio of 1.80 was obtained with application of boron recording Rs 97,850 /ha of net returns followed by mixture of micronutrients (1.74) recording Rs 88,900 /ha net returns compared to control (1.40) which recorded minimum net returns of Rs 53,250 /ha.

Narayan *et al.* (2008) tried treatments with organic manure, inorganic fertilizers and their combinations and showed significant differences in fruit yield and yield attributing traits. Among the treatments, application of 20 t FYM/ ha along with full dose of recommended NPK that is 150:60:60 kg NPK ha^{-1} recorded the highest fruit yield of 428.32 and 530.55 q ha^{-1} during the year 2002 and 2003, respectively with grand mean fruit yield of 479.43 q ha^{-1}. This treatment was on par with 40 tonnes FYM + ½ dose of recommended NPK during 2002 and 2003, which recorded mean fruit yield of 456.17 q ha^{-1}. Both these treatments were significantly superior to recommended inorganic NPK fertilizer treatment (435.57 q/ ha) as well as to application of different doses of organic manure alone such as FYM and green manure, indicating that integration of both organic manures and inorganic fertilizers are important for obtaining higher fruit yield in tomato. Addition of organic manure besides having favourable effect on crop yield was also found to be better in maintaining soil health and growth of succeeding crop.

Mohamed *et al.* (2010) revealed that the best plant growth measurements of squash were recorded when nitrogen (urea 1.5 %) + potassium (36.5 % K_2O) and/or nitrogen + calcium (Calborate, 14 % Ca) were applied as a foliar application. Whereas, the differences within these two treatments were no great to be significant. Also, the total and early fruits yield of squash and its physical properties (fruit length, diameter and weight) as well as the nutritional values of fruits (protein, N, P, K, Fe, Zn Cu and Mn). All of these measurements recorded their highest values when plants were sprayed with nitrogen + potassium and/or nitrogen + calcium.

Ayeni *et al.* (2010) reported that poultry manure significantly enhanced growth, yield and macronutrients content of tomato in savanna – forest transition zone of southwest Nigeria. The manure at 20 and 30 t ha^{-1} increased nutrient status and yield of tomato compared with 300 kg ha^{-1} N.P.K 15:15:15 fertilizer. The poultry manure at 30 t ha^{-1} maximizes yield and N, P, K and Ca content of tomato plant.

2.9 Dry matter accumulation and nutrients uptake by crops

In tomato, dry matter accumulation during the initial 30 days after transplanting (DAT) is low and is less than 5 per cent of the total dry matter produced by the end of the growth cycle (Hegde and Srinivas 1989a, 1989b). Later, there is an almost linear increase in dry matter production up to 90 DAT. It then slows, and during the final stages of the life cycle there may even be a slight decline in dry matter, due to leaf fall. The rate of dry matter accumulation in the stem and fruit continues to increase until the crop reaches full maturity. The proportion of dry matter distributed in fruits ranged from 51 per cent in crops without N fertilization, to 39 per cent in crops which had recieved 240 kg N/ha (Hegde and Srinivas, 1989a). Dry matter production and nutrient uptake are very closely related. During the four months after transplanting, about 5%, of total nutrient uptake will be achieved by 30, DAT, 12-15% by 45 DAT, 35-40 per cent by 60 DAT, 60-65 per cent by 75 DAT, 85-90 per cent by 90 DAT, and 95 per cent by 105 DAT. Thus, about 50 per cent of the total nutrient uptake takes place between 60 and 90 DAT, a period coinciding with peak fruit development.

The amount of nutrients taken up by these crops depends on the number of fruits and the amount of dry matter produced. This in turn is influenced by a number of genetic and environmental variables (Shukla and Naik, 1993). Hegde and Srinivas (1989a) studied NPK uptake by tomato in soils with different levels of soil matric potential and applied N. They observed that nutrient uptake declined with increasing soil moisture stress, and increased with higher levels of N application. They reported that a crop yielding 60.8 t ha^{-1} of fruit removed 147.8 kg N, 19.8 kg P and 156.2 kg K. Large variations between tomato varieties in N uptake were reported by Chakraborty *et al.* (1990). They reported that variety "Pusa Early Dwarf" absorbed 20.8, 87.6, 421.9, and 672.2 and mg N/plant at 6, 33, 47 and 58 days after transplanting (DAT). In contrast, Pusa Ruby absorbed 14.2, 69.5 308, and 893.2 mg N/plant. They further observed significant differences in N use efficiency between varieties, in terms of dry matter produced per unit of N absorbed. The highest concentrations of NPK in tomato were found in the fruit, and the lowest in the roots (Maestrey *et al.*, 1987).

Gupta *et al*. (1996) conducted a field experiment to study the effect of moisture regime and fertility level on growth, yield, nutrient uptake and moisture use by 'HUR 15' of French bean. Treatments comprised of 4 moisture regimes (IW:CPE ratios 0.25,0.50, 0.75 and 1.00) in main plots and 4 fertility levels [control ($N_oP_oK_o$) low ($N_{40}P_{12.9}K_{16.6}$), medium ($N_{80}P_{25.80}K_{33.2}$) and high ($N_{120}P_{38.7}K_{49.8}$) in subplots during winter season. Irrigation regimes significantly increased the pods/plant (61.3 per cent), seeds per plant (21.9 per cent), hundred seed weight (22.8 per cent), grain yield (32.4 per cent) and NPK uptake up to 0.75IW: CPE ratio (33.3 per cent) compared with 0.25IW: CPE ratio. NPK uptake increased significantly with corresponding increase in fertility level. Higher fertility level ($N_{120}P_{38.7}K_{49.8}$) led to 8.8 per cent higher moisture use.

A field experiment was conducted at New Delhi on sandy loam soils to study comparative performance of French bean variety and their responses to plant density and phosphate fertilizers. Among the varieties ‘PDR-14’ had the tallest plants with highest number of pods/plant and bolder seeds. ‘Hur 14’ recorded highest number of seeds per pod. ‘PDR 14’ gave highest mean yield. Lower plant densities of 222,000 plants/ha showed significant increase in number of pods per plant (Ahlawat and Sharma, 1996).

A field experiment was conducted during summer in cold desert, dry temperate region of Kinnaur, to study the effect of nitrogen and phosphorus on yield and uptake of nutrients by French bean. Plant height, pods/plant, seeds/pod, and seed yield increased significantly up to 15 kg nitrogen and 60 kg phosphorus (Devender *et. al.*, 1999).

Motis *et al.* (1998) suggested that the practice of applying a high percentage seasonal N requirement of crops through a drip system does not result in maximum yield. Yields appeared to be related to leaf K, not leaf N concentration and uptake of K by tomato is affected by N source and its placement. Apparently, increased K uptake with reduced levels of NH_4^+ or increased levels of NO_3^- resulted in increased production of marketable fruit. Malik and Kumar (1998) reported that the yields and fruit size of tomato were greatest when the supplementary fertilizer was supplied through the drip system compared to soil application.

Yield and N uptake of tomato crop in five successive rotations receiving· compound fertilizers (12-12-17 and 21-8-11, N-P_2O_5-K_2O) were studied by Jian Hua *et al.* (2004). The higher N fertilizer rate of 300 kg N ha^{-1} (versus 150 kg N ha^{-1}), recorded higher vegetable fruit yields and total above ground N uptake with the largest crop responses occurring for the low-N fertilizer (12: 12: 17) applied at 300 kg N ha^{-1} rather than with the high-N fertilizer (21:8: 11). Ammonium-N in the top 90 cm of the soil profile declined during the experiment, while nitrate-N remained at a similar level throughout the experiment with the lower rate of fertilizer N. At the higher rate of N fertilizer there was a continuous nitrate-N accumulation of over 800 kg N $ha^{-1.}$

Kadam *et al.* (2005) studied the effects of soluble fertilizers on nutrient uptake by tomato. The results of the experiment indicated that 100% recommended NPK rates through drip recorded the highest N and P concentrations, whereas that of 100 per cent recommended NPK applied to soil + drip irrigation and 70 % N, 80 per cent P and K fertigated through drip registered the highest (3.56 per cent) K contents in fruits. Total N (107.15 and 95.16 kg ha-^{1}) and K (168.53 and 156.00 kg ha^{-1}) uptake were greatest with 100 % recommended NPK rates through drip and 70 per cent N, 80 per cent P and K fertigated through drip. Application of 100 per cent recommended NPK rates through drip recorded the highest total P uptake (18.19 kg ha^{-1}) and fruit yield (47. 10 t ha^{-1}).

2.10 Economics of use of human urine and cattle urine for crop production

Ek *et al.* (2006) stated that the concentration with reverse osmosis gives the lowest cost, while precipitation of MAP (magnesium ammonium phosphate) and distillation of ammonia give the products with lowest amount of contaminants. These costs for recovered nutrients are realistic or even competitive regarding the urine because of the great amounts of nutrients recovered, but not for the case of reject water. For urine the savings in transport costs to the farmers and in storage should be added, but still the high cost is the separation of urine from the rest of the sewage. It is this separation that drastically decreases the load of N and P into the STP (sewage treatment plant). Source separated urine has a positive value from the start. Reject water has a negative value, since it is just a load on the STP. In this case the savings in the STP are an important benefit caused by the separation. A separation of P is necessary if one wants to digest Bio-P sludge and utilise the energy in it.

Sridevi *et al.* (2009) revealed that the higher gross returns are obtained in human urine applied treatments. The highest gross returns (Rs. 5,25,000.00 ha^{-1}) were recorded in RDN (Recommended Dose of Nitrogen) through ALW (Anthropogenic Liquid Waste) + gypsum. This might be due to increase in bunch yield. Higher cost of cultivation was incurred on production per hectare with T_2 treatment which received recommended dose of fertilizer (Rs. 59790.25). This may be due to higher amount spent towards fertilizers. Indeed lower cost of cultivation was recorded in human urine applied treatments, as it is available free of cost. A relatively higher net returns and benefit cost ratio was obtained in T_6 treatment which received RDN through ALW + gypsum. This might be due to lower cost of cultivation and higher bunch yield of banana and higher marketable price at the time of selling and difference in cost of cultivation.

MATERIAL AND METHODS

III MATERIAL AND METHODS

In order to assess the nutritive value of human urine and cattle urine, their changes in composition when incubated in open and closed conditions, the effect of repeated application of human urine and cattle urine with and without gypsum on soil properties, growth and yield of crops and the effect of heavy doses of human and cattle urine applied to three different soils in terms of soil properties, growth, yield and quality of tomato crop, laboratory experiments, green house experiments and field experiments were conducted. The details of materials used and methods adopted during the course of this investigation are described in this chapter.

3.1 Characterization of human urine and cattle urine

Human urine samples of different age group and diet and cattle urine from different genus and types were collected for the characterisation studies. The details are given below.

A. The different categories of human urine

i) Vegetarian diet persons of <20, 20-40 and >40 years age group

ii) Non-Vegetarian diet persons of <20, 20-40 and >40 years age group

B. The different categories of cattle urine

i) Indigenous cow

ii) Crossbreed cow (Holstein Freisian)

iii) Ox

iv) Buffalo

The human urine samples were collected from Swami Vivekananda Kannada Medium School, Doddaballapur from persons of less than 20 years age group whereas, 20 to 40 years age group and more than 40 years age group urine sample was collected from persons in the P. G. Hostel, College of agriculture, UAS, GKVK Bangalore. The human urine samples from persons of non-vegetarian diet was collected from respective places by feeding chicken for nearly ten days to the individuals who were selected for the same purpose.

Similarly the cattle urine samples were collected from farm house at GKVK and Doddaballapura area. The sample size was ten from all the categories of both human beings and cattle.

3.1.1 Chemical analysis of human urine and cattle urine

After collection, the urine samples were analyzed for all the quality parameters. then 50 % of the volume of the human urine samples of < 20 years age group of both vegetarian and non-vegetarian diet and cattle urine (indigenous cow, crossbreed cow, ox and buffalo) were kept in closed containers and the remaining 50 % of the samples were kept under open condition to monitor the changes in the chemical properties of urine under closed and open conditions. The samples from the containers incubated under both closed and opened condition were drawn on 30 and 60 days and analysed for chemical properties as per the methods and references given in the Table 3.1.

3.2 Field experiment to study the effect of repeated application of human and cattle urine on soil properties, growth and yield of crops

A field experiment was conducted during 2009-2011 in a farmer's field at Nagasandra village, Doddaballapur, Bangalore rural district. The plot is situated at 13° 292' North latitude 77° 543' East longitude and at an altitude of 880 meters (2890ft) above mean sea level. The details of the materials used and methods adopted during the course of experimentation are described below.

3.2.1 Soil characteristics of experimental site

Before the initiation of the experiment, composite soil sample of experimental site was collected from 0-15 cm depth. Soil sample was air dried, powdered, passed through 2 mm sieve and analyzed for physico-chemical properties, the details of methods adopted are given in Table 3.2.

Table 3.1 Methods followed for the analysis of human urine and cattle urine

Parameters	Methods	References
pH	Potentiometric method	Manivasakam, 1987
EC	Conductometric method	Manivasakam, 1987
Nitrogen	Kjeldahl digestion and distillation method	Piper, 1966
Phosphorus	Diacid digestion and vanadomolybdate yellow colour method	Piper, 1966
Potassium	Diacid digestion and flame photometer method	Piper, 1966
Calcium	Versenate titration method	Manivasakam, 1987
Magnesium	Versenate titration method	Manivasakam, 1987
Sulfur	Turbidimetry	Manivasakam, 1987
Sodium	Diacid digestion and flame photometer method	Piper, 1966
Carbonate	Titration method using phenolphthalein indicator	Manivasakam, 1987
Bicarbonate	Titration method using methyl orange indicator	Manivasakam, 1987
Chloride	Winkler's method using potassium chromate as indicator	Manivasakam, 1987
Iron	Atomic absorption spectrophotometry	Manivasakam, 1987
Zinc	Atomic absorption spectrophotometry	Manivasakam, 1987
Manganese	Atomic absorption spectrophotometry	Manivasakam, 1987
Copper	Atomic absorption spectrophotometry	Manivasakam, 1987

Table 3.2 Physico- chemical properties of the soils of experimental site and the methods followed for analysis

Particulars	Values	Methods followed
A. Physical properties		
Mechanical analysis (oven dry weight basis)		
Coarse sand (%)	27.5	International pipette method (Piper, 1966)
Fine sand (%)	37.3	
Silt (%)	11.3	
Clay (%)	23.9	
Textural class	Sandy clay loam (scl)	
B. Chemical properties		
pH (1:2.5)	7.15	Potentiometric method (Piper, 1966)
EC (dSm^{-1})	0.22	Conductometry (Jackson, 1973)
Organic carbon (%)	0.41	Wet oxidation method (Walkey and Black, 1934)
Available N (kg ha^{-1})	285.51	Alkaline potassium permanganate distillation method (Subbiah and Asija, 1956)
Available P_2O_5 (kg ha^{-1})	27.63	Olsen's extractant method, colorimetry (Jackson, 1973)
Available K_2O (kg ha^{-1})	312.25	Neutral N NH_4OAC extractant method, flame photometry (Jackson, 1973)
Exchangeable calcium [cmol (p+) kg^{-1}]	3.54	Ammonium acetate extraction and Versenate titration method (Jackson, 1973)
Exchangeable magnesium[cmol (p+) kg^{-1}]	2.12	
Available sulphur (ppm)	10.23	$CaCl_2$ extractant method, Turbidometry (Black, 1965)
Exchangeable Na [cmol (p+) kg^{-1}]	0.21	N NH_4OAC extractant method, Flame photometry (Jackson, 1973)
Available Fe (mg kg^{-1})	13.46	DTPA extraction method, Atomic absorption spectrophotometry (Lindsay and Norvell, 1978)
Available Mn (mg kg^{-1})	9.01	
Available Zn (mg kg^{-1})	1.82	
Available Cu (mg kg^{-1})	1.29	

The soil was sandy clay loam in texture with coarse sand, fine sand, silt and clay content of 27.5, 37.3, 11.3 and 23.9 per cent, respectively. The soil was neutral in reaction (pH-7.15), low in EC (0.22 dSm^{-1}) and low in organic carbon content (0.41 %). The soil was medium in available nitrogen (285.51 kg ha^{-1}), available phosphorus (27.63 kg ha^{-1}) and available potassium (312.25 kg ha^{-1}).

3.3 Climatic conditions

The monthly meteorological data recorded at Krishi Vigynana Kendra, Hadonahalli, Doddaballapura, Bengaluru rural district, for the period from February, 2009 to March, 2011 regarding normal, actual and deviation in weather parameters with respect to mean monthly rainfall, maximum and minimum temperatures, I and II hour relative humidity is presented in Tables 3.3 and 3.4.

3.3.1 Normal climatic condition

The normal annual rainfall of the station during 1976-2009 was 902.6 mm. The major portion of it was received during April to September with two peaks in the months of September (195.3) and October (170.2). The mean maximum air temperature ranged from 25.4^{0}C to 32.7^{0}C and mean minimum air temperature ranged from 13.6^{0}C to 19.9^{0}C. The highest mean maximum temperature was observed during April (32.7^{0}C) followed by March (31.7^{0}C). Lowest mean minimum temperature was observed during December (13.6^{0}C). The mean monthly I and II hour relative humidity ranged from 71.5 and 31.1per cent in March to 86.3 and 56.6 per cent in August.

The normal annual rainfall of the station during 2010-11 was 1102.6 mm. The major portion of it was received during April to October with two peaks in the months of September (201.7) and October (171.0). The mean maximum air temperature ranged from 26.2^{0}C to 34.6^{0}C and mean minimum air temperature ranged from 13.9^{0}C to 21.1^{0}C. The highest mean maximum temperature was recorded during April (34.6^{0}C), followed by May (34.0^{0}C). Lowest mean minimum temperature was observed during January (13.9^{0}C). The mean monthly I and II hour relative humidity ranged from 74.0 and 32.0 per cent in March to 89.0 and 58.0 per cent in August.

Table 3.3: Meteorological data indicating (1976-2009) monthly normal, actual (2009) and deviation from normal during experimental period at Krishi Vigyana Kendra, Hadonahalli, Doddaballapur taluk, Bengaluru rural district.

Month	Total rainfall (mm)			Mean air temperature (^{0}C)						Mean relative humidity (%)					
				Maximum			Minimum			I hour			II hour		
	N	A	D	N	A	D	N	A	D	N	A	D	N	A	D
Jan	1.4	0	-100.0	26.5	27.6	4.1	13.6	12.2	-10.0	82.4	92.0	11.7	41.9	38.0	-9.3
Feb	9.9	0	-100.0	29.0	30.8	6.1	15.1	12.2	-18.9	76.5	88.0	15.1	35.9	38.0	5.8
Mar	16.6	10.2	-38.6	31.7	32.7	3.3	17.4	14.2	-18.4	71.5	89.0	24.6	31.1	32.0	2.9
Apr	42.9	106	147.3	32.7	34.2	4.5	19.8	17.4	-12.1	75.5	88.0	16.6	33.1	31.0	-6.4
May	94.3	153	62.2	32.2	32.1	-0.3	19.9	20.2	1.4	78.4	90.0	14.8	39.1	31.0	-20.7
Jun	78.1	58.8	-24.7	28.8	29.4	2.2	18.9	19.9	5.1	83.3	93.0	11.6	50.9	37.0	-27.4
July	101.3	55.8	-44.9	27.4	28.7	4.8	18.4	19.4	5.2	85.3	93.0	9.0	54.7	46.0	-15.9
Aug	128.5	106.8	-16.9	26.8	28.3	5.6	18.2	19.5	6.9	86.3	94.0	8.9	56.6	49.0	-13.4
Sep	195.3	231.5	18.5	27.3	28.0	2.6	18.3	19.2	5.2	85.3	94.0	10.2	56.4	56.0	-0.7
Oct	170.2	29.6	-82.6	26.9	28.1	4.5	17.7	19.2	8.8	84.4	92.0	9.0	54.9	74.0	34.8
Nov	51.5	49.4	-4.1	25.8	27.0	4.5	16.1	17.5	8.7	84.3	94.0	11.5	55.4	55.0	-0.8
Dec	12.6	11	-12.6	25.4	26.8	5.4	13.9	17.7	27.4	83.4	92.0	10.3	49.5	54.0	9.2
Total	**902.6**	**812.1**	-	-	-	-	-	-	-	-	-	-	-	-	-

Note: **N**-Normal, **A-** Actual **D-** Deviation from normal (%). Normal values are average of years (Total rainfall-1976 to 2009, Max. and Min. temperature -1976 to 2009, Relative humidity –1976 to 2009)

Table 3.4: Meteorological data indicating (1976-2010) monthly normal, actual (2010) and deviation from normal during experimental period at Krishi Vigyana Kendra, Hadonahalli, Doddaballapur taluk, Bengaluru rural district.

Month	Total rainfall (mm)			Mean air temperature (^{0}C)						Mean relative humidity (%)					
				Maximum			Minimum			I hour			II hour		
	N	A	D	N	A	D	N	A	D	N	A	D	N	A	D
Jan-2010	1.4	0	-100.0	27.3	27.5	0.7	13.9	15.0	7.9	85.0	92.0	8.2	43.0	48.0	11.6
Feb	9.9	0	-100.0	29.9	31.1	4.0	15.4	15.7	1.9	79.0	90.0	13.9	37.0	38.0	2.7
Mar	16.9	18.5	9.5	32.6	34.2	4.9	17.8	18.7	5.1	74.0	85.0	14.9	32.0	34.0	6.3
Apr	45.8	44.8	-2.2	33.7	34.1	1.2	20.3	20.5	1.0	78.0	86.0	10.3	34.0	34.0	0.0
May	98.6	111	12.6	33.1	32.7	-1.2	20.5	20.6	0.5	81.0	84.0	3.7	40.0	39.0	-2.5
Jun	79.8	100.1	25.5	29.6	29.7	0.3	19.5	19.7	1.0	86.0	89.0	3.5	52.0	46.0	-11.5
July	102.9	38.5	-62.6	28.2	27.8	-1.4	19.0	19.2	1.1	88.0	94.0	6.8	56.0	53.0	-5.4
Aug	131.5	86.3	-34.4	27.6	27.1	-1.8	18.8	19.2	2.1	89.0	94.0	5.6	58.0	58.0	0.0
Sep	201.7	81.8	-59.4	28.1	27.2	-3.2	18.8	19.1	1.6	88.0	92.0	4.5	58.0	59.0	1.7
Oct	171.0	13.6	-92.0	27.7	28.0	1.1	18.2	19.0	4.4	87.0	93.0	6.9	57.0	54.0	-5.3
Nov	52.9	21.7	-58.9	26.6	26.3	-1.1	16.6	17.7	6.6	87.0	95.0	9.2	57.0	58.0	1.8
Dec	12.9	5	-61.2	26.2	25.7	-1.9	14.4	15.2	5.6	86.0	92.0	7.0	51.0	53.0	3.9
Jan-2011	1.4	0	-100.0	28.1	27.8	-0.9	14.3	12.7	-11.3	87.6	90.0	2.8	44.3	41.0	-7.5
Feb	9.9	0	-100.0	30.8	29.5	-4.1	15.8	13.6	-14.1	81.5	87.0	6.7	38.1	39.0	2.5
Mar	17.4	0	-100.0	33.6	32.9	-1.9	18.3	16.4	-10.5	76.4	85.0	11.3	32.9	33.0	0.2
Total	**1102.6**	**521.3**		-	-	-	-	-	-	-	-	-	-	-	-

Note: **N**-Normal, **A**- Actual **D**- Deviation from normal (%). Normal values are average of years (Total rainfall-1976 to 2010, Max. and Min. temperature -1976 to 2010, Relative humidity –1976 to 2010)

3.3.2 Weather conditions during the period of experimentation

The total annual rainfall was less during 2009 (812.1 mm) and during 2010 (521.3 mm) as compared to normal rainfall. The crop growth period is from February to December in both the years. During the crop growth period, September, 2009 and June, 2010 months recorded higher rainfall (231.5 and 100.1 mm, respectively) and was more as compared to normal annual rainfall

The mean maximum air temperature was highest in the month of April (34.2^{0}C) during 2009 and May (34.2^{0}C) during 2010. The mean minimum temperature was more than normal for most of the months. The mean monthly maximum relative humidity of 94.0 and 95 per cent in August 2009 and November, 2010. The mean monthly minimum relative humidity was more than normal for most of the months.

3.4 Experimental details

To study the effect of repeated application of human and cattle urine on soil properties, growth and yield of crops**,** field experiment was conducted in a famers field for two successive years in the same experimental field with ashgourd (*Benincasa hispida* (Thunb.) Cong.), french bean (*Phaseolus vulgaris* L.), pole bean (*Phaseolus vulgaris* L.) and pumpkin (*Cucurbita maxima*) as test crops. The experiment was conducted from June, 2009 to February, 2011 and the details are as follows.

3.4.1 Treatment details

There were fourteen treatments out of which twelve treatments were divided into three categores based on the application of human urine and cattle urine as N sources during crop growth period viz., single dose, two split doses and three split doses. The treatments, farmyard manure alone and recommended dose of fertilizer plus FYM were used as control. The plan of layout is given in Fig. 3.1 and general view of crops grown in field experiment is depicted in Plates 3.1 to 3.6.

T_1 : Farmyard Manure (FYM) alone

T_2 : Recommended dose of fertilizers (RDF)

T_3 : RDN through human urine in single dose

T_4 : RDN through human urine in single dose + gypsum

T_5 : RDN through cattle urine in single dose

T_6 : RDN through cattle urine in single dose + gypsum

T_7 : RDN through human urine in two split doses

T_8 : RDN through human urine in two split doses + gypsum

T_9 : RDN through cattle urine in two split doses

T_{10} : RDN through cattle urine in two split doses + gypsum

T_{11} : RDN through human urine in three split doses

T_{12} : RDN through human urine in three split doses + gypsum

T_{13} : RDN through cattle urine in three split doses

T_{14} : RDN through cattle urine in three split doses + gypsum

Where: RDN- Recommended dose of Nitrogen.

Note: 1) Balance of P and K were supplied through chemical fertilizers as single super phosphate and muriate of potash, respectively.

Design : RCBD

Replications : Three

Treatments : Fourteen

Gross plot size : 7.5 m × 3.2 m = 24.0 m^2

Table 3.5: Application of human and cattle urine at different intervals based on crop duration

Sl. No.	Crops	Application time (Days After Germination (DAG))		
		Single dose	Two splits	Three splits
1.	Ashgourd (*Benincasa hispida*)	10	10 and 40	10, 40 and 60
2.	French bean (*Phaseolus vulgaris* L.)	10	10 and 20	10, 20 and 30
3.	Pole bean (*Phaseolus vulgaris* L.)	10	10 and 40	10, 40 and 60
4.	Pumpkin (*Cucurbita maxima*)	10	10 and 40	10, 40 and 60

Plate 3.1: General view of the ashgourd crop grown by using anthropogenic liquid waste

Plate 3.2: Ashgourd crop grown by application of human urine in three split dose plus gypsum

Plate 3.3: Ashgourd crop grown by using farmyard manure alone as control

Plate 3.4: General view of french bean crop grown by using anthropogenic liquid waste

Plate 3.5: General view of pole bean crop grown by using anthropogenic liquid waste

Plate 3.6: General view of pumpkin crop grown by using anthropogenic liquid waste

The details of vegetable crops and varieties grown, recommended dose of fertilizer for particular crop and other details are given in the Table 3.6.

Table 3.6: Details of vegetable crops and varieties used as test crops

Sl. No.	Crops	Varieties	Spacing (cm)	RDF	Human urine (m^3 ha^{-1})	Cattle urine (m^3 ha^{-1})
1.	Ashgourd	C. O.- 1	200 X 100	50:50:0	16.67	20.00
2.	French bean	Arka Komal	30 X 20	63:100:75	21.00	25.20
3.	Pole bean	Kentuki Wonder	100 X 60	63:100:75	21.00	25.20
4.	Pumpkin	Arka Suryamukhi	120 X 80	100:100:40	33.33	40.00

Note: a) The quantity of gypsum applied @ 6.45 kg m^{-3} urine.

b) General composition of human urine, cattle urine and FYM is given below.

Nutrient content (%)	N	P_2O_5	K_2O
Human urine	0.30	0.17	0.18
Cow urine	0.25	0.12	0.16
FYM	0.45	0.20	0.35

3.4.1.1 Imposition of treatments

The quantity of human and cattle urine was calculated based on the N content of urine and dosage of nitrogen recommended for the crop by the university. The calculated quantity of human and cattle urine was applied in different split doses based on treatment and duration of the crop as per the treatment (Tables 3.7a to 3.7d).

For calculating the quantity of urine required to meet the N requirement of the crop, the N content of human urine was considered as 0.30% whereas the N content of cattle urine was considered as 0.25%.

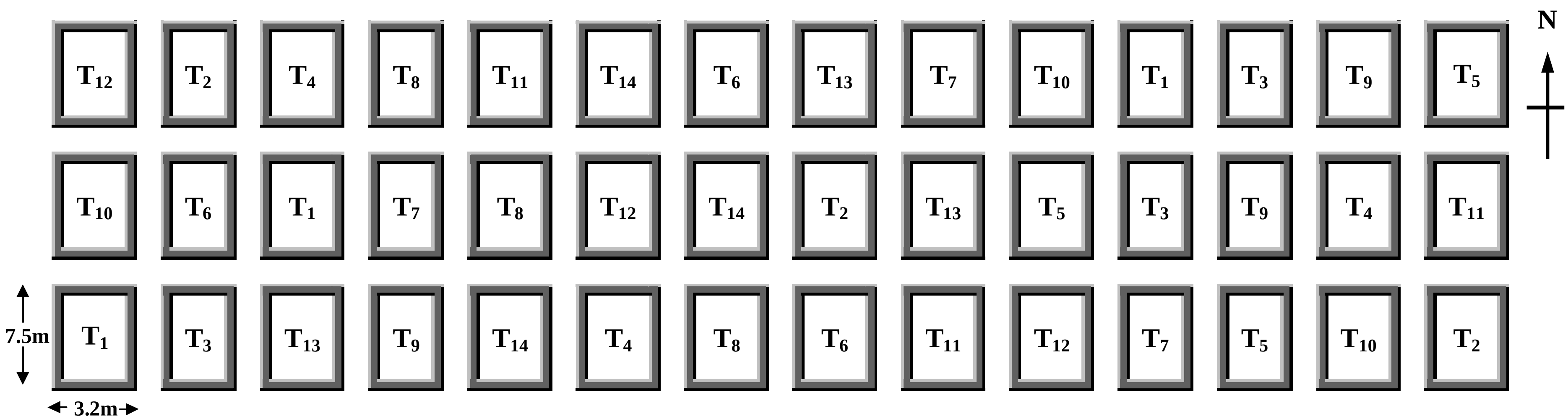


Fig. 3.1: Plan of layout of experiment II

Legend:

T_1	:	FYM (Farmyard Manure) alone
T_2	:	Recommended dose of fertilizer + Farmyard manure
T_3	:	RDN through human urine in single dose
T_4	:	RDN through human urine in single dose + gypsum
T_5	:	RDN through cattle urine in single dose
T_6	:	RDN through cattle urine in single dose+ gypsum
T_7	:	RDN through human urine in two split doses
T_8	:	RDN through human urine in two split doses+ gypsum
T_9	:	RDN through cattle urine in two split doses
T_{10}	:	RDN through cattle urine in two split doses+ gypsum
T_{11}	:	RDN through human urine in three split doses
T_{12}	:	RDN through human urine in three split doses+ gypsum
T_{13}	:	RDN through cattle urine in three split doses
T_{14}	:	RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine;
RDN: Recommended Dose of Nitrogen

3.4.1.1.2 Quantity of human urine applied to supplement nitrogen

The total quantity of human urine required per hectare to meet the recommended dose of nitrogen (kg/ha) to different crops was calculated using formula as given below.

$$\text{Quantity of human urine (} m^3\, ha^{-1}) = \frac{\text{Recommended dose of nitrogen} \times 100}{\text{Per cent total nitrogen in human urine (0.3)} \times 1000}$$

3.4.1.1.3 Quantity of cattle urine applied to supplement nitrogen

The total quantity of cattle urine required per hectare to meet the recommended dose of nitrogen (kg/ha) to different crops was calculated using formula.

$$\text{Quantity of cattle urine (} m^3\, ha^{-1}) = \frac{\text{Recommended dose of nitrogen} \times 100}{\text{Per cent total nitrogen in cattle urine (0.25)} \times 1000}$$

3.4.1.1.4 Gypsum application

The calculated quantity of gypsum was applied as basal dose only in case of treatments receiving the human urine and cattle urine with gypsum as per the treatment details to overcome the effect of sodium if any on soil physical and chemical properties. The quantity of gypsum applied was 6.45 kg per cubic meter of urine, which was arrived at by considering the per cent sodium percent in urine (an average of 0.3 per cent Na).

3.5 Salient features of crop varieties

3.5.1 Ashgourd: C O-1

It is a high yielding variety, the duration of the crop is 120 days. The fruits are medium sized and globular in shape. Number of fruits per vine ranged from 3 to 5 and average fruit weight is 3 to 4 kg.

3.5.2 French bean: Arka Komal

It is a high yielding variety with long pods and green in colour. The growth is erect, and gives first picking at 45 days after sowing, the duration of the crop is 70-80 days.

Table 3.7a: Quantity of nutrients (kg ha^{-1}) added through human urine, cattle urine and fertilizer as per the treatments to ashgourd crop.

Treatments	FYM (t ha^{-1})	Fertiliser			Human urine			Cattle urine			Balance P and K through fertilizer	
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	P_2O_5	K_2O
T_1	24.1											
T_2		50	50	-								
T_3					50.0	28.3	30.0				21.7	-
T_4					50.0	28.3	30.0				21.7	-
T_5								50.0	24.0	32.0	26.0	-
T_6								50.0	24.0	32.0	26.0	-
T_7					50	28.3	30.0				21.7	-
T_8					50	28.3	30.0				21.7	-
T_9								50.0	24.0	32.0	26.0	-
T_{10}								50.0	24.0	32.0	26.0	-
T_{11}					50.0	28.3	30.0				21.7	-
T_{12}					50.0	28.3	30.0				21.7	-
T_{13}								50.0	24.0	32.0	26.0	-
T_{14}								50.0	24.0	32.0	26.0	-

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen
RDF: 50:50:0 kg N, P_2O_5, K_2O ha^{-1}; **Quantity of human urine**: 16.67 m^3 ha^{-1}; **Quantity of cattle urine**: 20.00 m^3 ha^{-1}

Table 3.7b: Quantity of nutrients (kg ha^{-1}) added through human urine, cattle urine and fertilizer as per the treatments to french bean crop.

Treatments	FYM (t ha^{-1})	Fertiliser			Human urine			Cattle urine			Balance P and K through fertilizer	
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	P_2O_5	K_2O
T_1	39.0											
T_2		63	100	75								
T_3					63.0	35.7	37.8				64.3	37.2
T_4					63.0	35.7	37.8				64.3	37.2
T_5								63.0	30.2	40.3	69.8	34.7
T_6								63.0	30.2	40.3	69.8	34.7
T_7					63.0	35.7	37.8				64.3	37.2
T_8					63.0	35.7	37.8				64.3	37.2
T_9								63.0	30.2	40.3	69.8	34.7
T_{10}								63.0	30.2	40.3	69.8	34.7
T_{11}					63.0	35.7	37.8				64.3	37.2
T_{12}					63.0	35.7	37.8				64.3	37.2
T_{13}								63.0	30.2	40.3	69.8	34.7
T_{14}								63.0	30.2	40.3	69.8	34.7

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen
RDF: 63:100:75 kg N, P_2O_5, K_2O ha^{-1} ; **Quantity of human urine**: 21.00 m^3 ha^{-1}; **Quantity of cattle urine**: 25.20 m^3 ha^{-1}

Table 3.7c: Quantity of nutrients (kg ha^{-1}) added through human urine, cattle urine and fertilizer as per the treatments to pole bean crop.

Treatments	FYM (t ha^{-1})	Fertiliser			Human urine			Cattle urine			Balance P and K through fertilizer	
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	P_2O_5	K_2O
T_1	39.0											
T_2		63	100	75								
T_3					63.0	35.7	37.8				64.3	37.2
T_4					63.0	35.7	37.8				64.3	37.2
T_5								63.0	30.2	40.3	69.8	34.7
T_6								63.0	30.2	40.3	69.8	34.7
T_7					63.0	35.7	37.8				64.3	37.2
T_8					63.0	35.7	37.8				64.3	37.2
T_9								63.0	30.2	40.3	69.8	34.7
T_{10}								63.0	30.2	40.3	69.8	34.7
T_{11}					63.0	35.7	37.8				64.3	37.2
T_{12}					63.0	35.7	37.8				64.3	37.2
T_{13}								63.0	30.2	40.3	69.8	34.7
T_{14}								63.0	30.2	40.3	69.8	34.7

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen
RDF: 63:100:75 kg N, P_2O_5, K_2O ha^{-1}; **Quantity of human urine**: 21.00 m^3 ha^{-1}; **Quantity of cattle urine**: 25.20 m^3 ha^{-1}

Table 3.7d: Quantity of nutrients (kg ha^{-1}) added through human urine, cattle urine and fertilizer as per the treatments to pumpkin crop.

Treatments	FYM (t ha^{-1})	Fertiliser			Human urine			Cattle urine			Balance P and K through fertilizer	
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	P_2O_5	K_2O
T_1	47.2											
T_2		100	100	40								
T_3					100.0	56.7	60.0				43.3	-
T_4					100.0	56.7	60.0				43.3	-
T_5								100.0	48.0	64.0	52.0	-
T_6								100.0	48.0	64.0	52.0	-
T_7					100.0	56.7	60.0				43.3	-
T_8					100.0	56.7	60.0				43.3	-
T_9								100.0	48.0	64.0	52.0	-
T_{10}								100.0	48.0	64.0	52.0	-
T_{11}					100.0	56.7	60.0				43.3	-
T_{12}					100.0	56.7	60.0				43.3	-
T_{13}								100.0	48.0	64.0	52.0	-
T_{14}								100.0	48.0	64.0	52.0	-

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen; **RDF:** 100:100:40 kg N, P_2O_5, K_2O ha^{-1}; **Quantity of human urine**: 33.33 m^3 ha^{-1}; **Quantity of cattle urine**: 40.00 m^3 ha^{-1}

3.5.3 Pole bean: Kentuki Wonder

It is a high yielding exotic variety. The vine length varies from 3 to 5 meter, the duration of the crop is 110-115 days.

3.5.4 Pumpkin: Arka Suryamukhi

It is a short duration variety with 100 days growing period. Fruits are orange in colour. The average weight of the fruit is 1 to 1.5 kg and it has good shelf life. It is resistant to fruitfly.

3.6 Cultural operations (common for all the four crops)

The cultural operations carried out during the period of experimentation were as follows.

3.6.1 Land preparation

The land was ploughed with tractor drawn disc plough and cultivator was passed to crush the clods, remove weeds and for levelling the land.

3.6.2 Layout and sowing

The leveled land was made into plots of desired size by bunding and opening irrigation channels. Ridges and furrows were opened at spacing as per the crop (Table 3.6), and then sowing was done followed by light irrigation to get uniform germination and better establishment of the crop.

3.6.3 Gap filling

Gap filling was done in the spots where the plants have failed to establish.

3.6.4 Weeding

Weed free condition was maintained throughout the crop growth period by manual weeding.

3.6.5 Plant protection

Plants were sprayed with insecticides and fungicides at regular intervals to control the insects and diseases.

3.6.6 Observations

Plant biometric observations were taken at harvest.

3.6.7 Harvesting

The crops were harvest at appropriate recommended stage for the specific vegetable crop.

3.6.8 Plant and soil sample collection

Soil and plant samples were collected from each plot after harvest of the crop and analysed for different parameters.

3.7 Collection of experimental observations and plant sampling procedures

The details of observations recorded at harvest of the crops are indicated for all the four crops as follows.

3.7.1 Growth parameters

Observation	Method followed	Stage
Vine length/ plant height (cm)	From the base of the plant to the base of fully opened leaf.	At harvest
Number of branches (plant^{-1})	Number of branches counted in a plant.	
Number of leaves (plant^{-1})	Number of leaves counted in a plant.	
Leaf area (cm^2)	Leaf area was measured by disc method (Vivekanandan *et al.* 1972).	
Dry matter accumulation (g plant^{-1})	Five plants were selected at random for dry matter studies. The plants were separated into leaves, stem and fruit and their fresh weights were recorded. and dried in an oven at 65^{0}C till constant weight was recorded separately and then total dry matter per plant was calculated.	At harvest

3.7.2 Yield parameters

Observation	Method followed	Stage
Number of fruits (plant^{-1})	Number of fruits in five plants was counted manually.	At harvest
Fruit diameter (cm)	Diameter of five randomly selected fruits were measured using thread and expressed in centimeters	At harvest
Fresh fruit weight (kg plant^{-1})	Fresh weight of ten randomly selected fruits was recorded and the average was calculated.	At harvest
Dry weight of fruit (g)	The fruits taken for fresh weight were chopped in to slices and kept in oven at 65^{o}C to get the constant dry weight. The average dry weight was recorded.	At harvest
Yield (t ha^{-1})	Fruit yield per plot was multiplied by total number of plants per hectare and was converted to hectare basis	At harvest
Crop equivalent yield (t ha^{-1})	The conversion of crop yield in to one form to compare the crop grown mixed or intercropped or sequentially cropped. Conversion is done into monetary value (Ahlawat and Sharma, 1993)	At harvest

3.8 Chemical analysis of soil and fruit

The details of the chemical analysis of soil, and fruit samples after the harvest of crops grown in the field experiments is given below in the tabular form.

<table>
<tr><th>Parameters</th><th>Methods</th><th>Stage</th></tr>
<tr><td colspan="3">1. Plant analysis:</td></tr>
<tr><td>Nitrogen</td><td>Kjeldahl digestion distillation method (Piper, 1966)</td><td rowspan="7">At harvest</td></tr>
<tr><td>Phosphorus (P_2O_5)</td><td>Diacid digestion and vanadomolybdate yellow colour method (Piper, 1966)</td></tr>
<tr><td>Potassium (K_2O)</td><td>Diacid digestion and flame photometer method (Piper, 1966)</td></tr>
<tr><td>Calcium</td><td rowspan="2">Diacid digestion and Versenate titration (Jackson, 1973)</td></tr>
<tr><td>Magnesium</td></tr>
<tr><td>Sulphur</td><td>Diacid digestion and Turbidometry(Jackson, 1973)</td></tr>
<tr><td>Iron, Manganese, Zinc and Copper</td><td>Diacid digestion and Atomic Absorption Spectrophotometer method (Lindsay and Norvel 1978).</td></tr>
</table>

Nutrient uptake	The concentration of N, P_2O_5, K_2O, Ca, Mg, S, Fe, Mn, Zn and Cu was multiplied by total dry matter of plant at harvest to obtain uptake of N, P_2O_5, K_2O, Ca, Mg, S and expressed as kg ha^{-1} where as uptake of Fe, Mn, Zn and Cu expressed as g ha^{-1}.	
2. Soil analysis:		
Soil pH, EC, OC, available major secondary and micronutrients	The composite soil samples from 0 to 15 cm depth was collected from each treatment at harvest and were air dried in shade powdered and passed through 2 mm sieve and analysed for pH, EC, OC, available N, P, K, Ca, Mg, S, and micronutrients as per the details given Table 3.2.	Before planting and at harvest of the crop

3.9 Enumeration of microbial populations:

The enumeration of total bacteria, fungi, actinomycetes, free-living N_2 - fixers and PO_4 - solublizers in the soil samples was carried out by following the standard dilution plate count technique. Soil extract agar for bacteria, Martin's Rose Bengal streptomycin sulphate agar for fungi, Kuster's agar for actinomycetes, Waksman's medium for N_2 - fixers and Sperber's medium for PO_4 – Solublizers were used for enumeration. The petriplates were incubated at 30^0C for three to six days and population was counted and expressed as CFU g^{-1} of soil (Alef and Nannipieri, 1995 and Sundara Rao and Sinha, 1963).

3.10 Balance sheet of nitrogen, phosphorus, and potassium

Balance sheet of nitrogen, phosphorus and potassium was worked out by considering the initial soil available N, P_2O_5 and K_2O status, amount of N, P_2O_5 and K_2O added through human urine, cattle urine, FYM and fertilizers and uptake of N, P_2O_5 and K_2O. Expected balance of N, P_2O_5 and K_2O was calculated by subtracting N, P_2O_5 and K_2O by the plant uptake from total N, P_2O_5 and K_2O. Net gain or loss of nutrient was worked out by subtracting actual balance from the expected balance of the nutrients.

3.11 Economics

The cost of inputs, labour charges and the prevailing market rates for the produce were taken into consideration for working out cost of cultivation, gross and net returns per hectare. The net returns were calculated by deducting cost of cultivation from gross returns. Benefit-cost ratio was worked out as per the formula given below:

$$\text{Benefit: cost ratio} = \frac{\text{Gross return (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

3.12 Green House Experiment: To study the effect of rate of application of human and cattle urine on soil properties, crop growth and yield of tomato grown in three different soils

A green house experiment was conducted to study the effect of graded levels of human urine and cattle urine on properties of soils, growth and yield of tomato crop grown in red, laterite and black soils in the green house of Department of Soil Science and Agricultural Chemistry, at College of Agriculture, UAS, GKVK during October 2010 to January 2011. The details of the materials used and method adopted during the course of experimentation are described below.

3.12.1 Details of the soil used for the experimentation.

The red soil was collected from the field at D-block, ZARS, UAS, GKVK, Bangalore. The laterite soil was collected from the Seed Farm Unit, ZARS, UAS, Bramhavara, and the black soil was collected from farmer's field near Nanjanagud, Mysore district. The soil samples were analysed for physical and chemical properties as per the methods given in Table 3.2. the properties of soils are given in Table 3.8.

The red soil was sandy loam in texture with coarse sand, fine sand, silt and clay content of 51.10, 29.15, 9.20 and 10.55 per cent, respectively. Regarding chemical properties, the soil was slightly acidic in reaction (pH-6.19), low in EC (0.18 dSm^{-1}) and low in organic carbon content (0.39 %). The soil was low in available nitrogen (225.15 kg ha^{-1}), available phosphorus (21.01 kg ha^{-1}) and medium in available potassium (318.54 kg ha^{-1}) (Table 3.8). Available sulphur was low. The DTPA extractable iron, manganese, zinc and copper were sufficient.

Table 3.8 Physico- chemical properties of the red, laterite and black soils.

Parameters	Red soil	Laterite soil	Black soil
I. Physical properties			
Coarse fragments (Gravel) (%)	-	24.90	-
Coarse sand (%)	51.10	47.80	9.9
Fine sand (%)	29.15	19.80	18.3
Silt (%)	9.20	5.70	19.5
Clay (%)	10.55	1.80	52.3
Textural class	Sandy Loam	Gravelly sandy loam	Clay
II. Chemical properties			
pH (1:2.5)	6.19	4.97	8.43
EC (dS m^{-1})	0.18	0.09	0.29
Organic Carbon (%)	0.39	0.63	0.57
Available N (kg ha^{-1})	225.15	210.09	378.4
Available P_2O_5 (kg ha^{-1})	21.01	12.03	18.63
Available K_2O (kg ha^{-1})	318.54	115.93	515.30
Exchangeable Ca [c mol (p+) kg^{-1}]	3.14	2.99	27.29
Exchangeable Mg [c mol (p+) kg^{-1}]	1.78	1.09	12.19
Exchangeable Na [cmol (p+) kg^{-1}]	0.15	0.09	0.54
Available S (mg kg^{-1})	9.36	5.14	12.25
DTPA Extractable Fe (mg kg^{-1})	32.75	39.53	13.91
DTPA Extractable Mn (mg kg^{-1})	15.36	22.15	8.72
DTPA Extractable Zn (mg kg^{-1})	1.93	2.05	1.53
DTPA Extractable Cu (mg kg^{-1})	1.85	1.95	1.27

The laterite soil was gravelly sandy loam in texture with gravel, coarse sand, fine sand, silt and clay content of 24.90, 47.80, 19.80, 5.70 and 1.80 per cent, respectively. The soil was moderately acidic in reaction (pH-4.97), low in EC (0.09 dSm^{-1}) and medium in organic carbon content (0.63 %). The soil was low in available nitrogen (210.09 kg ha^{-1}), phosphorus (12.03 kg ha^{-1}) and medium in potassium (318.54 kg ha^{-1}) (Table 3.8). Available sulphur was low. The DTPA extractable iron, manganese, zinc and copper content was sufficient.

The black soil was clay in texture with coarse sand, fine sand, silt and clay content of 9.9, 18.30, 19.5, and 52.3%, respectively (Table 3.7). The soil was alkaline in reaction (pH-8.43), low in EC (0.29 dSm^{-1}) and medium in organic carbon content (0.57 %). The soil was low in available nitrogen (210.09 kg ha^{-1}), available phosphorus (12.03 kg ha^{-1}) and high in available potassium (515.30 kg ha^{-1}). The exchangeable calcium and magnesium content was high. The available sulphur content was medium while the DTPA extractable iron, manganese, zinc and copper content was in the sufficient range.

3.12.2 Treatment details

The treatments included recommended dose of NPK through fertilizers (control), 1.5 and 2 times the recommended dose of N through fertilizers plus recommended dose of P and K, recommended dose of N, 1.5 and 2 times the recommended dose of N through human urine/ cattle urine and balance of P and K through fertilizers.

T_1 : Control-Recommended dose of NPK

T_2 : 1.5 times the recommended dose of N through fertilizer + Recommended dose of P and K

T_3 : 2 times the recommended dose of N through fertilizer + Recommended dose of P and K

T_4 : Recommended dose of N through Human urine + Balance P & K through fertilizer

T_5 : 1.5 times the recommended dose of N through Human urine + Balance P & K through fertilizer

T_6 : 2 times the recommended dose of N through Human urine + Balance P & K through fertilizer

T_7 : Recommended dose of N through Cattle urine + Balance P & K through fertilizer

T_8 : 1.5 times the recommended dose of N through Cattle urine + Balance P & K through fertilizer

T_9 : 2 times the recommended dose of N through Cattle urine + Balance P & K through fertilizer

Where: **N-**Nitrogen; **P**-Phosphorus; **K**-Potassium.

Note: 1) Balance of P and K were supplied through single superphosphate (SSP) and Muriate of potash (MOP), respectively.

2) Application of urine was done at 10, 40 and 60 Days After Transplanting

Design	:	CRD
Replications	:	Three
Treatments	:	Nine for each soil
Total number of pots	:	27 for each soil
Pot size	:	15 kg capacity
Crop	:	Tomato
Variety		Arka Abhijith
Recommended dose of fertilizer	:	250:250:250 kg NPK ha^{-1}
Date of transplanting	:	14-10-2010
Number of plants pot^{-1}	:	One

The details of quantity of fertilizers, human urine and cattle urine used has been presented in Table 3.9. The general view of tomato crop grown in green house condition is depicted in Plates 3.7 and 3.8.

3.12.3 Salient features of tomato: Arka Abhijith

This hybrid was developed by IIHR, Bangalore. The plants are medium in height, the duration is 140 days. The fruits are reddish in colour with medium in size (65-70 g). It is resistant to bacterial blight and the yield is about 65 t ha^{-1}.

3.12.4 Transplanting

Fifteen kilogram of soil was weighed on to a polyethylene sheet and calculated quantity of fertilizers were added as per the treatment and soil was transferred to the pots. Then one month old tomato seedlings were transplanted and watering was done to reduce the transplanting shock to seeding and for better establishment of the crop.

3.12.5 Imposition of treatments

The quantity of human and cattle urine was caluculated based on the N content of urine and dosage of nitrogen recommended for the crop by the university. The calculated quantity of human and cattle urine was applied in different split doses based on treatment as per the treatment (Table 3.9)

For calculating the quantity of urine required to meet the N requirement of the crop, the N content of human urine was considered as 0.30% whereas the N content of cattle urine was considered as 0.25%. The total quantity of human urine, cattle urine and chemical fertilizers applied are depicted in the Table 3.9.

3.13 Collection of experimental observations and plant sampling procedures

The details of observations recorded, at harvest of tomato are indicated as under.

3.13.1 Growth parameters

Data on plant height (cm), number of branches, number of leaves ($plant^{-1}$) and dry matter accumulation (g $plant^{-1}$) of plant were as per the details given in section 3.7.1.

3.13.2 Yield parameters

Data on number of fruits (plant^{-1}), number of flower cluster (plant^{-1}), fresh fruit weight (kg plant^{-1}) and Yield (kg plant^{-1}) were as per the details given in section 3.7.2.

Plate 3.7: General view of tomato crop grown by application of graded levels of human and cattle urine in green house

Plate 3.8: Tomato crop grown in green house condition by application of 2 times the recommended dose of N through human urine

Table 3.9: Quantity of nutrients (kg ha^{-1}) added through human urine, cattle urine and fertilizer as per the treatments to tomato crop.

Treatments	HU/CU (m^3 ha^{-1})	Fertiliser			Human urine			Cattle urine			Balance P and K through fertilizer	
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	P_2O_5	K_2O
T_1	-	250	250	250							-	-
T_2	-	375	375	357							-	-
T_3	-	500	500	500							-	-
T_4	83.3				250.0	141.7	150.0				108.3	100.0
T_5	125.0				375.0	212.5	225.0				162.5	150.0
T_6	166.6				500.0	283.3	300.0				216.7	200.0
T_7	100.0							250.0	120.0	160.0	130.0	90.0
T_8	150.0							375.0	180.0	240.0	195.0	135.0
T_9	200.0							500.0	240.0	320.0	260.0	180.0

Legend :

T_1 : Control-Recommended dose of NPK

T_2 : 1.5 times the recommended dose of N through fertilizer + Balance P & K

T_3 : 2 times the recommended dose of N through fertilizer + Balance P & K

T_4 : Recommended dose of N through Human urine + Balance P & K

T_5 : 1.5 times the recommended dose of N through Human urine + Balance P & K

Note : -Balance P and K supplied through SSP and MOP respectively

: -Applied gypsum @ 6.45g l^{-1} urine to all urine applied treatments

T_6 : 2 times the recommended dose of N through Human urine + Balance P & K

T_7 : Recommended dose of N through Cattle urine + Balance P & K

T_8 : 1.5 times the recommended dose of N through Cattle urine + Balance P & K

T_9 : 2 times the recommended dose of N through Cattle urine + Balance P & K

RDF: 250:250:250 kg N, P_2O_5, K_2O ha^{-1}

Source of nutrients: human urine, cattle urine and chemical fertilizers

Where- N-Nitrogen**; P-**Phosphorus**; K-**Potassium**; HU-**Human urine**; CU-** Cattle urine

3.13.3 Quality parameters

Observation	Method followed	Stage
Fruit juice (%)	Fully ripened fruits weighed to 100 grams and squeeze then filter the juice and converted to %.	At harvest
Titrable acidity % of citric acid	Estimated by following method outlined in A.O.A.C. (1960) and expressed as percentage of citric acid on fresh weight of samples.	At harvest
Ascorbic acid (%)	Spectrophotometric measurements on ascorbic acid and expressed as percentage on fresh weight of samples (Hewitt and Dickes, 1961).	At harvest
Total Soluble Solids (^{0}Brix)	Total soluble solids (TSS) in the pulp of ten fruits were recorded using a ERMA hand refractometer (0-32% scale). The average of brix values of ten fruits was worked out and expressed in %.	At harvest

3.14 Chemical analysis of soil, plants and fruit

The soil, plant and fruit samples were analysed for nutrient composition after the harvest of tomato as per the procedure given in section 3.8.

3.15 Enumeration of microbial populations:

The enumeration of total bacteria, fungi, actinomycetes, free-living N_2 - fixers and PO_4 - Solublizers in the soil samples was carried out by following the standard dilution plate count technique as given in section 3.9.

3.16 Statistical analysis and interpretation of data

The analysis and interpretation of the data was done using the Fisher's method of analysis and variance technique as given by Panse and Sukhatme (1967). The level of significance used in 'F' and 't' test was at 5% probability level for field experiment where as at 1% probability level for green house experiment and wherever 'F' test was found significant, the 't' test was performed to estimate critical differences among various treatments.

EXPERIMENTAL RESULTS

IV EXPERIMENTAL RESULTS

The present investigation "studies on the effect of repeated application of human and cattle urine on soil properties, crop growth and yield" was conducted during 2009-11. This included characterization of human and cattle urine for their chemical composition, a field experiment to study the effect of repeated application of human urine and cattle urine on soil properties crop growth, and yield and a green house experiment conducted to study the effect of different quantities of human urine and cattle urine applied to red, black and laterite soils to study the changes in soil properties, growth, yield and quality of tomato crop. Besides, a laboratory incubation study was conducted to study the changes in composition of human and cattle urine when kept under open and closed conditions. The results of the investigation are presented in this chapter.

4.1 Characterization human urine and cattle urine

4.1.1 Chemical composition of human urine samples from vegetarian diet persons at initial stage

Chemical composition of representative human urine samples from ten persons each of vegetarian diet belonging to less than 20, 20 to 40 and more than 40 years age group collected during 2010 to 2011 at initial stage of collection are presented in Table 4.1.

The pH ranged from 4.97 to 6.51, 4.79 to 6.65 and 4.26 to 6.23with an average value of 5.73, 5.56 and 5.59 for sample collected from vegetarian diet persons of age group <20, 20-40, >40 years. The electrical conductivity ranged from 5.64 to 6.97, 6.85 to 8.17 and 6.81 to 7.89 dS m^{-1} with an average value of 6.36, 7.50 and 7.24 dS m^{-1} for samples of <20, 20 to 40 and >40 years age group, respectively.

The concentration of nitrogen varied from 0.21 to 0.41, 0.25 to 0.43 and 0.26 to 0.43 per cent with an average value of 0.30, 0.33 and 0.33 per cent. The phosphorus concentration varied from 0.17 to 0.22, 0.11 to 0.26 and 0.13 to 0.24 per cent with mean value of 0.19, 0.17 and 0.16 per cent. The potassium content varied from 0.12 to 0.23,

Table 4.1: Chemical composition of human urine samples from persons of vegetarian diet and different age group at initial stage.

Sl. No	Parameters	Mean values*			Range		
		<20 years	20- 40 years	> 40 years	<20 years	20- 40 years	> 40 years
1.	**pH**	5.73	5.56	5.59	4.97-6.51	4.79-6.65	4.26-6.23
2.	**EC (dS/m)**	6.36	7.50	7.24	5.64-6.97	6.85-8.17	6.81-7.89
3.	**N (%)**	0.30	0.33	0.33	0.21-0.41	0.25-0.43	0.26-0.42
4.	**P_2O_5 (%)**	0.19	0.17	0.16	0.17-0.22	0.11-0.26	0.13-0.24
5.	**K_2O (%)**	0.16	0.17	0.19	0.12-0.23	0.14-0.20	0.17-0.22
6.	**Na (%)**	0.26	0.17	0.18	0.22-0.31	0.13-0.23	0.14-0.22
7.	**Ca (meq/l)**	11.80	12.60	17.00	8.00-16.00	6.00-18.00	10.00-24.00
8.	**Mg (meq/l)**	23.70	29.23	36.94	15.80-33.58	21.73-43.46	31.60-41.48
9.	**S (%)**	0.12	0.14	0.12	0.10-0.17	0.09-0.21	0.07-0.20
10	**CO^-_3 (meq/l)**	-	-	-	-	-	-
11.	**HCO^-_3 (meq/l)**	9.09	10.37	9.60	5.12-11.52	7.68-14.08	6.40-14.08
12.	**Cl^- (meq//l)**	28.65	32.66	31.41	22.72-32.08	28.07-36.54	26.29-36.09
13.	**Zn (mg/l)**	18.02	19.70	20.90	16.20-19.80	17.00-22.40	17.00-23.40
14.	**Fe (mg/l)**	120.44	122.40	126.90	98.60-139.40	114.20-131.80	118.80-143.00
15.	**Mn (mg/l)**	22.36	22.42	23.26	17.80-27.00	17.80-27.00	18.20-27.00
16.	**Cu (mg/l)**	44.83	45.83	46.69	41.82-47.84	41.82-48.04	43.82-48.04

*Average of ten samples

0.14 to 0.20 and 0.17 to 0.22 per cent with an average value of 0.16, 0.17 and 0.19 per cent for samples of <20, 20 to 40 and >40 years age group respectively.

The concentration of calcium ranged from 8.00 to 16.00, 6.00 to 18.00 and 10.00 to 24.00 meql^{-1} with the mean value of 11.80, 12.60 and 17.00 meqL^{-1} and magnesium content varied from 15.80 to 33.58, 21.73 to 43.46 and 31.60 to 41.48 meqL^{-1} with an average value of 23.70, 29.23 and 36.94 meqL^{-1}. The concentration of sulfur ranged from 0.10 to 0.17, 0.09 to 0.21 and 0.74 to 0.20 per cent with mean value of 0.12, 0.14 and 0.12 per cent and the sodium concentration varied from 0.22 to 0.31, 0.13 to 0.23 and 0.14 to 0.22 per cent with mean value of 0.26, 0.17 and 0.18 per cent for samples of <20, 20 to 40 and >40 years age group respectively.

Among the anions, the carbonate was absent in all the samples whereas the bicarbonate ranged from 5.12 to 11.52, 7.68 to 14.08 and 6.40 to 14.08 meql^{-1} with an average value of 9.09, 10.37 and 9.60 meqL^{-1}. The chloride content varied from 22.72 to 32.08, 28.70 to 36.54 and 26.29 to 36.09 meqL^{-1} with an average value of 28.65, 32.66 and 31.41 meqL^{-1} for samples of <20, 20 to 40 and >40 years age group respectively.

Human urine also contained appreciable amounts of micronutrients. The zinc concentration varied from 16.20 to 19.80, 17.00 to 22.40 and 17.0 to 23.4 mgL^{-1} with an average value of 18.02, 19.70 and 20.90 mgL^{-1}. The iron content varied from 98.60 to 139.40, 114.20 to 131.80 and 118.80 to 143.00 mgl^{-1} with mean value of 120.44, 122.40 and 126.90 mgl^{-1}. The manganese concentration varied from 17.80 to 27.00, 17.80 to 27.00 and 18.20 to 27.00 mgl^{-1} average value of 22.36, 22.42 and 23.26 mgL^{-1}. The copper content ranged from 41.82 to 47.84, 41.82 to 48.04 and 43.82 to 48.04 mgL^{-1} with the mean of 44.83, 45.83 and 46.69 mgl^{-1} for samples of <20, 20 to 40 and >40 years age group respectively.

4.1.2 Chemical composition of human urine samples from non-vegetarian diet persons at initial stage

Chemical composition of human urine collected from non-vegetarian diet persons belonging to different age groups (less than 20, 20 to 40 and more than 40 years) at initial stage is presented in Table 4.2.

The pH ranged from 4.96 to 6.81, 5.29 to 6.29 and 4.93 to 6.19 with an average value of 5.77, 5.79 and 5.45. The electrical conductivity ranged from 6.68 to 7.97, 7.41 to 8.75 and 7.06 to 8.32 dS m^{-1} with an average value of 7.30, 8.03 and 7.88 dS m^{-1} for samples of <20, 20 to 40 and >40 years age group respectively.

The concentration of nitrogen varied from 0.31 to 0.50, 0.33-0.55 and 0.36 to 0.45 per cent with an average value of 0.40, 0.39 and 0.40 per cent. The phosphorus concentration varied from 0.13 to 0.30, 0.13 to 0.23 and 0.12 to 0.25 per cent with mean value of 0.19, 0.18 and 0.18 per cent. The potassium content varied from 0.15 to 0.22, 0.12 to 0.25 and 0.17 to 0.24 per cent with an average value of 0.19, 0.18 and 0.20 per cent for samples of <20, 20 to 40 and >40 years age group respectively.

The concentration of calcium ranged from 8.00 to 20.00, 14.00 to 22.00 and 14.00 to 26.00 $meql^{-1}$ with the mean value of 14.60, 17.60 and 17.80 $meqL^{-1}$ and magnesium content varied from 21.73 to 37.53, 27.65 to 39.51 and 31.60 to 39.51$meql^{-1}$ with an average value of 27.65, 32.99 and 34.96 $meqL^{-1}$. The concentration of sulfur ranged from 0.11 to 0.22, 0.10 to 0.18 and 0.09 to 0.15 per cent with mean value of 0.16, 0.14 and 0.13 per cent. The sodium concentration varied from 0.24 to 0.34, 0.12 to 0.30 and 0.15 to 0.23 per cent with mean value of 0.28, 0.21 and 0.19 per cent for samples of <20, 20 to 40 and >40 years age group respectively.

The carbonate was absent in all the samples where as the bicarbonate concentration ranged from 5.12 to 14.08, 7.68 to 16.64 and 6.40 to 16.64 $meqL^{-1}$ with an average value of 9.60, 11.90 and 11.39 $meqL^{-1}$. The chloride content varied from 23.61 to 37.87, 26.29 to 38.76 and 28.07 to 37.87 $meqL^{-1}$ with an average value of 32.44, 33.37 and 33.60 $meqL^{-1}$ for samples of <20, 20 to 40 and >40 years age group respectively.

Table 4.2: Chemical composition of human urine samples from persons of non-vegetarian diet and different age group at initial stage.

Sl. No	Parameters	Mean values*			Range		
		<20 years	20- 40 years	> 40 years	<20 years	20- 40 years	> 40 years
1.	pH	5.77	5.79	5.45	4.96-6.81	5.29-6.29	4.93-6.19
2.	EC (dS/m)	7.30	8.03	7.88	6.68-7.97	7.41-8.75	7.06-8.32
3.	N (%)	0.40	0.39	0.40	0.31-0.50	0.33-0.55	0.36-0.45
4.	P_2O_5 (%)	0.19	0.18	0.18	0.13-0.30	0.13-0.23	0.12-0.25
5.	K_2O (%)	0.19	0.18	0.20	0.15-0.22	0.12-0.25	0.17-0.24
6.	Na (%)	0.28	0.21	0.19	0.24-0.34	0.12-0.30	0.15-0.23
7.	Ca (meq/l)	14.60	17.60	17.80	8.00-20.00	14.00-22.00	14.00-26.00
8.	Mg (meq/l)	27.65	32.99	34.96	21.73-37.53	27.65-39.51	31.60-39.51
9.	S (%)	0.16	0.14	0.13	0.11-0.22	0.10-0.18	0.09-0.15
10	CO^-_3 (meq/l)	-	-	-	-	-	-
11.	HCO^-_3 (meq/l)	9.60	11.90	11.39	5.12-14.08	7.68-16.64	6.40-16.64
12.	Cl^- (meq//l)	32.44	33.37	33.60	23.61-37.87	26.29-38.76	28.07-37.87
13.	Zn (mg/l)	18.62	21.08	21.20	16.40-20.40	23.00-18.60	17.40-23.80
14.	Fe (mg/l)	145.68	127.88	128.34	116.60-164.80	119.40-134.80	119.40-134.80
15.	Mn (mg/l)	24.76	23.40	23.68	22.20-27.00	17.80-27.00	17.80-26.40
16.	Cu (mg/l)	47.17	46.27	46.28	45.96-48.78	41.82-48.44	41.82-48.44

*Average of ten samples

The zinc concentration varied from 16.40 to 20.40, 23.00 to 18.60 and 17.40 to 23.80 mgL^{-1} with an average value of 18.62, 21.08 and 21.20 mgL^{-1}. The iron content varied from 116.60 to 164.80, 119.40 to 134.80 and 119.40 to 134.80 mgl^{-1} with mean value of 145.68, 127.88 and 128.34 mgL^{-1}. The manganese concentration varied from 22.20 to 27.00, 17.80 to 27.00 and 17.80 to 26.40 mgL^{-1} average value of 24.76, 23.40 and 23.68 mgL^{-1}. The copper content ranged from 45.96 to 48.78, 41.82 to 48.44 and 41.82 to 48.44 mgL^{-1} with the mean of 47.17, 46.26 and 46.28 mgl^{-1} for samples of <20, 20 to 40 and >40 years age group respectively.

4.1.3 Chemical composition of cattle urine samples at initial stage.

Chemical composition of urine samples from cattle of different categories *viz.* HF (Holstein friesian), cow, ox and buffalo at initial stage are presented in Table 4.3.

The pH ranged from 6.69 to 7.10, 5.23 to 6.35, 5.37 to 6.65 and 6.69 to 7.16 with an average value of 6.04, 5.97, 6.09 and 6.17. The electrical conductivity ranged from 7.52 to 9.10, 6.75 to 8.19, 6.69 to 8.38 and 7.52 to 9.17 dS m^{-1} with an average value of 7.65, 7.36, 7.55 and 7.58 dS m^{-1} for HF, cow, ox and buffalo urine samples respectively.

The concentration of nitrogen varied from 0.20 to 0.34, 0.21 to 0.35, 0.22 to 0.35 and 0.21 to 0.37 per cent with an average value of 0.28, 0.26, 0.28 and 0.28 per cent, respectively. The phosphorus concentration varied from 0.13 to 0.21, 0.15 to 0.23, 0.15-0.23 and 0.12-0.21 per cent with mean value of 0.17, 0.18, 0.18 and 0.17 per cent. The potassium content varied from 0.194 to 0.248, 0.19 to 0.23, 0.18 to 0.26 and 0.02 to 0.22 per cent with an average value of 0.22, 0.21, 0.22 and 0.22 per cent for HF, cow, ox and buffalo urine samples respectively.

The concentration of calcium ranged from 16.00 to 32.00, 16.00 to 22.00, 16.00 to 24.00 and 16.00 to 30.00 $meqL^{-1}$ with the mean value of 22.80, 19.60, 20.60 and 22.60 $meqL^{-1}$. The magnesium content varied from 41.48 to 61.23, 33.58 to 51.36, 26.29 to 37.43 and 35.56 to 59.26 $meqL^{-1}$ with an average value of 49.78, 43.26, 31.19 and 48.40 $meqL^{-1}$. The concentration of sulfur ranged from 0.06 to 0.09, 0.07-0.10, 0.07 to 0.11 and 00.06 to 0.09 per cent with mean value of 0.077, 0.081, 0.084 and 0.07 per cent. The

Table 4.3: Chemical composition of urine samples from different types of cattle at initial stage.

Sl. No	Parameters	Mean values*				Range			
		HF	Indigenous			HF	Indigenous		
			Cow	Ox	Buffalo		Cow	Ox	Buffalo
1.	**pH**	6.04	5.97	6.09	6.17	6.69-7.10	5.23-6.35	5.37-6.65	6.69-7.16
2.	**EC (dS/m)**	7.65	7.36	7.55	7.58	7.52-9.10	6.75-8.19	6.69-8.38	7.52-9.17
3.	**N (%)**	0.28	0.26	0.28	0.28	0.20-0.34	0.21-0.35	0.22-0.35	0.21-0.37
4.	**P_2O_5 (%)**	0.17	0.18	0.18	0.17	0.13-0.21	0.15-0.23	0.15-0.23	0.12-0.21
5.	**K_2O (%)**	0.22	0.21	0.22	0.22	0.19-0.25	0.19-0.23	0.18-0.26	0.02-0.22
6.	**Na (%)**	0.19	0.20	0.19	0.13	0.09-0.30	0.09-0.39	0.09-0.30	0.09-0.19
7.	**Ca (meq/l)**	22.80	19.60	20.60	22.60	16.00-32.00	16.00-22.00	16.00-24.00	16.00-30.00
8.	**Mg (meq/l)**	49.78	43.26	31.19	48.40	41.48-61.23	33.58-51.36	26.29-37.43	35.56-59.26
9.	**S (%)**	0.077	0.08	0.08	0.07	0.06-0.09	0.07-0.10	0.067-0.11	0.06-0.09
10.	**CO^-_3 (meq/l)**	-	-	-	-	-	-	-	-
11.	**HCO^-_3 (meq/l)**	10.62	9.73	10.50	11.01	6.40-15.36	6.40-14.08	6.40-15.36	7.68-15.36
12.	**Cl^- (meq//l)**	32.17	30.39	31.19	32.44	27.18-36.98	26.29-37.87	26.29-37.43	28.07-37.87
13.	**Zn (mg/l)**	18.2	17.66	18.32	18.20	19.40-16.40	16.40-19.80	15.80-19.80	16.4-19.8
14.	**Fe (mg/l)**	121.68	121.6	121.38	121.56	118.2-127.2	118.80-125.80	117.80-124.60	117.8-125.8
15.	**Mn (mg/l)**	21.78	21.72	22.48	22.86	17.40-25.40	17.40-26.60	17.80-25.40	17.40-25.40
16.	**Cu (mg/l)**	35.49	35.85	34.21	35.39	29.22-39.84	29.22-39.84	31.22-37.96	29.08-39.70

*Average of ten samples; **HF**- Hostine freshian sodium concentration varied from 0.09 to 0.30, 0.09 to 0.39, 0.09 to 0.30 and 0.09-0.19 per cent with mean value of 00.19, 0.20, 0.19 and 0.13 per cent for HF, cow, ox and buffalo urine samples respectively.

The carbonate was absent in all the samples where as the bicarbonate concentration ranged from 6.40 to 15.36, 6.40 to 14.08, 6.40 to 15.36 and 7.68 to 15.36 meqL^{-1} with an average value of 10.62, 9.73, 10.50 and 11.01 meqL^{-1}. The chloride content varied from 27.18 to 36.98, 26.29 to 37.87, 26.29 to 37.43 and 28.07 to 37.87 meqL^{-1} with an average value of 32.17, 30.39, 31.19 and 32.44 meql^{-1} for HF, cow, ox and buffalo urine samples respectively.

The zinc concentration varied from 19.40 to 16.40, 16.40 to 19.80, 15.80 to 19.80 and 16.40 to 19.80 mgL^{-1} with an average value of 18.20, 17.66, 18.32 and 18.20 mgL^{-1}. The iron content varied from 118.20 to 127.20, 118.80 to 125.80, 117.80 to 124.60 and 117.80 to 125.80 mgl^{-1} with mean value of 121.68, 121.60, 121.38 and 121.56 mgL^{-1}. The manganese concentration varied from 17.40 to 25.40, 17.40-26.60, 17.80 to 25.40 and 17.40 to 25.40 mgL^{-1} average value of 21.78, 21.72, 22.48 and 22.86 mgL^{-1}. The content of copper ranged from 29.22 to 39.84, 29.22 to 39.84, 31.22 to 37.96 and 29.08 to 39.70 mgl^{-1} with the mean of 35.49, 35.85, 34.21 and 35.39 mgL^{-1} for HF, cow, ox and buffalo urine samples respectively.

4.2 Laboratory incubation experiment

4.2.1 Changes in chemical composition of human urine samples from vegetarian diet persons of less than 20 years age group incubated under open and closed condition

Changes in chemical composition of human urine samples collected from persons of <20 years age group of vegetarian diet incubated under open and closed condition are presented in Table 4.4.

In general an increase in pH, carbonate and bicarbonate content, a decrease in nitrogen and micronutrients content was observed when incubated for 30 and 60 days and the increase or decrease was more with incubation period. The nitrogen content was found to be less in samples incubated under open condition than closed condition. The initial samples did not have any carbonate but upon incubation, appreciable amount of carbonates was detected and the values were more in samples kept under open condition and increased with time.

4.2.1.1 Open condition.

A gradual increase in pH of urine was observed with time. The pH ranged from 7.93 to 8.93 and 8.09 to 9.11 with an average value of 8.66 and 8.84 for samples of <20 years age group at 30 and 60 days after incubation, respectively.

There was a slight reduction in the nitrogen concentration of urine kept under closed condition. The nitrogen content varied from 0.16 to 0.32 and 0.16 to 0.31 per cent with an average value of 0.24 and 0.24 per cent. The phosphorus content varied from 0.16 to 0.28 and 0.16 to 0.27 per cent with mean value of 0.20 and 0.19 per cent on 30 and 60th day. The potassium content varied from 0.14 to 0.26 and 0.13 to 0.25 per cent with an average value of 0.18 and 0.18 per cent at 30 and 60 days after incubation, respectively.

Though the fresh urine sample was not having carbonates, there was appreciable quantities of carbonates upon incubation while the bicarbonates content has increased further. The carbonate concentration ranged from 8.00 to 18.00 and 9.30 to 20.93 meqL^{-1} with mean values of 14.20 and 16.51 meqL^{-1}, the bicarbonate concentration ranged from 61.88 to 70.07 and 58.01 to 65.69 meqL^{-1} with an average value of 65.88 and 61.77 meqL^{-1}, for samples of <20 years age group at 30 and 60 days after incubation, respectively.

There was slight reduction in the concentration of micronutrients. The zinc concentration varied from 13.12 to 16.04 and 12.33 to 15.07 mgL^{-1} with an average value of 14.60 and 13.72 mgL^{-1}. The iron content varied from 79.87 to 112.91 and 75.05 to 106.10 mgl^{-1} with mean value of 97.56 and 91.67 mgl^{-1}, the manganese concentration varied from 14.42 to 21.87 and 13.55 to 20.55 mgl^{-1} average value of 18.11 and 17.02 mgL^{-1}. The copper content ranged from 33.87 to 38.75 and 31.83 to 36.41 mgL^{-1} with the mean of 36.31 and 34.12 mgL^{-1} for samples of <20 years age group at 30 and 60 days after incubation, respectively.

4.2.1.2 Closed condition.

Changes in chemical composition of human urine samples collected from persons of less than 20 years age group of vegetarian diet is presented in Table 4.4.

There was slight decrease in pH of urine incubated under closed condition compared to open condition. The pH ranged from 7.85 to 8.84 and 7.85 to 8.84 with an average value of 8.58 and 8.58 for the samples at 30 and 60 days after incubation, respectively.

The concentration of nitrogen varied from 0.19 to 0.38 and 0.19 to 0.37 per cent with an average value of 0.28 and 0.27 per cent. The phosphorus concentration varied from 0.15 to 0.23 and 0.16 to 0.28 per cent with mean value of 0.17 and 0.19 per cent and the potassium content varied from 0.14 to 0.21 and 0.14 to 0.26 per cent with an average value of 0.18 and 0.18 per cent for the samples at 30 and 60 days after incubation, respectively.

The carbonate concentration ranged from 7.20 to 16.20 and 8.65 to 19.47 $meqL^{-1}$ with mean values of 12.78 and 15.36 $meqL^{-1}$, the bicarbonate concentration ranged from 56.70 to 61.78 and 55.11 to 62.41 $meqL^{-1}$ with an average value of 58.56 and 58.68 $meqL^{-1}$ for the samples at 30 and 60 days after incubation, respectively.

Among micronutrients, the zinc concentration varied from 13.25 to 16.20 and 13.44 to 16.43 mgL^{-1} with an average value of 14.74 and 14.95 mgL^{-1}. The iron content varied from 81.25 to 114.87 and 79.10 to 111.83 mgL^{-1} with mean value of 99.24 and 96.62 mgL^{-1}. The manganese concentration varied from 14.43 to 21.89 and 14.14 to 21.45 mgL^{-1} average value of 18.13 and 17.77 mgL^{-1} , while the content of copper ranged from 33.94 to 38.82 and 32.12 to 36.74 mgl^{-1} with the mean of 36.38 and 34.43 mgl^{-1} for the samples at 30 and 60 days after incubation, respectively.

Table 4.4: Changes in chemical composition of human urine samples from vegetarian diet persons of less than 20 years age group incubated under open and closed conditions.

Sl. No	Parameters	Open			Closed		
		Initial	30 DAI	60 DAI	Initial	30 DAI	60 DAI
1.	pH	4.97-6.51 (5.73)	7.93-8.93 (8.66)	8.09-9.11 (8.84)	4.97-6.51 (5.73)	7.85-8.84 (8.58)	7.85-8.84 (8.58)
2.	N (%)	0.21-0.41 (0.30)	0.16-0.32 (0.24)	0.16-0.31 (0.24)	0.21-0.41 (0.30)	0.19-0.38 (0.28)	0.19-0.37 (0.27)
3.	P_2O_5 (%)	0.17-0.22 (0.19)	0.16-0.28 (0.20)	0.16-0.27 (0.19)	0.17-0.22 (0.19)	0.15-0.23 (0.17)	0.16-0.28 (0.19)
4.	K_2O (%)	0.12-0.23 (0.16)	0.14-0.26 (0.18)	0.13-0.25 (0.18)	0.12-0.23 (0.16)	0.14-0.21 (0.18)	0.14-0.26 (0.18)
5.	CO^-_3 (meq/l)	-	8.00-18.00 (14.20)	9.30-20.93 (16.51)	-	7.20-16.20 (12.78)	8.65-19.47 (15.36)
6.	HCO^-_3 (meq/l)	5.12-11.52 (9.09)	61.88-70.07 (65.88)	58.01-65.69 (61.77)	5.12-11.52 (9.09)	56.70-61.78 (58.56)	55.11-62.41 (58.68)
7.	Zn (mg/l)	16.20-19.80 (18.02)	13.12-16.04 (14.60)	12.33-15.07 (13.72)	16.20-19.80 (18.02)	13.25-16.20 (14.74)	13.44-16.43 (14.95)
8.	Fe (mg/l)	98.60-139.40 (120.44)	79.87-112.91 (97.56)	75.05-106.10 (91.67)	98.60-139.40 (120.44)	81.25-114.87 (99.24)	79.10-111.83 (96.62)
9.	Mn (mg/l)	17.80-27.00 (22.36)	14.42-21.87 (18.11)	13.55-20.55 (17.02)	17.80-27.00 (22.36)	14.43-21.89 (18.13)	14.14-21.45 (17.77)
10.	Cu (mg/l)	41.82-47.84 (44.83)	33.87-38.75 (36.31)	31.83-36.41 (34.12)	41.82-47.84 (44.83)	33.94-38.82 (36.38)	32.12-36.74 (34.43)

-Values in the parenthesis are average of ten samples; **DAI**- Days After Incubation

4.2.2 Changes in chemical composition of human urine samples from non-vegetarian diet persons of less than 20 years age group incubated under open and closed condition

Changes in chemical composition of human urine samples collected from persons of <20 years age group of non-vegetarian diet incubated under open and closed condition are presented in Table 4.5.

4.2.2.1 Open condition.

The changes in chemical composition of human urine samples of less than 20 years of non-vegetarian diet persons incubated under open condition are presented in Table 4.5.

The pH ranged from 8.15 to 9.20 and 8.31 to 9.38 with an average value of 8.91 and 9.09 in samples of <20 years age group at 30 and 60 days after incubation, respectively.

The concentration of nitrogen varied from 0.24 to 0.40 and 0.24 to 0.39 per cent with an average value of 0.31 per cent at 30 and 60 days after incubation. The phosphorus concentration varied from 0.14 to 0.36 and 0.14 to 0.32 per cent with mean value of 0.20 per cent while the potassium content varied from 0.15 to 0.22 and 0.15 to 0.22 per cent with an average value of 0.19 per cent at 30 and 60 days after incubation.

The carbonate concentration ranged from 8.00 to 22.00 and 9.30 to 25.58 $meql^{-1}$ with the mean of 15.00 and 17.44 $meqL^{-1}$, the bicarbonate concentration ranged from 50.96 to 67.34 and 47.78 to 63.13 $meqL^{-1}$ with an average value of 60.24 and 56.48 $meqL^{-1}$ in samples of <20 years age group at 30 and 60 days after incubation, respectively.

The zinc concentration varied from 13.28 to 16.52 and 12.48 to 15.53 mgL^{-1} with an average value of 15.08 and 14.17 mgL^{-1}. The iron content varied from 94.45 to 133.49 and 88.75 to 125.43 mgL^{-1} with mean value of 118.00 and 110.88 mgL^{-1}, the manganese concentration varied from 17.98 to 21.87 and 16.90 to 20.55 mgL^{-1} average value of

20.06 and 18.85 mgL^{-1} , while the content of copper ranged from 37.23 to 39.51 and 34.98 to 37.13 mgL^{-1} with the mean of 38.21 and 35.91 mgL^{-1} in samples of <20 years age group at 30 and 60 days after incubation, respectively.

4.2.2.2 Closed condition.

Chemical composition of human urine samples of less than 20 years age group from non-vegetarian diet persons incubated under closed condition is presented in Tables 4.5.

The pH ranged from 8.07 to 9.11 with an average value of 8.82 for the samples of <20 years age group both at 30 and 60 days after incubation, respectively.

The concentration of nitrogen varied from 0.28 to 0.47 and 0.29 to 0.46 per cent with an average value of 0.37 and 0.36 per cent, phosphorus concentration varied from 0.13 to 0.35 and 0.14 to 0.21 per cent with mean value of 0.20 and 0.18 per cent and the potassium content varied from 0.16 to 0.22 and 0.15 to 0.22 per cent with an average value of 0.19 and 0.19 per cent for the samples of <20 years age group at 30 and 60 days after incubation, respectively.

The carbonate concentration ranged from 7.20 to 19.80 and 8.65 to 23.79 $meqL^{-1}$ with the mean of 13.50 and 16.22 $meqL^{-1}$, the bicarbonate concentration ranged from 53.32 to 65.52 and 45.39 to 59.98 $meqL^{-1}$ with the mean value of 60.64 and 53.65 $meqL^{-1}$ for the samples of <20 years age group at 30 and 60 days after incubation, respectively.

The zinc concentration varied from 13.28 to 16.52 and 13.61 to 16.92 mgL^{-1} with an average value of 15.08 and 15.45 mgL^{-1}, the iron content varied from 96.08 to 135.80 and 93.54 to 132.21 mgL^{-1} with mean value of 120.04 and 116.87 mgL^{-1}. The manganese concentration varied from 18.00 to 21.89 and 17.64 to 21.45 mgL^{-1} average value of 20.08 and 17.56 mgL^{-1} , while the content of copper ranged from 37.28 to 39.58 and 35.30 to 37.46 mgL^{-1} with the mean of 38.28 and 36.23 mgL^{-1} for the samples of <20 years age group at 30 and 60 days after incubation, respectively.

Table 4.5: Changes in chemical composition of human urine samples from non-vegetarian diet persons of less than 20 years age group incubated under open and closed conditions.

Sl. No	Parameters	Open			Closed		
		Initial	30 DAI	60 DAI	Initial	30 DAI	60 DAI
1.	pH	4.96-6.81 (5.77)	8.15-9.20 (8.91)	8.31-9.38 (9.09)	4.96-6.81 (5.77)	8.07-9.11 (8.82)	8.07-9.11 (8.82)
2.	N (%)	0.31-0.50 (0.40)	0.24-0.40 (0.31)	0.24-0.39 (0.31)	0.31-0.50 (0.40)	0.28-0.47 (0.37)	0.29-0.46 (0.36)
3.	P_2O_5 (%)	0.13-0.30 (0.19)	0.14-0.36 (0.20)	0.14-0.32 (0.20)	0.13-0.30 (0.19)	0.13-0.35 (0.20)	0.14-0.21 (0.18)
4.	K_2O (%)	0.15-0.22 (0.19)	0.15-0.22 (0.19)	0.15-0.22 (0.19)	0.15-0.22 (0.19)	0.16-0.22 (0.19)	0.15-0.22 (0.19)
5.	CO^-_3 (meq/l)	-	8.00-22.00 (15.00)	9.30-25.58 (17.44)	-	7.20-19.80 (13.50)	8.65-23.79 (16.22)
6.	HCO^-_3 (meq/l)	5.12-14.08 (9.60)	50.96-67.34 (60.24)	47.78-63.13 (56.48)	5.12-14.08 (9.60)	53.32-65.52 (60.64)	45.39-59.98 (53.65)
7.	Zn (mg/l)	16.40-20.40 (18.62)	13.28-16.52 (15.08)	12.48-15.53 (14.17)	16.40-20.40 (18.62)	13.28-16.52 (15.08)	13.61-16.92 (15.45)
8.	Fe (mg/l)	116.60-164.80 (145.68)	94.45-133.49 (118.00)	88.75-125.43 (110.88)	116.60-164.80 (145.68)	96.08-135.80 (120.04)	93.54-132.21 (116.87)
9.	Mn (mg/l)	22.20-27.00 (24.76)	17.98-21.87 (20.06)	16.90-20.55 (18.85)	22.20-27.00 (24.76)	18.00-21.89 (20.08)	17.64-21.45 (17.56)
10.	Cu (mg/l)	45.96-48.78 (47.174)	37.23-39.51 (38.21)	34.98-37.13 (35.91)	45.96-48.78 (47.174)	37.28-39.58 (38.28)	35.30-37.46 (36.23)

-Values in the parenthesis are average of ten samples; **DAI**- Days After Incubation

4.2.3 Changes in chemical composition of cattle urine samples incubated under different condition.

Changes in chemical composition of urine samples collected from different types of cattle incubated under open and closed conditions are presented in Tables 4.6a to 4.7b.

4.2.3.1 Open condition.

Changes in chemical composition of urine samples from different categories of cattle *viz.* HF, cow, ox and buffalo after one month of incubation under open condition are presented in Tables 4.6a and 4.6b.

The pH ranged from 8.57 to 9.21, 8.49 to 9.23, 8.52 to 9.19 and 8.64 to 9.24 with a mean value of 8.93, 8.89, 8.85 and 8.92 in samples from HF, cow, ox and buffalo, respectively.

The concentration of nitrogen varied from 0.16 to 0.27, 0.17 to 0.27, 0.16 to 0.28, and 0.17 to 0.29 per cent with an average value of 0.22, 0.22, 0.21 and 0.22 per cent. The phosphorus concentration varied from 0.14 to 0.19, 0.15 to 0.21, 0.15 to 0.21 and 0.14 to 0.19 per cent with mean value of 0.16, 0.18, 0.18 and 0.16 per cent respectively for samples from HF, cow, ox and buffalo, respectively. The potassium content varied from 0.17 to 0.19, 0.17 to 0.20, 0.17 to 0.20 and 0.17 to 0.19 per cent with an average value of 0.18 per cent in urine samples of all the four categories of cattle.

The carbonate concentration was ranged from 10.00 to 24.00, 10.00 to 24.00, 10.00 to 22.00 and 12.00 to 24.00 meqL^{-1} with mean value of 16.60, 16.40, 15.20 and 17.20 meqL^{-1}, the bicarbonate concentration ranged from 37.31 to 56.42, 47.32 to 58.24, 47.32 to 58.24 and 44.59 to 55.51 meqL^{-1} with mean value of 51.23, 52.60, 52.60 and 51.05 meqL^{-1}in urine samples of HF, local cow, ox and buffalo, respectively.

The zinc concentration varied from 13.28 to 15.55, 2.80 to 16.04, 13.28 to 16.04 and 13.28 to 16.04 mgL^{-1} with mean value of 14.69, 14.84, 14.30 and 14.74 mgL^{-1}. The iron content varied from 95.74 to 103.03, 95.42 to 100.93, 96.23 to 101.90 and 95.42 to 101.90 mgL^{-1} with mean value of 98.56, 98.32, 98.50 and 98.46 mgL^{-1}. The manganese concentration varied from 14.09 to 20.57, 14.42 to 20.57, 14.09 to 21.55 and 14.09 to 20.57 mgL^{-1} average value of 17.64, 18.21, 17.59 and 18.52 mgL^{-1}. The copper content ranged from 23.67 to 32.27, 25.29 to 30.75, 23.67 to 32.27 and 23.667 to 32.27 mgL^{-1} with the mean of 35.49, 35.85, 34.21 and 35.39 mgL^{-1} in urine samples of HF, local cow, ox and buffalo, respectively.

Changes in chemical composition of urine samples from different categories of cattle *viz.* HF, local cow, ox and buffalo after two months of incubation under open condition were analyzed for different parameters and the results are presented in Tables 4.6a and 4.6b.

The pH ranged from 8.74 to 9.39, 8.66 to 9.41, 8.69 to 9.37 and 8.81 to 9.42 with mean value of 9.11, 9.07, 9.03 and 9.09 for urine samples of HF, local cow, ox and buffalo respectively.

The concentration of nitrogen varied from 0.16 to 0.27, 0.17 to 0.27, 0.16 to 0.28, and 0.17 to 0.29 per cent with an average value of 0.22, 0.22, 0.21 and 0.22 per cent. The phosphorus concentration varied from 0.14 to 0.19, 0.15 to 0.21, 0.15 to 0.21 and 0.14 to 0.19 per cent with mean value of 0.16, 0.18, 0.18 and 0.16 per cent for urine samples from HF, local cow, ox and buffalo respectively the potassium content varied from 0.19 to 0.21, 0.18 to 0.22, 0.18 to 0.22 and 0.18 to 0.21 per cent with mean value of 0.20 per cent from all the four categories of cattle.

The carbonate concentration was ranged from 11.63 to 27.91, 11.63 to 27.91, 11.63 to 25.58 and 13.95 to 27.91 $meqL^{-1}$ with mean value of 19.30, 19.07, 17.68 and 20.00 $meqL^{-1}$, the bicarbonate concentration ranged from 34.98 to 52.90, 44.36 to 54.60, 44.36 to 54.60 and 41.80 to 52.04 $meqL^{-1}$ with mean value of 48.03, 49.31, 49.31 and 47.86 $meqL^{-1}$ for urine samples of HF, local cow, ox and buffalo respectively.

The zinc concentration varied from 12.48 to 14.61, 12.03 to 15.07, 12.48 to 15.07 and 12.48 to 15.07 mgL^{-1} with mean value of 13.81, 13.94, 13.44 and 13.85 mgL^{-1}, the iron content varied from 89.97 to 96.82, 89.66 to 94.84, 90.42 to 95.75 and 89.66 to 95.75 mgL^{-1} with mean value of 92.61, 92.39, 92.55 and 92.52 mgL^{-1}, the manganese

Table 4.6a: Changes in chemical composition of urine samples from different types of cattle incubated under open condition.

Sl. No	Parameters	HF			Cow		
		Initial	30 DAI	60 DAI	Initial	30 DAI	60 DAI
1.	pH	6.69-8.10 (6.04)	8.57-9.21 (8.93)	8.74-9.39 (9.11)	5.23-6.35 (5.97)	8.49-9.23 (8.89)	8.66-9.41 (9.07)
2.	N (%)	0.20-0.34 (0.28)	0.16-0.27 (0.22)	0.16-0.27 (0.22)	0.21-0.35 (0.26)	0.17-0.27 (0.22)	0.17-0.27 (0.22)
3.	P_2O_5 (%)	0.13-0.21 (0.17)	0.14-0.19 (0.16)	0.14-0.19 (0.16)	0.15-0. 23 (0.18)	0.15-0.21 (0.18)	0.15-0.21 (0.18)
4.	K_2O (%)	0.19-0.25 (0.22)	0.17-0.19 (0.18)	0.19-0.21 (0.20)	0.19-0.23 (0.21)	0.17-0.20 (0.18)	0.18-0.22 (0.20)
5.	CO^-_3 (meq/l)	-	10.00-24.00 (16.60)	11.63-27.91 (19.30)	-	10.00-24.00 (16.40)	11.63-27.91 (19.07)
6.	HCO^-_3 (meq/l)	6.40-15.36 (10.62)	37.31-56.42 (51.23)	34.98-52.90 (48.03)	6.40-14.08 (9.73)	47.32-58.24 (52.60)	44.36-54.60 (49.31)
7.	Zn (mg/l)	19.40-16.40 (18.2)	13.28-15.55 (14.69)	12.48-14.61 (13.81)	16.40-19.80 (17.66)	2.80-16.04 (14.84)	12.03-15.07 (13.94)
8.	Fe (mg/l)	118.2-127.2 (121.68)	95.74-103.03 (98.56)	89.97-96.82 (92.61)	118.80-125.80 (121.6)	95.42-100.93 (98.32)	89.66-94.84 (92.39)
9.	Mn (mg/l)	17.40-25.40 (21.78)	14.09-20.57 (17.64)	13.24-19.33 (16.58)	17.40-26.60 (21.72)	14.42-20.57 (18.21)	13.55-19.33 (17.11)
10.	Cu (mg/l)	29.22-39.84 (35.49)	23.67-32.27 (28.75)	22.24-30.32 (27.01)	29.22-39.84 (35.85)	25.29-30.75 (27.71)	23.76-28.89 (26.04)

-Values in the parenthesis are average of ten samples; **DAI**- Days After Incubation; **HF**- Hostine freshian

Table 4.6b: Changes in chemical composition of urine samples from different types of cattle incubated under open condition.

Sl. No	Parameters	Ox			Buffalo		
		Initial	30 DAI	60 DAI	Initial	30 DAI	60 DAI
1.	pH	5.37-6.65 (6.09)	8.52-9.19 (8.85)	8.69-9.37 (9.03)	6.69-8.16 (6.17)	8.64-9.24 (8.92)	8.81-9.42 (9.09)
2.	N (%)	0.22-0.35 (0.28)	0.16-0.28 (0.21)	0.16-0.28 (0.21)	0.21-0.37 (0.28)	0.17-0.29 (0.22)	0.17-0.29 (0.22)
3.	P_2O_5 (%)	0.15-0.23 (0.18)	0.15-0.21 (0.18)	0.15-0.21 (0.18)	0.12-0.21 (0.17)	0.14-0.19 (0.16)	0.14-0.19 (0.16)
4.	K_2O (%)	0.18-0.26 (0.22)	0.17-0.20 (0.18)	0.18-0.22 (0.20)	0.02-0.22 (0.22)	0.17-0.19 (0.18)	0.18-0.21 (0.20)
5.	CO^-_3 (meq/l)	-	10.00-22.00 (15.20)	11.63-25.58 (17.68)	-	12.00-24.00 (17.20)	13.95-27.91 (20.00)
6.	HCO^-_3 (meq/l)	6.40-15.36 (10.50)	47.32-58.24 (52.60)	44.36-54.60 (49.31)	7.68-15.36 (11.01)	44.59-55.51 (51.05)	41.80-52.04 (47.86)
7.	Zn (mg/l)	15.8-19.8 (18.32)	13.28-16.04 (14.30)	12.48-15.07 (13.44)	16.4-19.8 (18.20)	13.28-16.04 (14.74)	12.48-15.07 (13.85)
8.	Fe (mg/l)	117.8-124.6 (121.38)	96.23-101.90 (98.50)	90.42-95.75 (92.55)	117.8-125.8 (121.56)	95.42-101.90 (98.46)	89.66-95.75 (92.52)
9.	Mn (mg/l)	17.8-25.4 (22.48)	14.09-21.55 (17.59)	13.24-20.25 (16.53)	17.40-25.40 (22.86)	14.09-20.57 (18.52)	13.24-19.33 (17.40)
10.	Cu (mg/l)	31.2-37.9 (34.21)	23.67-32.27 (29.04)	22.24-30.32 (27.29)	29.08-39.70 (35.39)	23.667-32.27 (28.69)	22.24-30.32 (26.96)

-Values in the parenthesis are average of ten samples; **DAI-** Days After Incubation concentration varied from 13.24 to 19.33, 13.55 to 19.33, 13.24 to 20.25 and 13.24 to 19.33 mgL^{-1} average value of 16.58, 17.11, 16.53 and 17.40 mgL^{-1}. The copper content ranged from 22.24 to 30.32, 23.76 to 28.89, 22.24 to 30.32 and 22.24 to 30.32 mgL^{-1} with the mean of 27.01, 26.04, 27.29 and 26.96 mgL^{-1} for urine samples of HF, local cow, ox and buffalo respectively.

4.2.3.2 Closed condition.

Changes in pH, nutrient content, cationic and anionic concentration in urine samples from different categories of cattle *viz.* HF, local cow, ox and buffalo one month after incubation under in closed condition are presented in Tables 4.7a and 4.7b.

The pH ranged from 8.48 to 9.12, 8.40 to 9.14, 8.43 to 9.10 and 8.55 to 9.15 with mean value of 8.84, 8.80, 8.76 and 8.83 for urine samples of HF, local cow, ox and buffalo respectively.

The concentration of nitrogen varied from 0.19 to 0.31, 0.20 to 0.32, 0.19 to 0.32, and 0.19 to 0.34 per cent with an average value of 0.25, 0.25, 0.24 and 0.26 per cent, phosphorus concentration varied from 0.15 to 0.20, 0.16 to 0.19, 0.15 to 0.22 and 0.15 to 0.20 per cent with mean value of 0.16, 0.17, 0.19 and 0.17 per cent and the potassium content varied from 0.17 to 0.22, 0.19 to 0.22, 0.18 to 0.22 and 0.18 to 0.22 per cent with an average value of 0.20, 0.20, 0.20and 0.21 per cent for urine samples of HF, local cow, ox and buffalo respectively.

The carbonate concentration ranged from 9.00 to 21.60, 9.00 to 21.60, 9.00 to 19.80 and 10.80 to 21.60 $meqL^{-1}$ with mean value of 14.94, 14.76, 13.68 and 15.48 $meqL^{-1}$, the bicarbonate concentration ranged from 34.70 to 52.47, 44.01 to 55.01, 44.01 to 54.16 and 41.47 to 51.62 $meqL^{-1}$ with an average value of 47.65, 49.76, 48.92 and 47.48 $meqL^{-1}$for urine samples of HF, local cow, ox and buffalo respectively.

The zinc concentration varied from 13.28 to 15.55, 12.80 to 16.04, 13.28 to 16.04 and 13.28 to 16.04 mgL^{-1} with mean value of 14.69, 14.84, 14.30 and 14.74 mgL^{-1}, the iron content varied from 97.40 to 104.81, 97.07 to 102.67, 97.89 to 103.66 and 97.07 to

103.66 mgL^{-1} with mean value of 100.26, 100.02, 100.20 and 100.17 mgL^{-1}, the manganese concentration varied from 14.110 to 20.60, 14.43 to 20.60, 14.110 to 21.57and 14.110 to 20.60 mgL^{-1} average value of 17.66, 18.23, 17.61 and 18.54 mgL^{-1}. The copper content ranged from 23.71 to 32.33, 25.33 to 30.80, 23.71 to 32.33 and 23.71 to 32.33 mgL^{-1} with the mean of 28.80, 27.76, 29.09 and 28.74 mgL^{-1} for urine samples of HF, local cow, ox and buffalo respectively.

Changes in pH, nutrient content, cationic and anionic concentration in urine samples from different categories of cattle *viz.* HF, local cow, ox and buffalo two months after incubation are presented in Tables 4.7a and 4.7b.

The pH ranged from 8.48-9.12, 8.40-9.14, 8.43-9.10 and 8.55-9.15 with an average value of 8.84, 8.80, 8.76 and 8.83 for urine samples of HF, local cow, ox and buffalo respectively.

The concentration of nitrogen varied from 0.19 to 0.32, 0.20 to 0.32, 0.19 to 0.33, and 0.20 to 0.35 per cent with mean value of 0.26, 0.26, 0.25 and 0.27 per cent, phosphorus concentration varied from 0.15 to 0.20, 0.15 to 0.18, 0.15 to 0.22 and 0.14 to 0.20 per cent with mean value of 0.16, 0.16, 0.19 and 0.16 per cent for urine samples from HF, local cow, ox and buffalo, respectively. The potassium content varied from 0.19 to 0.21, 0.18 to 0.22, 0.11 to 0.22 and 0.18 to 0.22 per cent with an average value of 0.20 per cent from all the four categories of cattle.

The carbonate concentration ranged from 10.81 to 25.96, 10.81 to 25.96, 10.81 to 23.79 and 12.98 to 25.96 $meqL^{-1}$ with mean value of 17.95, 17.74, 16.44 and 18.60 $meqL^{-1}$, the bicarbonate concentration ranged from 33.23 to 50.25, 42.15 to 52.68, 42.15 to 51.87 and 39.71 to 49.44 $meqL^{-1}$ with mean value of 45.63, 47.66, 46.85 and 45.47 $meqL^{-1}$ for urine samples of HF, local cow, ox and buffalo respectively.

The zinc concentration varied from 13.61-15.93, 13.11-16.43, 13.61-16.43 and 13.61-16.43 mgL^{-1} with an average value of 15.05, 15.20, 14.65 and 15.10 mgL^{-1}, the iron content varied from 94.82-102.04, 94.50-99.96, 95.31-100.92 and 94.50-100.92 mgL^{-1} with mean value of 97.62, 97.37, 97.55and 97.52 mgL^{-1}. The manganese

Table 4.7a: Changes in chemical composition of urine samples from different types of cattle incubated under closed condition.

Sl. No	Parameters	HF				Cow		
		Initial	30 DAI	60 DAI		Initial	30 DAI	60 DAI
1.	pH	6.69-8.10 (6.04)	8.48-9.12 (8.84)	8.48-9.12 (8.84)		5.23-6.35 (5.97)	8.40-9.14 (8.80)	8.40-9.14 (8.80)
2.	N (%)	0.20-0.34 (0.28)	0.19-0.31 (0.25)	0.19-0.32 (0.26)		0.21-0.35 (0.26)	0.20-0.32 (0.25)	0.20-0.32 (0.26)
3.	P_2O_5 (%)	0.13-0.21 (0.17)	0.15-0.20 (0.16)	0.15-0.20 (0.16)		0.15-0.23 (0.18)	0.16-0.19 (0.17)	0.15-0.18 (0.16)
4.	K_2O (%)	0.19-0.25 (0.22)	0.17-0.22 (0.20)	0.19-0.21 (0.20)		0.19-0.23 (0.21)	0.19-0.22 (0.20)	0.18-0.22 (0.20)
5.	CO^-_3 (meq/l)	-	9.00-21.60 (14.94)	10.81-25.96 (17.95)		-	9.00-21.60 (14.76)	10.81-25.96 (17.74)
6.	HCO^-_3 (meq/l)	6.40-15.36 (10.62)	34.70-52.47 (47.65)	33.23-50.25 (45.63)		6.40-14.08 (9.73)	44.01-55.01 (49.76)	42.15-52.68 (47.66)
7.	Zn (mg/l)	19.40-16.40 (18.2)	13.28-15.55 (14.69)	13.61-15.93 (15.05)		16.40-19.80 (17.66)	12.80-16.04 (14.84)	13.11-16.43 (15.20)
8.	Fe (mg/l)	118.2-127.2 (121.68)	97.40-104.81 (100.26)	94.82-102.04 (97.62)		118.80-125.80 (121.6)	97.07-102.67 (100.02)	94.50-99.96 (97.37)
9.	Mn (mg/l)	17.40-25.40 (21.78)	14.110-20.60 (17.66)	13.83-20.18 (17.31)		17.40-26.60 (21.72)	14.43-20.60 (18.23)	14.14-20.18 (17.86)
10.	Cu (mg/l)	29.22-39.84 (35.49)	23.71-32.33 (28.80)	22.44-30.60 (27.26)		29.22-39.84 (35.85)	25.33-30.80 (27.76)	23.98-29.15 (26.27)

-Values in the parenthesis are average of ten samples; **DAI**- Days After Incubation; **HF**- Hostine freshian

Table 4.7b: Changes in chemical composition of urine samples from different types of cattle incubated under closed condition.

Sl. No	Parameters	Ox			Buffalo		
		Initial	30 DAI	60 DAI	Initial	30 DAI	60 DAI
1.	pH	5.37-6.65 (6.09)	8.43-9.10 (8.76)	8.43-9.10 (8.76)	6.69-8.16 (6.17)	8.55-9.15 (8.83)	8.55-9.15 (8.83)
2.	N (%)	0.22-0.35 (0.28)	0.19-0.32 (0.24)	0.19-0.33 (0.25)	0.21-0.37 (0.28)	0.19-0.34 (0.26)	0.20-0.35 (0.27)
3.	P_2O_5 (%)	0.15-0.23 (0.18)	0.15-0.22 (0.19)	0.15-0.22 (0.19)	0.12-0.21 (0.17)	0.15-0.20 (0.17)	0.14-0.20 (0.16)
4.	K_2O (%)	0.18-0.26 (0.22)	0.18-0.22 (0.20)	0.11-0.22 (0.20)	0.02-0.22 (0.22)	0.18-0.22 (0.21)	0.18-0.22 (0.20)
5.	CO^-_3 (meq/l)	-	9.00-19.80 (13.68)	10.81-23.79 (16.44)	-	10.80-21.60 (15.48)	12.98-25.96 (18.60)
6.	HCO^-_3 (meq/l)	6.40-15.36 (10.50)	44.01-54.16 (48.92)	42.15-51.87 (46.85)	7.68-15.36 (11.01)	41.47-51.62 (47.48)	39.71-49.44 (45.47)
7.	Zn (mg/l)	15.8-19.8 (18.32)	13.28-16.04 (14.30)	13.61-16.43 (14.65)	16.4-19.8 (18.20)	13.28-16.04 (14.74)	13.61-16.43 (15.10)
8.	Fe (mg/l)	117.80-124.60 (121.38)	97.89-103.66 (100.20)	95.31-100.92 (97.55)	117.8-125.8 (121.56)	97.07-103.66 (100.17)	94.50-100.92 (97.52)
9.	Mn (mg/l)	17.8-25.4 (22.48)	14.110-21.57 (17.61)	13.83-21.14 (17.26)	17.40-25.40 (22.86)	14.110-20.60 (18.54)	13.83-20.18 (18.16)
10.	Cu (mg/l)	31.22-37.96 (34.21)	23.71-32.33 (29.09)	22.44-30.60 (27.53)	29.08-39.70 (35.39)	23.71-32.33 (28.74)	22.44-30.60 (27.20)

-Values in the parenthesis are average of ten samples; **DAI**- Days After Incubation

concentration varied from 13.83-20.18, 14.14-20.18, 13.83-21.14 and 13.83-20.18 mgL^{-1} average value of 17.31, 17.86, 17.26 and 18.16 mgL^{-1}. The copper concentration ranged from 22.44-30.60, 23.98-29.15, 22.44-30.60 and 22.44-30.60 mgL^{-1} with the mean of 27.26, 26.27, 27.53 and 27.20 mgL^{-1} for urine samples of HF, local cow, ox and buffalo respectively.

Field Experiment – Studies on the effect of repeated application of human and cattle urine on soil properties, crop growth and yield

4.2 Biometric observations for different crops

4.2.1 Growth components

The data on vine length/ plant height, number of branches $plant^{-1}$, number of leaves $plant^{-1}$, leaf area index, dry matter production and yield as influenced by application of human urine and cattle urine based on nitrogen requirement of ashgourd, french bean, pole bean and pumpkin crops at different growth stages are presented in Tables 4.8 to 4.11.

4.2.1.1 Vine length or plant height (cm)

The data on vine length (cm) as influenced by split application of human urine and cattle urine with and without gypsum at harvest of ashgourd crop is presented in Table 4.8.

The vine length differed significantly due to human urine and cattle urine applied on N basis at harvest of ashgourd crop.

Significantly higher vine length of ashgourd plants was observed with application of human urine in three split doses plus gypsum (T_{12}) at harvest (590.8 cm) which was on par with cattle urine in three split doses plus gypsum (T_{14}), recommended dose of fertilizers (T_2), human urine in three split doses without gypsum (T_{11}) and cattle urine in three split doses without gypsum (T_{13}). Application of farmyard manure (FYM) alone (T_1) recorded significantly lower vine length (440.0 cm) and it was on par with application of human urine in single dose without gypsum (T_3) and with gypsum (T_4), cattle urine in single dose without gypsum (T_5) and with gypsum (T_6).

Similar trend was observed at harvest with respect to plant height in french bean and vine length in pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in same plot where ashgourd crop was grown (Table 4.8). The trend of variation in vine length/ plant height observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

4.2.1.2 Number of branches plant^{-1}

The number of branches plant^{-1} showed significant differences at harvest of four vegetable crops (Table 4.8).

In case of ashgourd significantly more number of branches plant^{-1} at harvest was recorded in treatment with human urine in three split doses plus gypsum and balance P_2O_5 and K_2O (T_{12}: 4.99) which was on par with T_{14}, T_2, T_{11}, and T_{13}. Application of farmyard manure (FYM) alone (T_1) recorded significantly lower number of branches plant^{-1} (2.70) and it was on par with T_3, T_4, T_5 and T_6. The same trend was observed at harvest in french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown (Table 4.8). The trend of variation in number of branches observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

4.2.1.3 Number of leaves plant^{-1}

The number of leaves plant^{-1} as influenced by application of human urine and cattle urine on N basis at harvest of four vegetable crops are presented in Table 4.8. Significant difference in the number of leaves at harvest of ashgourd crop was noticed due to treatments (Table 4.8).

Table 4.8: Effect of split application of human and cattle urine with and without gypsum on vine length/ plant height (cm), number of branches (plant^{-1}), number of leaves (plant^{-1}) and leaf area index at harvest of different vegetable crops.

Treatments	Ashgourd				French bean*			
	Vine length	No. of branches	No. of leaves	Leaf area index	Plant height	No. of branches	No. of leaves	Leaf area index
T_1	440.0	2.70	27.4	0.15	27.3	8.9	10.3	1.11
T_2	570.3	4.70	51.7	0.28	49.0	14.5	18.2	1.33
T_3	463.9	3.12	29.8	0.16	29.7	9.4	11.3	1.14
T_4	479.6	3.58	32.7	0.17	30.8	10.2	12.3	1.18
T_5	451.4	2.89	28.8	0.16	29.5	9.0	10.7	1.13
T_6	472.3	3.42	31.4	0.17	30.0	10.0	12.0	1.14
T_7	512.6	3.65	40.8	0.21	33.0	11.4	14.0	1.23
T_8	528.0	3.82	46.7	0.24	39.5	12.6	15.0	1.25
T_9	507.8	3.61	39.9	0.21	31.2	10.9	13.7	1.21
T_{10}	515.7	3.77	44.8	0.23	37.0	11.9	14.5	1.22
T_{11}	563.8	4.65	50.3	0.27	47.8	14.2	17.8	1.30
T_{12}	590.8	4.99	55.5	0.29	52.5	15.5	20.7	1.36
T_{13}	558.0	4.59	49.6	0.27	46.8	13.6	17.7	1.29
T_{14}	582.1	4.87	54.2	0.29	50.7	15.1	19.0	1.35
S.Em ±	**17.9**	**0.46**	**2.43**	**0.01**	**3.60**	**0.49**	**1.39**	**0.03**
C.D.(P=0.05)	**52.0**	**2.70**	**7.06**	**0.03**	**10.46**	**1.42**	**4.04**	**0.09**

***plant height**

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

Table 4.8: Continued...

Treatments	Pole bean				Pumpkin			
	Vine length	No. of branches	No. of leaves	Leaf area index	Vine length	No. of branches	No. of leaves	Leaf area index
T_1	255.3	6.12	28.3	0.30	397.2	2.58	24.5	0.32
T_2	416.7	9.08	55.3	0.41	521.5	4.37	51.4	0.54
T_3	279.0	6.55	30.6	0.31	421.8	2.82	27.8	0.34
T_4	305.7	6.92	34.3	0.33	436.0	3.34	31.6	0.36
T_5	270.3	6.25	29.0	0.30	409.8	2.74	27.2	0.32
T_6	292.0	6.82	32.8	0.32	429.4	3.18	30.0	0.35
T_7	325.0	7.33	39.1	0.34	466.0	3.64	37.4	0.43
T_8	340.6	7.74	45.9	0.37	482.2	3.94	42.7	0.50
T_9	314.3	7.21	36.8	0.33	461.7	3.56	36.6	0.41
T_{10}	335.2	7.50	43.5	0.37	470.1	3.72	41.1	0.47
T_{11}	406.0	8.96	54.4	0.41	516.7	4.25	49.6	0.53
T_{12}	452.0	9.60	58.9	0.45	537.1	4.73	53.0	0.56
T_{13}	394.2	8.70	52.9	0.40	511.0	4.22	48.6	0.53
T_{14}	427.3	9.30	57.2	0.43	532.0	4.47	52.2	0.55
S.Em ±	**20.3**	**0.58**	**3.99**	**0.02**	**14.8**	**0.24**	**3.14**	**0.02**
C.D.(P=0.05)	**58.9**	**1.68**	**11.61**	**0.05**	**43.0**	**0.69**	**9.11**	**0.06**

Legend:

T_1	:	FYM (Farmyard manure) alone	**T_8**	:	RDN through human urine in two split doses+ gypsum
T_2	:	Recommended dose of fertilizer + Farmyard manure	**T_9**	:	RDN through cattle urine in two split doses
T_3	:	RDN through human urine in single dose	**T_{10}**	:	RDN through cattle urine in two split doses+ gypsum
T_4	:	RDN through human urine in single dose + gypsum	**T_{11}**	:	RDN through human urine in three split doses
T_5	:	RDN through cattle urine in single dose	**T_{12}**	:	RDN through human urine in three split doses+ gypsum
T_6	:	RDN through cattle urine in single dose+ gypsum	**T_{13}**	:	RDN through cattle urine in three split doses
T_7	:	RDN through human urine in two split doses	**T_{14}**	:	RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

Application of human urine plus gypsum in three split doses (T_{12}) recorded significantly higher number of leaves plant^{-1} (55.5) at harvest of ashgourd crop and it was on par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower number of leaves plant^{-1} (26.6) was observed in farm yard manure alone (T_1) and it was on par with T_3, T_4, T_5 and T_6.

The same trend was observed at harvest of french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown (Table 4.8). The trend of changes in number of leaves observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots received same treatments.

4.2.1.4 Leaf area index

The data on leaf area index at harvest of four vegetable crops as influenced by application of human urine and cattle urine with and without gypsum are presented in Table 4.8.

In case of ashgourd crop, the leaf area index varied significantly due to human urine and cattle urine application and was highest in treatment with recommended dose of nitrogen through human urine plus gypsum (T_{12}) at harvest of ashgourd crop (0.29). Significantly lower leaf area index was noticed with application of farm yard manure alone i.e., T_1 (0.15). Similar results were observed at harvest in case of french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown (Table 4.8). The trend of variation in leaf area index observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

4.2.2 Total dry matter accumulation at harvest of crops

Dry matter accumulation varied significantly due to application of human urine and cattle urine to different vegetable crops (Table 4.9).

Table 4.9: Effect of split application of human urine and cattle urine with and without gypsum on total dry weight (g plant^{-1}) at harvest of different vegetable crops.

Treatments	Ashgourd	French bean	Pole bean	Pumpkin
T_1	518.9	19.6	113.6	522.3
T_2	676.1	25.0	148.7	699.9
T_3	534.1	20.0	119.7	537.3
T_4	551.1	20.7	118.1	557.1
T_5	524.9	20.1	116.9	530.5
T_6	542.3	20.2	120.6	547.6
T_7	561.6	21.6	125.9	574.9
T_8	603.5	23.1	136.4	616.2
T_9	554.9	21.2	121.4	564.3
T_{10}	592.9	22.0	131.6	599.9
T_{11}	664.1	24.6	147.1	691.4
T_{12}	701.7	26.2	156.8	719.3
T_{13}	650.7	24.5	144.9	679.3
T_{14}	691.1	22.8	150.2	711.4
S.Em ±	**20.4**	**0.64**	**4.01**	**19.4**
C.D.(P=0.05)	**59.3**	**1.85**	**11.7**	**56.3**

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

Significant differences among the treatments with respect to total dry weight (g plant^{-1}) was observed at harvest of ashgourd crop (Table 4.9). Significantly higher total dry weight plant^{-1} was recorded in treatment with recommended dose of nitrogen through human urine plus gypsum in three split doses (T_{12}: 701.7 g plant^{-1}) and it was on par with T_{14}, T_2, T_{11}, and $T_{13.}$ Significantly lower total dry weight was recorded due to application of farm yard manure alone (T_1: 518.9 g plant^{-1}) and it was at par with recommended dose of nitrogen through human urine without gypsum (T_3) and with gypsum (T_4) in single dose, recommended dose of nitrogen through cattle urine without gypsum (T_5) and with gypsum (T_6) in single dose. Similar trend was observed at harvest of french bean, pole bean and pumpkin crops. The trend of variation in total dry matter accumulation at harvest observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

4.3 Yield and yield parameters of crops

The data pertaining to yield parameters such as number of fruits or pods plant^{-1}, fruit or pod length, fruit diameter, fresh fruit weight, mean fruit weight plant^{-1} and fruit yield (t ha^{-1}) of ashgourd, french bean, pole bean and pumpkin crops as influenced by application of human urine and cattle urine on N basis with and without gypsum are furnished in Tables 4.10a, 4.10b and 4.11.

4.3.1 Number of fruits plant^{-1}

Number of fruits plant^{-1} in case of ashgourd crop varied significantly due to application of human urine and cattle urine (Table 4.10a).

Significantly higher number of fruits per plant (2.13 plant^{-1}) was registered in treatment receiving recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}) and it was at par with T_{14}, T_2, T_{11}, and T_{13} (2.10, 2.09, 1.97 and 1.93 plant^{-1}, respectively). Significantly lower number of fruits per plant was recorded with farm yard manure alone treatment (T_1: 1.29 plant^{-1}) and in case of ashgourd crop which was on par with T_3, T_4, T_5, and T_6. Similar results were observed at harvest with

Table 4.10a: Effect of split application of human urine and cattle urine with and without gypsum on yield parameters of different crops.

Treatments	Ashgourd		French bean		Pole bean		Pumpkin	
	Number of fruits plant^{-1}	Fruit length (cm)	Number of pods plant^{-1}	Pod length (cm)	Number of pods plant^{-1}	Pod length (cm)	Number of fruits plant^{-1}	Fruit length (cm)
T_1	1.29	13.6	13.7	12.1	93.0	13.9	3.20	9.4
T_2	2.09	21.3	17.8	15.4	132.7	18.5	4.60	14.0
T_3	1.35	13.9	14.3	12.2	100.0	14.5	3.53	9.6
T_4	1.42	15.0	15.0	12.7	105.5	15.0	3.77	10.4
T_5	1.33	13.8	13.9	12.2	97.1	14.4	3.40	9.5
T_6	1.37	14.0	14.7	12.5	102.5	14.7	3.67	9.6
T_7	1.57	16.1	15.3	13.0	111.8	15.6	3.90	11.1
T_8	1.80	18.4	16.0	13.6	125.1	16.2	4.08	11.9
T_9	1.47	15.7	15.2	12.9	108.8	15.4	3.80	10.7
T_{10}	1.67	16.9	15.7	13.2	119.0	15.7	3.97	11.6
T_{11}	1.97	20.5	17.7	15.3	130.5	18.2	4.53	13.8
T_{12}	2.13	23.7	17.9	15.8	141.2	19.0	4.73	14.2
T_{13}	1.93	21.0	17.6	14.7	128.5	17.9	4.43	13.7
T_{14}	2.10	22.7	17.9	15.8	136.5	18.7	4.67	14.6
S.Em $\pm$	**0.12**	**1.70**	**13.7**	**12.1**	**6.54**	**0.76**	**0.22**	**1.27**
C.D.(P=0.05)	**0.34**	**4.95**	**17.8**	**15.4**	**19.01**	**2.20**	**0.63**	**3.70**

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

respect to number of pods per plant in french bean, pole bean and number of fruits plant^{-1} in pumpkin crop. The trend of changes in number of fruits observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

4.3.2 Fruit length (cm)

Fruit length varied significantly among the treatments in ashgourd crop (Table 4.10a). Significantly higher fruit length was registered due to application of human urine in three split doses on N basis with gypsum (T_{12}: 23.7 cm) and significantly lower fruit length was recorded in farmyard manure alone treatment (T_1: 13.6 cm) which was on par with T_3, T_4, T_5, and T_6. Similar trend of results were observed at harvest in french bean, pole bean and pumpkin crops. The trend of variation in fruit length observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

4.3.3 Fruit diameter (cm)

The mean fruit diameter recorded at harvest differed significantly among the treatments (Table 4.10b) in case ashgourd crop.

Application of human urine in three split doses with gypsum (T_{12}) recorded significantly higher fruit diameter (17.49 cm) over treatment receiving farm yard manure alone (T_1: 10.45 cm), recommended dose of nitrogen through human urine without gypsum (T_3) and with gypsum (T_4), recommended doses of nitrogen through cattle urine without gypsum (T_5) and with gypsum (T_6) in single dose during crop growth period but was found on par with other treatments in case of ashgourd. Similar results were observed at harvest of french bean, pole bean and pumpkin crops. The trend of changes in fruit diameter observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

4.3.4 Fresh weight (g fruit^{-1})

The data on fresh fruit weight as influenced by human urine and cattle urine with and without gypsum are presented in Table 4.10b.

Fresh fruit weight of ashgourd crop at harvest was significantly higher in treatment receiving recommended dose of N through human urine in three split doses plus gypsum (T_{12}: 4.51 kg fruit^{-1}) and it was on par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower fruit weight was recorded with farm yard manure alone treatment (T_1: 3.20 kg fruit^{-1}). Similar results were also observed in case of french bean, pole bean and pumpkin crops. The trend of variation in fresh fruit weight observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

4.3.5 Mean fruit weight (kg plant^{-1})

The mean fruit weight recorded at harvest varied significantly among the treatments (Table 4.10b).

Application of recommended dose of N through human urine in three split doses plus gypsum (T_{12}) recorded significantly higher mean fruit weight (9.63 kg) in case of ashgourd crop and it was significantly superior over application of farm yard manure alone (T_1: 4.12 kg), recommended dose of N through human urine in single dose without gypsum (T_3) and with gypsum (T_4), recommended dose of N through cattle urine in single dose without gypsum (T_5) and with gypsum (T_6) but it was at par with T_{14}, T_2, T_{11}, and T_{13}. Similar trend was also noticed in french bean, pole bean and pumpkin crops. The trend of variation in mean fruit weight observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

4.3.6 Fruit yield (t ha^{-1})

The data on ashgourd fruit yield ha^{-1} as influenced by human urine and cattle urine with and without gypsum are presented in Table 4.11. In general the ashgourd and

Table 4.10b: Effect of split application of human urine and cattle urine with and without gypsum on yield parameters of different crops.

Treatments	Ashgourd			French bean		Pole bean		Pumpkin		
	Fruit diameter (cm)	Fresh fruit weight (kg/fruit)	Mean fruit weight (kg/plant)	Fresh pod weight (g/pod)	Green pod weight (g/plant)	Fresh pod weight (g/pod)	Green pod weight (g/plant)	Fruit diameter (cm)	Fresh fruit weight (g/fruit)	Mean fruit weight (g/plant)
T_1	10.45	3.20	4.12	4.77	65.1	6.49	603.9	8.15	643.1	2058.1
T_2	15.88	4.09	8.54	5.79	102.9	7.88	1044.3	12.38	843.3	3879.2
T_3	11.11	3.32	4.47	4.87	69.9	6.75	674.8	8.67	653.3	2309.6
T_4	12.43	3.49	4.97	4.95	74.2	6.92	729.9	9.70	655.3	2458.5
T_5	10.78	3.24	4.29	4.79	66.8	6.65	645.3	8.41	646.4	2197.3
T_6	11.59	3.48	4.79	4.90	72.2	6.88	705.3	9.04	667.0	2454.3
T_7	12.87	3.59	5.61	5.06	77.3	7.03	786.6	10.04	774.3	3019.0
T_8	13.31	3.77	6.78	5.29	84.5	7.34	918.6	10.38	811.0	3311.3
T_9	12.39	3.51	5.28	5.00	75.9	6.98	759.2	9.67	762.9	2897.6
T_{10}	12.21	3.69	6.14	5.14	80.4	7.11	846.8	9.52	794.6	3152.5
T_{11}	14.08	4.05	7.93	5.74	101.4	7.83	1021.6	10.98	838.2	3800.8
T_{12}	17.49	4.51	9.63	5.93	106.2	8.16	1150.0	13.64	863.6	4087.7
T_{13}	15.40	3.91	7.55	5.74	100.9	7.75	997.3	12.01	832.2	3687.5
T_{14}	16.17	4.15	8.80	5.90	105.4	8.02	1095.0	12.61	849.1	3961.2
S.Em ±	**1.36**	**0.25**	**0.68**	**0.20**	**3.36**	**0.14**	**50.29**	**0.99**	**32.30**	**213.18**
C.D.(P=0.05)	**3.97**	**0.72**	**1.98**	**0.59**	**9.77**	**0.41**	**146.20**	**2.87**	**93.9**	**619.7**

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

pumpkin crop recorded high fruit yield as compare to french bean and pole bean crop. However, on conversion into equivalent yield of ashgourd, all the crops recorded comparable yields. The fruit yield of ashgourd differed significantly among the treatments. Fruit yield was significantly higher in treatment receiving recommended dose of N through human urine in three split doses plus gypsum (T_{12}: 39.2 t ha^{-1}) and it was on par with recommended dose of N through cattle urine in three splits plus gypsum (T_{14}: 38.0 t ha^{-1}), recommended dose of fertilizers (T_2: 36.7 t ha^{-1}), recommended dose of N through human urine in three splits plus without gypsum (T_{11}: 36.5 t ha^{-1}) and recommended dose of N through cattle urine plus gypsum in three split (T_{13}: 35.4 t ha^{-1}). Application of farm yard manure alone (T_1) recorded significantly lower fruit yield (19.7 t ha^{-1}) and it was at par with T_3 (22.2 t ha^{-1}), T_4 (23.6 t ha^{-1}), T_5 (21.1 t ha^{-1}) and T_6 (23.5 t ha^{-1}).

The converted yields of french bean, pole bean and pumpkin crops interms of ashgourd yield also followed the similar trend as that of growing ashgourd. The maximum converted yield of french bean, pole bean and pumpkin was observed in T_{12} treatment receiving recommended dose of N through human urine in three split doses plus gypsum as found in case of ashgourd. Similarly application of human urine/ cattle urine with or without gypsum was superior to two split application and one time application. However, in all the treatments the addition of gypsum noticeably increased the ashgourd yield as well as the converted yields of french bean, pole bean and pumpkin.

In all the crops application of human/ cattle urine in three split doses was statistically equivalent to the yield recorded by application of recommended fertilizers plus farmyard manure.

4.4 Nutrients content of crops

The nitrogen, phosphorus, potassium, calcium, magnesium and sulphur content (% basis) in fruits of ashgourd, french bean, pole bean and pumpkin crops as influenced by application of human urine and cattle urine at harvest stage are presented in Tables 4.12 to 4.14.

Table 4.11: Effect of split application of human urine and cattle urine with and without gypsum on vegetable yield (t ha^{-1}) and ashgourd equivalent yield (t ha^{-1}) for different vegetable crops.

Treatments	Ashgourd	French bean		Pole bean		Pumpkin	
	Actual yield	Actual yield	Ashgourd Equivalent yield	Actual yield	Ashgourd Equivalent yield	Actual yield	Ashgourd Equivalent yield
T_1	19.7	8.7	24.7	9.2	24.5	19.5	22.8
T_2	36.7	13.7	38.8	15.8	42.1	36.8	42.9
T_3	22.2	9.3	26.4	10.2	27.2	21.9	25.6
T_4	23.6	9.9	28.1	11.1	29.6	23.3	27.2
T_5	21.1	8.9	25.2	9.8	26.1	20.8	24.3
T_6	23.5	9.6	27.2	10.7	28.5	23.3	27.2
T_7	29.0	10.3	29.2	11.9	31.7	28.6	33.4
T_8	31.8	11.3	32.0	13.9	37.1	31.4	36.6
T_9	27.8	10.1	28.6	11.5	30.7	27.5	32.1
T_{10}	30.2	10.7	30.3	12.8	34.1	29.9	34.9
T_{11}	36.5	13.5	38.3	15.5	41.3	36.0	42.0
T_{12}	39.2	14.2	40.2	17.4	46.4	38.7	45.2
T_{13}	35.4	13.5	38.3	15.1	40.3	35.0	40.8
T_{14}	38.0	14.1	40.0	16.6	44.3	37.5	43.8
S.Em ±	**2.01**	**0.4**		**0.76**		**2.02**	
C.D.(P=0.05)	**5.8**	**1.3**		**2.22**		**5.9**	

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

4.4.1 Nitrogen content (%)

The nitrogen content in fruits of different crops as influenced by application of human urine and cattle urine are presented in Table 4.12.

Nitrogen content in ashgourd fruits differed significantly due to application of human urine and cattle urine. Significantly higher nitrogen content in ashgourd was registered in treatment with application of recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 4.09 %) which was on par with cattle urine in three split doses plus gypsum (T_{14}: 4.02 %), recommended dose of fertilizers (T_2: 3.96 %), human urine in three split doses without gypsum (T_{11}: 3.89 %) and cattle urine in three split doses without gypsum (T_{13}: 3.61, 3.03 and 3.83 %). Application of farmyard manure (FYM) alone (T_1) recorded significantly lower nitrogen content (3.24 %) and it was on par with application of human urine without gypsum (T_3: 3.37 %) and with gypsum (T_4: 3.50 %), cattle urine without gypsum (T_5: 3.44, 2.62 and 3.31 %) in single dose and with gypsum (T_6: 3.44 %).

Similar trend was observed at harvest of french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown. The trend of variation in nitrogen content observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

At harvest, application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher nitrogen content was 4.49 %, 4.01 % and 4.33 % in case of french bean, pole bean and pumpkin crops compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower nitrogen content was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 3.37 %, 3.30 % and 3.48 %, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.4.2 Phosphorus content (%)

Phosphorus content in fruit as influenced by application of human urine and cattle urine is furnished in Table 4.12.

The phosphorus content of ashgourd fruit was significantly higher in treatment with recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 0.37 %) and it was at par with T_{14}, T_2, T_{11}, and T_{13}. Phosphorus content in ashgourd fruit was significantly lower due to application of farm yard manure alone to soil (T_1: 0.23 %) in case ashgourd crop. Similar results were also observed in french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown. The trend of changes in phosphorus content observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

At harvest, application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher phosphorus content (0.36 %, 0.33 % and 0.39 % in case of french bean, pole bean and pumpkin crops) compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower phosphorus content was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 0.22 %, 0.19 % and 0.25 %, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.4.3 Potassium content (%)

Application of human urine and cattle urine significantly influenced the potassium content in fruits of four different vegetables (Table 4.12).

Potassium content in ashgourd fruit was significantly higher in treatment with recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 3.70 %) and it was significantly superior over farmyard manure alone treatment (T_1), but it was at par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower potassium content was noticed with farmyard manure alone treatment (T_1: 2.70 %) it was at par with T_3, T_4, T_5 and $T_{6.}$ Similar trend was also continued in french bean, pole bean and pumpkin crops.

Table 4.12: Nitrogen, phosphorus and potassium content (%) in fruits of different vegetable crops at harvest as influenced by split application of human urine and cattle urine with and without gypsum.

Treatments	Ashgourd			French bean			Pole bean			Pumpkin		
	N	P	K	N	P	K	N	P	K	N	P	K
T_1	3.24	0.23	2.70	3.37	0.22	2.49	3.30	0.19	1.97	3.48	0.25	3.56
T_2	3.96	0.35	3.60	4.32	0.34	3.54	3.90	0.33	2.80	4.20	0.37	4.04
T_3	3.37	0.25	3.11	3.54	0.24	2.62	3.41	0.21	2.12	3.61	0.27	3.65
T_4	3.50	0.27	3.22	3.71	0.26	2.75	3.49	0.23	2.27	3.74	0.29	3.74
T_5	3.31	0.24	3.06	3.45	0.23	2.55	3.36	0.20	2.04	3.55	0.26	3.61
T_6	3.44	0.26	3.17	3.63	0.25	2.68	3.47	0.22	2.49	3.68	0.28	3.69
T_7	3.63	0.30	3.33	3.89	0.28	2.88	3.63	0.25	2.42	3.87	0.31	3.82
T_8	3.73	0.32	3.41	4.03	0.30	3.01	3.71	0.27	2.51	3.99	0.33	3.91
T_9	3.57	0.28	3.28	3.80	0.27	2.81	3.57	0.25	2.34	3.81	0.30	3.81
T_{10}	3.70	0.31	3.38	3.97	0.30	2.94	3.68	0.27	2.49	3.94	0.33	3.86
T_{11}	3.89	0.34	3.54	4.23	0.33	3.14	3.85	0.30	2.72	4.13	0.36	4.00
T_{12}	4.09	0.37	3.70	4.49	0.36	3.33	4.01	0.33	2.95	4.33	0.39	4.13
T_{13}	3.83	0.34	3.49	4.14	0.32	3.07	3.79	0.29	2.64	4.07	0.35	3.95
T_{14}	4.02	0.36	3.65	4.40	0.35	3.27	3.95	0.32	2.87	4.26	0.38	4.08
S.Em ±	**0.12**	**0.01**	**0.15**	**0.15**	**0.016**	**0.11**	**0.10**	**0.016**	**0.14**	**0.11**	**0.017**	**0.07**
C.D.(P=0.05)	**0.35**	**0.04**	**0.43**	**0.45**	**0.046**	**0.32**	**0.29**	**0.046**	**0.40**	**0.32**	**0.050**	**0.20**

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

The trend of variation in potassium content observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

At harvest, application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher potassium content (3.33 %, 2.95 % and 4.13 % in case of french bean, pole bean and pumpkin crops) compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower potassium content was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 2.49 %, 1.97 % and 3.56 %, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.4.4 Calcium content (%)

Calcium content in ashgourd fruits differed significantly due to application of human urine and cattle urine (Table 4.13). Significantly higher calcium content in fruit was registered in treatment with recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 1.12 %) and it was on par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower calcium content was recorded with the application of farmyard manure alone (T_1) and the value was 0.70 %, in fruits and it was on par with recommended dose of nitrogen through human urine without gypsum (T_3) and with gypsum (T_4) in single dose, recommended dose of nitrogen through cattle urine without gypsum (T_5) and with gypsum (T_6) in single dose. Similar trend was observed in french bean, pole bean and pumpkin crops. The trend of variation in calcium content observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

At harvest, application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher calcium content of 1.20 %, 1.32 % and 1.32 % in case of french bean, pole bean and pumpkin crops compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower calcium content was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 0.78 %, 0.76 % and 0.90 %, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.4.5 Magnesium (%)

Magnesium content in fruits/ pods of different vegetable crops as influenced by application of human urine and cattle urine is furnished in Table 4.13.

The magnesium content in ashgourd fruits was significantly higher (0.37 %) in treatment with recommended dose of nitrogen through human urine plus gypsum in three split doses (T_{12}) and it was at par with T_{14}, T_2, T_{11}, and T_{13}. Magnesium content in fruit was significantly lower in farmyard manure alone (T_1) treatment (0.23 %). Similar trend was also recorded in french bean, pole bean and pumpkin crops. The trend of variation in magnesium content observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

At harvest, application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher magnesium content of 0.40 %, 0.51 % and 0.39 % in case of french bean, pole bean and pumpkin crops compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower magnesium content was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 0.26 %, 0.37 % and 0.25 %, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.4.6 Sulfur content (%)

Sulfur content in different vegetable crops as influenced by application of human urine and cattle urine are presented in Table 4.13.

Significantly higher sulfur content in ashgourd fruits was recorded in treatment receiving recommended dose of nitrogen through human urine plus gypsum in three split doses (T_{12}: 0.34 %) and it was on par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower sulfur content was recorded with the application of farmyard manure alone (T_1: 0.20 %) and it was at par with recommended dose of nitrogen through human urine in single dose without gypsum (T_3) and with gypsum (T_4), recommended dose of nitrogen through cattle urine in single dose without gypsum (T_5) and with gypsum (T_6). Similar trend was observed in french bean, pole bean and pumpkin crops. The trend of variation in sulfur

Table 4.13: Calcium, magnesium and sulphur content (%) in fruits of different vegetable crops at harvest as influenced by split application of human urine and cattle urine with and without gypsum.

Treatments	Ashgourd			French bean			Pole bean			Pumpkin		
	Ca	Mg	S	Ca	Mg	S	Ca	Mg	S	Ca	Mg	S
T_1	0.70	0.23	0.20	0.78	0.26	0.20	0.76	0.37	0.16	0.90	0.25	0.22
T_2	1.06	0.35	0.32	1.14	0.38	0.32	1.24	0.49	0.27	1.26	0.37	0.34
T_3	0.77	0.25	0.22	0.85	0.27	0.22	0.85	0.39	0.18	0.97	0.27	0.24
T_4	0.83	0.27	0.24	0.91	0.30	0.24	0.94	0.41	0.20	1.03	0.29	0.26
T_5	0.73	0.24	0.21	0.81	0.27	0.21	0.80	0.38	0.17	0.93	0.26	0.23
T_6	0.80	0.26	0.23	0.88	0.29	0.24	0.89	0.40	0.19	1.00	0.28	0.25
T_7	0.89	0.30	0.27	0.98	0.32	0.27	1.02	0.44	0.23	1.10	0.32	0.29
T_8	0.96	0.31	0.28	1.03	0.33	0.28	1.11	0.45	0.24	1.16	0.33	0.30
T_9	0.86	0.28	0.25	0.94	0.31	0.25	0.98	0.42	0.21	1.06	0.30	0.27
T_{10}	0.96	0.31	0.28	1.01	0.33	0.28	1.07	0.45	0.24	1.13	0.33	0.30
T_{11}	1.03	0.34	0.31	1.11	0.37	0.31	1.19	0.48	0.27	1.23	0.36	0.33
T_{12}	1.12	0.37	0.34	1.20	0.40	0.34	1.32	0.51	0.30	1.32	0.39	0.36
T_{13}	0.99	0.33	0.30	1.07	0.35	0.30	1.15	0.47	0.26	1.19	0.35	0.32
T_{14}	1.09	0.38	0.33	1.17	0.39	0.33	1.28	0.50	0.29	1.29	0.38	0.35
S.Em ±	**0.05**	**0.02**	**0.018**	**0.055**	**0.02**	**0.018**	**0.06**	**0.02**	**0.017**	**0.05**	**0.016**	**0.018**
C.D.(P=0.05)	**0.15**	**0.06**	**0.051**	**0.161**	**0.06**	**0.053**	**0.18**	**0.06**	**0.049**	**0.16**	**0.045**	**0.052**

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

content observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

At harvest, application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher sulfur content of 0.34 %, 0.30 % and 0.36 % in case of french bean, pole bean and pumpkin crops compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower sulfur content was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 0.20 %, 0.16 % and 0.22 %, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.4.7 Iron content (ppm)

Iron content in different vegetable crops as influenced by application of human urine and cattle urine are presented in Table 4.14.

Iron content in fruits of ashgourd crop differed significantly due to application of human urine and cattle urine. Significantly higher iron content in ashgourd fruits was recorded due to application of human urine in three split doses plus gypsum (T_{12}: 39.1 ppm) which was on par with cattle urine in three split doses plus gypsum (T_{14}: 38.4 ppm), recommended dose of fertilizers (T_2: 37.7 ppm), human urine in three split doses without gypsum (T_{11}: 37.0 ppm) and cattle urine in three split doses without gypsum (T_{13}: 36.4 ppm). Application of farmyard manure (FYM) alone (T_1) recorded significantly lower iron content (29.8 ppm) and it was on par with application of human urine without gypsum (T_3: 31.5 ppm) and with gypsum (T_4: 32.9 ppm), cattle urine in single dose without gypsum (T_5: 30.8 ppm) and with gypsum (T_6: 32.2 ppm).

Similar trend was observed at harvest of french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plots where ashgourd crop was grown. The trend of variation in iron content observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in same plot receiving same treatments.

At harvest, application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher iron content (49.3 ppm, 43.5 ppm, and 42.8 ppm in case of french bean, pole bean and pumpkin crops) compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower iron content was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 32.3 ppm, 27.5 ppm and 31.7 ppm, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.4.8 Manganese content (ppm)

Manganese content in different vegetable crops as influenced by application of human urine and cattle urine is presented in Table 4.14.

Application of human urine and cattle urine significantly influenced the manganese content in fruits of ashgourd crop. Manganese content in fruit of ashgourd crop was significantly higher in treatment with recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}) and value was 31.8 ppm and it was significantly superior over farmyard manure alone treatment (T_1), but it was at par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower manganese content was noticed with T_1 (19.8 ppm). Similar trend was observed in french bean, pole bean and pumpkin crops. The trend of variation in manganese content observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

At harvest, application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher manganese content of 31.1 ppm, 26.3 ppm, and 35.4 ppm in case of french bean, pole bean and pumpkin crops compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower manganese content was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 19.0 ppm, 17.3 ppm and 23.3 ppm, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.4.9 Zinc content (ppm)

Zinc content in fruits of ashgourd crop differed significantly due to application of human urine and cattle urine (Table 4.14). Significantly higher zinc content in ashgourd fruit was recorded in treatment receiving recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 27.4 ppm) and it was on par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower zinc content was recorded with the application of farmyard manure alone to soil (T_1: 19.4 ppm) and it was at par with recommended dose of nitrogen through human urine in single dose without gypsum (T_3) and with gypsum (T_4), recommended dose of nitrogen through cattle urine in single dose without gypsum (T_5) and with gypsum (T_6). Similar trend was observed in french bean, pole bean and pumpkin crops. The trend of variation in zinc content observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plot receiving same treatments.

At harvest, application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher zinc content of 36.38 ppm, 31.1 ppm, and 27.1 ppm in case of french bean, pole bean and pumpkin crops compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower zinc content was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 33.32 ppm, 19.0 ppm and 20.0 ppm, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.4.10 Copper content (ppm)

Copper content in ashgourd fruit as influenced by application of human urine and cattle urine is furnished in Table 4.14.

The copper content of fruit was significantly higher in treatment receiving recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 4.69 ppm) and it was at par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower copper content with farmyard manure alone treatment (T_1) and the value was 3.43 ppm which was on par with T_3, T_4, T_5 and T_6. Similar results were also observed in french bean, pole

Table 4.14: Iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) content (ppm) in fruits of different vegetable crops at harvest as influenced by split application of human urine and cattle urine with and without gypsum.

Treatments	Ashgourd				French bean				Pole bean				Pumpkin			
	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
T_1	29.8	19.8	19.4	3.43	32.3	19.0	33.32	4.51	27.5	17.3	19.0	4.32	31.7	23.3	20.0	3.52
T_2	37.7	30.0	26.2	4.50	46.7	30.5	34.37	5.69	41.0	24.9	29.2	5.28	41.0	33.5	26.0	4.59
T_3	31.5	21.6	20.7	3.62	34.9	20.8	25.33	4.72	29.9	18.7	20.8	4.50	33.4	25.2	21.1	3.71
T_4	32.9	23.5	21.9	3.82	37.5	22.7	27.34	4.94	32.4	20.1	22.7	4.67	35.1	27.0	22.2	3.91
T_5	30.8	20.4	20.0	3.52	33.6	19.9	24.33	4.61	28.7	18.0	19.9	4.41	32.2	24.2	20.6	3.61
T_6	32.2	22.5	21.3	3.72	36.2	21.8	26.34	4.83	31.1	19.4	21.8	4.59	34.2	26.1	21.7	3.81
T_7	34.3	25.3	23.1	4.01	40.1	25.2	29.35	5.09	34.8	21.5	24.6	4.84	36.8	28.9	23.3	4.10
T_8	35.2	27.2	24.4	4.20	41.7	26.4	31.36	5.37	37.3	22.5	26.4	5.01	38.5	31.1	24.4	4.29
T_9	33.6	24.4	22.5	3.91	38.8	23.6	28.35	5.05	33.6	20.8	23.6	4.76	35.9	27.9	22.7	4.00
T_{10}	35.0	26.3	23.8	4.11	41.4	25.5	30.36	5.27	36.1	22.2	25.5	4.93	37.7	29.8	23.8	4.20
T_{11}	37.0	29.1	25.6	4.40	45.4	28.3	33.37	5.69	39.8	24.2	28.3	5.19	40.2	32.6	25.4	4.49
T_{12}	39.1	31.8	27.4	4.69	49.3	31.1	36.38	5.97	43.5	26.3	31.1	5.45	42.8	35.4	27.1	4.78
T_{13}	36.4	28.1	24.9	4.33	44.4	27.4	32.36	5.48	38.5	23.6	27.3	5.10	39.3	31.6	24.9	4.39
T_{14}	38.4	30.9	26.8	4.59	44.6	30.1	35.38	5.80	42.2	25.6	30.1	5.36	41.9	34.4	26.5	4.68
S.Em ±	**1.24**	**1.45**	**1.73**	**0.14**	**2.54**	**1.41**	**1.61**	**0.18**	**1.71**	**1.27**	**1.44**	**0.15**	**1.25**	**1.40**	**0.86**	**0.17**
C.D.(P=0.05)	**3.59**	**4.21**	**5.02**	**0.41**	**7.37**	**4.09**	**4.68**	**0.52**	**4.98**	**3.68**	**4.18**	**0.43**	**3.65**	**4.08**	**2.50**	**0.48**

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

bean and pumpkin crops. The trend of variation in copper content observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

At harvest, application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher copper content (5.97 ppm, 5.45 ppm, and 4.78 ppm in case of french bean, pole bean and pumpkin crops) compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower copper content was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 4.51 ppm, 4.32 ppm and 3.52 ppm, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.5 Uptake of nutrients by crops

Uptake of nitrogen, phosphorus, potassium, calcium, magnesium and sulphur (kg ha^{-1}) and iron, manganese, zinc and copper (g ha^{-1}) by ashgourd, french bean, pole bean and pumpkin crops as influenced by application of human urine and cattle urine at harvest of crops are presented in Tables 4.15 to 4.17.

4.5.1 Nitrogen (N) uptake (kg ha^{-1})

Nitrogen uptake by different crops as influenced by application of human urine and cattle urine are presented in Table 4.15.

Total nitrogen uptake at harvest of ashgourd crop varied significantly among different treatments due to application of human urine and cattle urine. Significantly higher nitrogen uptake was observed due to application of human urine in three split doses plus gypsum (T_{12}:108.92 kg ha^{-1}) and it was at par with T_{14}, T_2, T_{11}, and T_{13} but significantly lower nitrogen uptake (60.33 kg ha^{-1}) was observed in farmyard manure alone treatment (T_1) and it was on par with T_3, T_4, T_5 and T_6. Similar trend was also observed in french bean, pole bean and pumpkin crops**.** The trend of variation in nitrogen uptake observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plot receiving same treatments.

Application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher nitrogen uptake at harvest and the values being 134.3 kg ha^{-1}, 148.8 kg ha^{-1}, and 162.8 kg ha^{-1} in case of french bean, pole bean and pumpkin crops compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower nitrogen uptake was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 64.6, 77.5, and 67.7 kg ha^{-1}, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.5.2 Phosphorus (P_2O_5) uptake (kg ha^{-1})

Phosphorus uptake by crops as influenced by application of human urine and cattle urine is furnished in Table 4.15.

Total phosphorus uptake by ashgourd crop differed significantly due to human urine and cattle urine application. Phosphorus uptake was significantly higher (9.88 kg ha^{-1}) in treatment with recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}) and it was at par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower (4.65 kg ha^{-1}) phosphorus uptake was recorded with application of farmyard manure alone (T_1) which was on par with recommended dose of nitrogen through human urine in single dose without gypsum (T_3) and with gypsum (T_4), recommended dose of nitrogen through cattle urine in single dose without gypsum (T_5) and with gypsum (T_6). Similar trend was observed in case of french bean, pole bean and pumpkin crops. The trend of variation in phosphorus uptake observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

Application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher phosphorus uptake at harvest (10.73 kg ha^{-1}, 11.05 kg ha^{-1}, and 16.5 kg ha^{-1} in case of french bean, pole bean and pumpkin crops) compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower phosphorus uptake was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 4.82 kg ha^{-1}, 5.25 kg ha^{-1}, and 5.7 kg ha^{-1}, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.5.3 Potassium (K_2O) uptake (kg ha^{-1})

Potassium uptake by different crops as influenced by application of human urine and cattle urine is given in Table 4.15.

Total potassium uptake by ashgourd crop was significantly influenced by human urine and cattle urine application (Table 4.15). Significantly higher potassium uptake was recorded in treatment receiving recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 101.98 kg ha^{-1}) and it was on par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower potassium uptake (64.19 kg ha^{-1}) was recorded in farmyard manure alone treatment (T_1) which was at par with T_3, T_4, T_5 and T_6. Similar trend was also observed in french bean, pole bean and pumpkin crops. The trend of variation in potassium uptake observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

Application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher potassium uptake at harvest was 117.4 kg ha^{-1}, 109.1 kg ha^{-1}, and 150.8 kg ha^{-1} in case of french bean, pole bean and pumpkin crops compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower potassium uptake was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 59.1 kg ha^{-1}, 54.2 kg ha^{-1}, and 62.0 kg ha^{-1}, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.5.4 Calcium (Ca) uptake (kg ha^{-1})

Calcium uptake by different crops as influenced by human urine and cow urine application are presented in Table 4.16.

Calcium uptake at harvest of ashgourd crop varied significantly among different treatments due to application of human urine and cattle urine. Significantly higher calcium uptake was observed in treatment with recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 27.45 kg ha^{-1}) and it was at par with T_{14}, T_2, T_{11}, and T_{13} but was found significantly superior over the treatment T_1 with

Table 4.15: Nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) uptake (kg ha^{-1}) by different vegetable crops as influenced by split application of human urine and cattle urine with and without gypsum.

Treatments	Ashgourd			French bean			Pole bean			Pumpkin		
	N	P	K	N	P	K	N	P	K	N	P	K
T_1	60.33	4.65	64.19	64.6	4.82	59.1	77.5	5.25	54.2	67.7	5.7	62.0
T_2	101.21	8.95	96.16	123.4	9.67	110.4	142.1	10.40	102.9	146.1	14.6	135.4
T_3	74.76	5.80	72.78	74.1	5.56	66.3	86.6	6.14	62.0	77.1	7.1	74.9
T_4	80.25	6.45	78.11	84.1	6.36	74.5	97.2	6.87	69.9	91.5	8.6	86.8
T_5	72.46	5.58	70.49	68.8	5.20	62.4	82.6	5.74	58.3	70.7	6.3	68.8
T_6	77.11	6.13	75.21	78.8	6.03	70.6	94.9	6.63	69.5	83.9	7.9	81.0
T_7	85.41	7.15	82.82	94.8	7.19	83.9	107.6	7.67	77.5	106.0	10.3	101.1
T_8	90.18	7.80	87.02	103.4	7.90	90.0	117.5	8.42	84.3	118.2	11.8	113.1
T_9	82.66	6.79	80.24	89.5	6.86	79.0	102.4	7.31	74.1	99.4	9.5	95.1
T_{10}	88.91	7.52	85.85	100.1	7.68	87.9	113.0	8.13	82.4	113.2	11.1	107.4
T_{11}	98.32	8.69	94.33	118.4	9.13	102.8	131.4	9.49	95.0	139.0	13.8	129.7
T_{12}	108.92	9.88	101.98	134.3	10.73	117.4	148.8	11.05	109.1	162.8	16.5	150.8
T_{13}	95.90	8.52	91.88	112.5	8.65	97.4	125.0	8.98	89.9	130.9	12.9	121.1
T_{14}	104.49	9.50	99.30	130.8	10.24	112.2	144.2	10.54	104.4	154.2	15.8	144.0
S.Em ±	**3.24**	**0.58**	**4.08**	**7.98**	**0.81**	**8.9**	**8.5**	**0.79**	**7.9**	**6.7**	**0.6**	**6.4**
C.D.(P=0.05)	**9.42**	**1.68**	**11.85**	**23.19**	**2.35**	**25.8**	**24.6**	**2.30**	**23.1**	**19.6**	**1.9**	**18.6**

Legend:

T_1	:	FYM (Farmyard manure) alone
T_2	:	Recommended dose of fertilizer + Farmyard manure
T_3	:	RDN through human urine in single dose
T_4	:	RDN through human urine in single dose + gypsum
T_5	:	RDN through cattle urine in single dose
T_6	:	RDN through cattle urine in single dose+ gypsum
T_7	:	RDN through human urine in two split doses
T_8	:	RDN through human urine in two split doses+ gypsum
T_9	:	RDN through cattle urine in two split doses
T_{10}	:	RDN through cattle urine in two split doses+ gypsum
T_{11}	:	RDN through human urine in three split doses
T_{12}	:	RDN through human urine in three split doses+ gypsum
T_{13}	:	RDN through cattle urine in three split doses
T_{14}	:	RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

farmyard alone and was par with T_3, T_4, T_5 and T_6. Lowest calcium uptake was observed in T_1 (13.28 kg ha^{-1}). Similar trend was also observed in french bean, pole bean and pumpkin crops. The trend of variation in calcium uptake observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

Application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher calcium uptake at harvest and the values being 37.13 kg ha^{-1}, 41.28 kg ha^{-1}, and 76.1 kg ha^{-1} in case of french bean, pole bean and pumpkin crops compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower calcium uptake was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 15.61 kg ha^{-1}, 17.67 kg ha^{-1}, and 43.1 kg ha^{-1}, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.5.5 Magnesium (Mg) uptake (kg ha^{-1})

Magnesium uptake by vegetable crops as influenced by application of human urine and cattle urine is presented in Table 4.16. Magnesium uptake by ashgourd crop differed significantly due to application of human urine and cattle urine (Table 4.16). Magnesium uptake was significantly higher (9.66 kg ha^{-1}) in treatment with recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}) and it was at par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower magnesium uptake was registered with application of farmyard manure alone to soil (T_1: 3.96 kg ha^{-1}) which was on par with T_3, T_4, T_5 and T_6. The similar results were also recorded in french bean, pole bean and pumpkin crops. The trend of variation in magnesium uptake observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

Application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher magnesium uptake at harvest, the values being 12.32 kg ha^{-1}, 12.80 kg ha^{-1}, and 22.87 kg ha^{-1} in case of french bean, pole bean and pumpkin crops compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower magnesium uptake was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 4.59 kg ha^{-1}, 5.31 kg ha^{-1}, and 11.43 kg ha^{-1}, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.5.6 Sulfur (S) uptake (kg ha^{-1})

Sulfur uptake by different crops as influenced by application of human urine and cattle urine are presented in Table 4.16. Sulfur uptake at harvest of ashgourd crop varied significantly among different treatments due to application of human urine and cattle urine. Significantly higher calcium uptake was observed in treatment receiving recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 9.56 kg ha^{-1}) and it was at par with T_{14}, T_2, T_{11}, and T_{13} but was found significantly superior over the treatment T_1 with FYM alone and was par with T_3, T_4, T_5 and T_6 treatments. Significantly lower calcium uptake was observed in T_1 (3.71 kg ha^{-1}). Similar trend was observed in french bean, pole bean and pumpkin crops. The trend of variation in sulfur uptake observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plot receiving same treatments.

Application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher sulfur uptake at harvest (10.87 kg ha^{-1}, 11.85 kg ha^{-1}, and 20.62 kg ha^{-1} in case of french bean, pole bean and pumpkin crops) compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower sulfur uptake was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 3.99 kg ha^{-1}, 4.88 kg ha^{-1}, and 9.71 kg ha^{-1}, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.5.7 Iron (Fe) uptake (g ha^{-1})

Iron uptake by different vegetable crops as influenced by application of human urine and cattle urine are presented in Table 4.17.

Total iron uptake at harvest of ashgourd crop varied significantly due to application of human urine and cattle urine. Significantly higher iron uptake was

Table 4.16: Calcium (Ca), magnesium (Mg) and sulphur (S) uptake (kg ha^{-1}) by different vegetable crops as influenced by split application of human urine and cattle urine with and without gypsum.

Treatments	Ashgourd			French bean			Pole bean			Pumpkin		
	Ca	Mg	S	Ca	Mg	S	Ca	Mg	S	Ca	Mg	S
T_1	13.28	3.96	3.71	15.61	4.59	3.99	17.67	5.31	4.88	43.1	11.43	9.71
T_2	25.19	8.86	8.54	33.72	10.78	9.51	38.21	11.64	10.56	71.0	20.99	18.52
T_3	16.87	5.19	4.90	17.42	5.39	4.77	20.16	6.24	5.74	47.4	12.99	11.16
T_4	18.68	5.87	5.66	20.74	6.56	5.77	23.81	7.19	6.65	52.1	14.45	12.70
T_5	16.10	4.86	4.62	16.13	5.02	4.36	19.05	5.82	5.40	45.4	12.14	10.44
T_6	17.79	5.53	5.35	19.63	6.08	5.36	23.02	7.05	6.37	50.0	13.57	12.01
T_7	20.21	6.66	6.48	23.88	7.56	7.18	27.15	8.36	7.65	56.9	16.39	14.44
T_8	21.84	7.30	7.17	26.64	8.50	7.51	30.60	9.27	8.46	61.9	17.67	15.73
T_9	19.46	6.24	6.09	22.37	7.08	6.30	25.82	7.79	7.24	54.9	15.34	13.59
T_{10}	21.62	7.01	6.84	25.81	8.21	7.29	29.56	8.85	8.15	59.7	17.07	15.17
T_{11}	24.11	8.30	8.22	31.18	10.09	9.05	35.13	10.63	9.78	68.1	19.91	17.87
T_{12}	27.45	9.66	9.56	37.13	12.23	10.87	41.28	12.80	11.85	76.1	22.87	20.62
T_{13}	23.21	7.87	7.86	29.38	9.44	8.48	32.96	10.08	9.28	65.0	18.76	17.08
T_{14}	26.16	9.22	9.13	35.00	11.47	10.26	39.37	12.06	10.98	73.5	21.82	19.58
S.Em ±	**1.48**	**0.67**	**0.60**	**2.67**	**0.96**	**0.83**	**3.61**	**1.03**	**0.93**	**4.3**	**0.60**	**0.71**
C.D.(P=0.05)	**4.31**	**1.93**	**1.75**	**7.77**	**2.79**	**2.42**	**10.48**	**2.98**	**2.71**	**12.5**	**1.75**	**2.07**

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

observed in treatment with human urine in three split doses plus gypsum (T_{12}: 171.6 g ha^{-1}) and it was at par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower iron uptake (126.3 g ha^{-1}) was observed in farmyard manure alone (T_1) treatment and it was on par with T_3, T_4, T_5 and T_6 treatments. Similar trend was observed in french bean, pole bean and pumpkin crops. The trend of variation in iron uptake observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plot receiving same treatments.

Application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher iron uptake at harvest the values being 172.0 g ha^{-1}, 185.1 g ha^{-1}, and 197.5 g ha^{-1} in case of french bean, pole bean and pumpkin crops compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower iron uptake was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 81.1 g ha^{-1}, 86.8 g ha^{-1}, and 96.9 g ha^{-1}, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.5.8 Manganese (Mn) uptake (g ha^{-1})

Manganese uptake by different vegetable crops as influenced by application of human urine and cattle urine is given in Table 4.17.

Application of human urine and cattle urine significantly influenced the manganese uptake by ashgourd (Table 4.17). Total manganese uptake at harvest of ashgourd crop varied significantly among different treatments due to application of human urine and cattle urine. Significantly higher manganese uptake was observed in treatment receiving human urine in three split doses plus gypsum (T_{12}: 159.1 g ha^{-1}) and it was at par with T_{14}, T_2, T_{11}, and T_{13} treatments. Significantly lower manganese uptake (85.2 g ha^{-1}) was observed in farmyard manure alone (T_1) and it was on par with T_3, T_4, T_5 and T_6. Similar trend was also observed in french bean, pole bean and pumpkin crops. The trend of variation in manganese uptake observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

Application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher manganese uptake at harvest and the values being 148.5 g ha^{-1}, 154.2 g ha^{-1}, and 164.6 g ha^{-1} in case of french bean, pole bean and pumpkin crops compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower manganese uptake was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 76.1 g ha^{-1}, 80.8 g ha^{-1}, and 68.6 g ha^{-1}, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.5.9 Zinc (Zn) uptake (g ha^{-1})

Zinc uptake by different crops as influenced by application of human urine and cattle urine are presented in Table 4.17.

Zinc uptake at harvest of ashgourd crop varied significantly among different treatments due to application of human urine and cattle urine. Significantly higher zinc uptake was observed in treatment receiving recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 153.5 g ha^{-1}) and it was at par with T_{14}, T_2, T_{11}, and T_{13} but was found significantly superior over the treatment T_1 which was on par with T_3, T_4, T_5 and T_6 treatments. Significantly lower zinc uptake was observed in T_1 (88.1 g ha^{-1}). Similar trend was also observed in french bean, pole bean and pumpkin crops. The trend of variation in zinc uptake observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plot receiving same treatments.

Application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher zinc uptake at harvest (151.6 g ha^{-1}, 161.5 g ha^{-1}, and 163.8 g ha^{-1} in case of french bean, pole bean and pumpkin crops) compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower zinc uptake was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 65.2 g ha^{-1}, 74.8 g ha^{-1}, and 89.7 g ha^{-1}, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.5.10 Copper (Cu) uptake (g ha^{-1})

Copper uptake by different vegetable crops as influenced by application of human urine and cattle urine is furnished in Table 4.17.

The total copper uptake by ashgourd crop differed significantly due to human urine and cattle urine application. Copper uptake was significantly higher in treatment receiving recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 60.0 g ha^{-1}) and it was at par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower copper uptake was registered with application of farmyard manure alone treatment (T_1: 33.4 g ha^{-1}) which was on par with recommended dose of nitrogen through human urine without gypsum (T_3) and with gypsum (T_4) in single dose, recommended dose of nitrogen through cattle urine in single dose without gypsum (T_5) and with gypsum (T_6). Similar trend was observed in french bean, pole bean and pumpkin crops. The trend of variation in copper uptake observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

Application of human urine in three split doses plus gypsum (T_{12}) recorded significantly higher copper uptake at harvest (51.0 g ha^{-1}, 55.4 g ha^{-1}, and 29.3 g ha^{-1} in case of french bean, pole bean and pumpkin crops) compared to other treatments but it was on par with T_{14}, T_2, T_{11} and T_{13}. Significantly lower copper uptake was recorded in french bean, pole bean and pumpkin crops in treatment receiving farmyard manure alone (T_1: 23.7 g ha^{-1}, 30.5 g ha^{-1}, and 16.8 g ha^{-1}, respectively) followed by T_3, T_4, T_5 and T_6 treatments.

4.6 Changes in chemical properties of soil as affected by repeated application of human urine and cattle urine

The data on chemical properties of soil such as soil pH, electrical conductivity, available nitrogen, phosphorus, potassium, exchangeable calcium, magnesium, sodium, available sulfur, DTPA extractable iron, manganese, zinc and copper content as

Table 4.17: Iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) uptake (g ha^{-1}) by different vegetable crops as influenced by split application of human urine and cattle urine with and without gypsum.

Treatments	Ashgourd				French bean				Pole bean				Pumpkin			
	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
T_1	126.3	85.2	88.1	33.4	81.1	76.1	65.2	23.7	86.8	80.8	74.8	30.5	96.9	68.6	89.7	16.8
T_2	166.0	147.0	142.1	55.6	156.0	137.0	133.5	45.9	172.0	144.4	142.2	50.6	180.9	147.9	150.1	27.2
T_3	141.8	99.9	97.6	37.3	92.5	84.4	70.6	27.0	100.1	89.8	75.2	33.7	110.7	81.4	99.0	18.5
T_4	144.5	112.7	103.3	41.5	105.1	94.7	83.1	31.1	113.6	99.9	88.6	37.2	125.4	95.1	109.5	20.3
T_5	135.9	91.8	93.4	36.0	86.4	80.4	66.4	25.0	93.5	85.2	70.1	32.1	102.9	74.7	94.1	17.5
T_6	140.8	106.2	99.9	39.6	97.8	89.4	77.7	28.7	110.5	96.7	82.8	35.5	118.1	88.0	104.8	19.3
T_7	150.1	120.7	111.7	45.2	117.7	105.8	94.7	34.7	127.9	109.6	100.9	41.0	140.7	108.6	120.4	22.2
T_8	154.9	129.4	118.4	48.8	130.5	116.2	108.6	38.2	141.4	121.7	115.7	44.3	155.3	124.0	131.8	23.7
T_9	145.8	116.6	108.3	43.1	112.0	99.7	90.5	32.6	120.8	105.2	96.4	39.1	133.1	102.4	108.1	21.3
T_{10}	152.4	124.5	114.8	47.0	125.1	110.7	103.6	36.9	135.9	115.8	110.4	42.8	148.4	117.4	126.3	23.1
T_{11}	163.0	141.3	130.2	53.4	149.9	130.6	127.1	44.0	159.5	136.5	135.4	49.2	172.9	140.0	145.4	26.2
T_{12}	171.6	159.1	153.5	60.0	172.0	148.5	151.6	51.0	185.1	154.2	161.5	55.4	197.5	164.6	163.8	29.3
T_{13}	159.4	145.9	126.4	51.3	141.9	123.9	119.7	41.6	151.0	129.0	127.5	46.9	165.4	131.8	138.4	25.2
T_{14}	168.6	152.5	143.9	58.3	159.6	142.5	143.4	48.9	177.2	148.6	152.3	53.0	190.0	123.9	157.6	28.4
S.Em ±	**4.30**	**5.0**	**9.2**	**3.3**	**10.3**	**5.0**	**11.3**	**3.6**	**8.8**	**8.8**	**11.8**	**3.5**	**11.2**	**12.2**	**4.4**	**0.7**
C.D.(P=0.05)	**12.49**	**14.5**	**26.6**	**9.5**	**30.1**	**14.6**	**32.9**	**10.3**	**25.6**	**25.5**	**34.3**	**10.2**	**32.7**	**35.4**	**12.9**	**2.2**

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

influenced by application of human urine and cattle urine are presented in Tables 4.18 to 4.21.

4.6.1 Soil pH

The data on soil pH after harvest of ashgourd crop as influenced by application of human urine and cattle urine is presented in Table 4.18.

The soil pH differed significantly at harvest of ashgourd crop due to application of human urine and cattle urine on N basis and balance P and K applied through fertilizers. Significantly higher soil pH was observed at harvest of ashgourd with application of human urine in three split doses without gypsum (T_{11}:7.55) which was on par with cattle urine in three split doses without gypsum (T_{13}: 7.47), recommended dose of nitrogen through application of human urine in two split doses without gypsum (T_7: 7.35) and application of cattle urine in two split doses without gypsum (T_9). Application of farmyard manure (FYM) alone (T_1) recorded significantly lower soil pH (6.78) and it was on par with application of human urine in three split doses plus gypsum (T_{12}), application of cattle urine in three split doses plus gypsum (T_{14}) and recommended dose of nitrogen through fertilizer plus farmyard manure (T_2). Similar trend was observed at harvest of french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop grown. The trend of variation in soil pH observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

The slight increase in soil pH by application of human/ cattle urine was restricted to treatment without gypsum application was observed. Whereas, the original soil pH was not much affected in treatments with gypsum. Therefore, a slight increase in pH was observed at harvest of french bean (7.81), pole bean (8.04) and pumpkin (7.94) crops with treatment involving application of human urine in three split doses without gypsum (T_{11}) compared to other treatments.

4.6.2 Electrical conductivity (dS m^{-1})

The electrical conductivity of soil at harvest of ashgourd crop as influenced by application of human urine and cattle urine is presented in Table 4.18.

The electrical conductivity of soil at harvest of ashgourd crop differed significantly due to application of human urine and cattle urine on N basis with balance P_2O_5 and K_2O applied through fertilizers.

Significantly higher electrical conductivity of soil was observed at harvest with application of human urine in three split doses without gypsum (T_{11}: 0.27 dS m^{-1}) which was on par with cattle urine in three split doses without gypsum (T_{13}: 0.26 dS m^{-1}), recommended dose of nitrogen through human urine in two split doses without gypsum (T_7: 0.26 dS m^{-1}) and application of cattle urine in two split doses without gypsum (T_9). Application of farmyard manure (FYM) alone (T_1) recorded significantly lower electrical conductivity of soil (0.26 dS m^{-1}) and it was on par with application of human urine in three split doses with gypsum (T_{12}), application of cattle urine in three split doses with gypsum (T_{14}) and recommended dose of nitrogen through fertilizer plus farmyard manure (T_2). Similar trend was observed at harvest of french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown. The trend of variation in electrical conductivity of soil observed at harvest of ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in same plot receiving same treatments.

The slight increase in electrical conductivity of soil by application of human/ cattle urine was restricted to treatment with and without gypsum application. Whereas, the electrical conductivity of soil was not much affected in treatments with gypsum. Therefore a slight increase in electrical conductivity of soil was observed at harvest of french bean (0.35 dS m^{-1}), pole bean (0.44 dS m^{-1}) and pumpkin (0.48 dS m^{-1}) crops with treatment involving application of human urine in three split doses without gypsum (T_{11}) compared to other treatments.

Table 4.18: Effect of split application of human urine and cattle urine with and without gypsum on pH and electrical conductivity (dS m^{-1}) of soil at harvest of different vegetable crops.

Treatments	Ashgourd		French bean		Pole bean		Pumpkin	
	pH	EC	pH	EC	pH	EC	pH	EC
T_1	6.78	0.21	7.02	0.23	6.78	0.32	7.13	0.39
T_2	6.83	0.21	7.08	0.24	6.86	0.33	7.14	0.39
T_3	7.19	0.25	7.44	0.33	7.54	0.40	7.57	0.45
T_4	6.87	0.22	7.11	0.26	7.04	0.35	7.23	0.41
T_5	7.19	0.24	7.44	0.32	7.46	0.39	7.57	0.44
T_6	6.84	0.22	7.08	0.25	6.95	0.34	7.20	0.40
T_7	7.35	0.26	7.61	0.34	7.72	0.42	7.73	0.46
T_8	7.03	0.23	7.28	0.29	7.27	0.37	7.40	0.42
T_9	7.24	0.25	7.50	0.34	7.63	0.41	7.62	0.46
T_{10}	6.92	0.23	7.17	0.28	7.12	0.36	7.29	0.41
T_{11}	7.55	0.27	7.81	0.35	8.04	0.44	7.94	0.48
T_{12}	7.13	0.24	7.38	0.31	7.37	0.39	7.50	0.44
T_{13}	7.47	0.26	7.74	0.34	8.06	0.43	7.87	0.47
T_{14}	7.06	0.24	7.31	0.30	7.29	0.38	7.43	0.43
S.Em ±	**0.15**	**0.01**	**0.15**	**0.01**	**0.17**	**0.01**	**0.15**	**0.01**
C.D.(P=0.05)	**0.43**	**0.02**	**0.45**	**0.04**	**0.49**	**0.04**	**0.45**	**0.03**

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

4.6.3 Available nitrogen (kg ha^{-1}) in soil

Application of human urine and cattle urine had significant influence on the available N content of soil at harvest of ashgourd crop (Table 4.19).

The available nitrogen content of soil at harvest of ashgourd crop varied significantly due to application of human urine and cattle urine and was highest in treatment receiving recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 290.9 kg ha^{-1}) and it was on par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower available nitrogen was recorded with application of farm yard manure alone treatment (T_1: 269.6 kg ha^{-1}) which was on par with T_3, T_4, T_5 and T_6. Similar results were observed at harvest of french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown. The trend of variation in available nitrogen content of soil recorded at harvest of ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

A slight increase in available nitrogen content of soil was recorded after the harvest of french bean, pole bean and pumpkin crops (291.3, 298.2 and 302.2 kg ha^{-1}, respectively) due to continuous application of human urine in three split doses plus gypsum (T_{12}) followed by T_{14}, T_2, T_{11} and T_{13}. Lower available nitrogen content of soil was recorded in treatment receiving farmyard manure alone (T_1) followed by T_3, T_4, T_5 and T_6 treatments.

4.6.4 Available phosphorus (kg ha^{-1}) in soil

The available phosphorus content of soil differed significantly among the treatments at harvest (Table 4.19) of ashgourd crop and was significantly higher in treatment with recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 31.4 kg ha^{-1}) and it was on par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower available phosphorus was recorded with application of farmyard manure alone (T_1: 25.3 kg ha^{-1}) at harvest. Similar results were noticed at harvest of french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown. The trend of variation in available phosphorus content of soil recorded at harvest of ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments

The marginal variation in available phosphorus content of soil was recorded after the harvest of french bean, pole bean and pumpkin crops (32.29, 31.8 and 31.9 kg ha^{-1}, respectively) due to continuous application of human urine in three split doses plus gypsum (T_{12}) followed by T_{14}, T_2, T_{11} and T_{13}. Lower available phosphorus content of soil was recorded in treatment receiving farmyard manure alone (T_1) followed by T_3, T_4, T_5 and T_6 treatments.

4.6.5 Available potassium (kg ha^{-1}) in soil

Human urine and cattle urine application significantly influenced the available potassium content of soil at harvest of ashgourd crop (Table 4.19). The available potassium content of soil was significantly higher in treatment with recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 319.9 kg ha^{-1}) and it was on par with T_{14}, T_2, T_{11}, and T_{13} but was found significantly superior over other treatments (T_1, T_3, T_4, T_5 and T_6). Significantly lower available potassium was recorded in farmyard manure alone treatment (T_1: 274.0 kg ha^{-1}) and it was at par with recommended dose of nitrogen through human urine in single dose without gypsum (T_3) and with gypsum (T_4), recommended dose of nitrogen through cattle urine in single dose without gypsum (T_5) and with gypsum (T_6). Similar trend was observed at harvest of french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown. The trend of changes in available potassium content of soil recorded at harvest of ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments

Continuous application of human urine in three split doses plus gypsum (T_{12}) recorded marginal increase in available potassium content of soil after the harvest of

Table 4.19: Effect of split application of human urine and cattle urine with and without gypsum on available nitrogen, phosphorus and potassium (kg ha^{-1}) content of soil at harvest of vegetable crops

Treatments	Ashgourd			French bean			Pole bean			Pumpkin		
	Avail. N	Avail. P_2O_5	Avail. K_2O	Avail. N	Avail. P_2O_5	Avail. K_2O	Avail. N	Avail. P_2O_5	Avail. K_2O	Avail. N	Avail. P_2O_5	Avail. K_2O
T_1	269.6	25.3	274.0	266.5	24.45	265.9	256.2	23.3	259.0	261.0	22.9	257.2
T_2	288.0	30.1	316.2	285.5	30.62	314.5	289.9	30.0	314.3	292.5	30.0	317.9
T_3	272.7	26.7	277.4	270.6	26.24	283.4	264.1	25.2	278.0	265.6	24.9	274.9
T_4	273.4	27.4	284.3	270.6	27.19	293.1	267.5	26.3	288.6	269.3	26.0	286.2
T_5	271.8	26.3	275.7	267.8	25.78	279.0	259.7	24.8	273.2	264.4	24.4	269.8
T_6	273.2	27.1	280.6	275.4	26.71	288.2	265.2	25.8	283.3	266.6	25.5	280.5
T_7	275.1	28.2	291.0	277.0	28.17	296.5	273.2	27.4	299.2	276.2	27.2	297.5
T_8	276.8	28.9	303.1	278.0	29.10	297.0	274.1	28.4	306.2	281.8	28.2	299.4
T_9	273.6	27.8	284.9	276.1	27.70	293.6	268.8	26.8	294.0	271.5	26.6	292.0
T_{10}	275.4	28.6	297.8	277.0	28.65	296.9	273.9	27.9	304.4	279.4	27.7	298.8
T_{11}	283.6	29.4	313.8	282.7	29.72	306.5	281.1	29.1	313.7	289.0	29.0	315.5
T_{12}	290.9	31.4	319.9	291.3	32.29	324.2	298.2	31.8	323.7	302.2	31.9	330.9
T_{13}	281.0	29.3	310.2	281.0	29.63	300.3	280.1	28.9	309.9	286.7	28.9	314.3
T_{14}	287.0	30.5	317.8	288.4	31.09	321.0	294.0	30.6	320.3	295.6	30.6	324.3
S.Em ±	**3.0**	**0.8**	**5.7**	**3.0**	**0.97**	**8.8**	**7.9**	**1.0**	**5.8**	**5.3**	**1.1**	**10.4**
C.D.(P=0.05)	**8.8**	**2.2**	**16.5**	**8.6**	**2.83**	**25.7**	**23.0**	**3.0**	**16.8**	**15.5**	**3.1**	**30.3**

Legend:

T_1	:	FYM (Farmyard manure) alone
T_2	:	Recommended dose of fertilizer + Farmyard manure
T_3	:	RDN through human urine in single dose
T_4	:	RDN through human urine in single dose + gypsum
T_5	:	RDN through cattle urine in single dose
T_6	:	RDN through cattle urine in single dose+ gypsum
T_7	:	RDN through human urine in two split doses
T_8	:	RDN through human urine in two split doses+ gypsum
T_9	:	RDN through cattle urine in two split doses
T_{10}	:	RDN through cattle urine in two split doses+ gypsum
T_{11}	:	RDN through human urine in three split doses
T_{12}	:	RDN through human urine in three split doses+ gypsum
T_{13}	:	RDN through cattle urine in three split doses
T_{14}	:	RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

french bean, pole bean and pumpkin crops (324.2, 323.7 and 330.9 kg ha^{-1}, respectively) followed by T_{14}, T_2, T_{11} and T_{13}. Lower available potassium content of soil was recorded in treatment receiving farmyard manure alone (T_1) followed by T_3, T_4, T_5 and T_6 treatments.

4.6.6 Exchangeable calcium (cmol (p^+) kg^{-1}) in soil

The data on exchangeable calcium content of soil showed significant differences at harvest of ashgourd crop (Table 4.20).

Significantly higher exchangeable calcium in soil was recorded in treatment receiving recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 4.87 cmol (p^+) kg^{-1}) and it was on par with T_{14}, T_8, $T_{10,}$ T_4 and T_6. Significantly lower exchangeable calcium in soil was recorded in farmyard manure alone treatment (T_1: 3.38 cmol (p^+) kg^{-1}) and it was at par with recommended dose of nitrogen through cattle urine in single dose without gypsum (T_5) and recommended dose of nitrogen through human urine in single dose without gypsum (T_3), recommended dose of nitrogen through cattle urine in two split doses without gypsum (T_9) and recommended dose of nitrogen through human urine in two split doses without gypsum (T_7). Similar trend was observed at harvest of french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown. The trend of variation in exchangeable calcium content of soil recorded at harvest of ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments

The marginal variation in exchangeable calcium content of soil was recorded after the harvest of french bean, pole bean and pumpkin crops (5.85, 5.35 and 5.36 cmol (p+) kg^{-1}, respectively) due to continuous application of human urine in three split doses plus gypsum (T_{12}) followed by T_{14}, T_2, T_{11} and T_{13}. Lower exchangeable calcium content of soil was recorded in treatment receiving farmyard manure alone (T_1) followed by T_3, T_4, T_5 and T_6 treatments.

4.6.7 Exchangeable magnesium (cmol (p^+) kg^{-1}) in soil

The exchangeable magnesium content of soil after the harvest of ashgourd crop was significantly influenced by application of human urine and cattle urine (Table 4.20).

Significantly higher exchangeable magnesium was recorded in treatment receiving recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 2.83 cmol (p^+) kg^{-1}) and it was on par with T_{14}, T_8, T_{10}, T_4 and T_6. Significantly lower exchangeable magnesium in soil was recorded in farmyard manure alone treatment (T_1: 1.99 cmol (p^+) kg^{-1}) and it was at par with recommended dose of nitrogen through cattle urine in single dose without gypsum (T_5) and recommended dose of nitrogen through human urine in single dose without gypsum (T_3), recommended dose of nitrogen through cattle urine in two split doses without gypsum (T_9) and recommended dose of nitrogen through human urine in two split doses without gypsum (T_7). Similar trend was observed at harvest of french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown. The trend of changes in exchangeable magnesium content of soil recorded at harvest of ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments

Continuous application of human urine in three split doses plus gypsum (T_{12}) recorded slight increase in the exchangeable magnesium content of soil after the harvest of french bean, pole bean and pumpkin crops (2.69, 3.25 and 3.52 cmol (p^+) kg^{-1}, respectively) followed by T_{14}, T_2, T_{11} and T_{13}. Lowest exchangeable magnesium content of soil was recorded in treatment receiving farmyard manure alone (T_1) followed by T_3, T_4, T_5 and T_6 treatments.

4.6.8 Exchangeable sodium (cmol (p^+) kg^{-1}) in soil

The exchangeable sodium content of soil after harvest of ashgourd crop differed significant due to application of human urine and cattle urine (Table 4.20).

Significantly higher exchangeable sodium was recorded in treatment receiving recommended dose of nitrogen through human urine in three split doses without gypsum (T_{11}: 0.26 cmol (p^+) kg^{-1}) and it was on par with T_{13}, T_7, T_9, T_3 and $T_{5.}$ Significantly lower exchangeable sodium was recorded in farmyard manure alone treatment (T_1: 0.15 cmol (p^+) kg^{-1}) and it was at par with treatment which was received recommended dose of fertilizer (T_2), recommended dose of nitrogen through human urine in single dose with gypsum (T_4) and recommended dose of nitrogen through cattle urine in single dose with gypsum (T_6), , recommended dose of nitrogen through human urine in two split dose with gypsum (T_8) and recommended dose of nitrogen through cattle urine in two split dose with gypsum (T_{10}). Similar trend was observed at harvest of french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown.

Repeated application of human urine in three split doses without gypsum (T_{11}: 0.29, 0.37 and 0.51 cmol (p^+) kg^{-1}, respectively) recorded slight increase in the exchangeable sodium content of soil after the harvest of french bean, pole bean and pumpkin crops followed by T_{13}, T_7, $T_{9,}$ T_3 and T_5. Lower exchangeable sodium content of soil was recorded in treatment receiving farmyard manure alone (T_1) followed by T_2, T_4, $T_{6,}$ T_8 and T_{10} treatments.

4.6.9 Available sulfur (kg ha^{-1})

Data on available sulfur content of soil after the harvest of ashgourd crop as influenced by application of human urine and cattle urine is given in Table 4.20.

Available sulfur content of soil at harvest of ashgourd crop was highest in treatment receiving recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 14.0 kg ha^{-1}) and it was on par with T_{14}, T_8, $T_{10,}$ T_4 and T_6. Significantly lower available sulfur in soil was recorded in farmyard manure alone treatment (T_1: 9.9 kg ha^{-1}) and it was at par with recommended dose of nitrogen through cattle urine in single dose without gypsum (T_5) and recommended dose of nitrogen through human urine in single dose without gypsum (T_3), recommended dose of nitrogen through cattle urine in two split doses without gypsum (T_9) and recommended dose of

Table 4.20: Effect of split application of human urine and cattle urine with and without gypsum on exchangeable calcium, magnesium, sodium [cmol (p+) kg^{-1}] and available sulphur (kg ha^{-1}) content of soil after harvest of vegetable crops

Treatments	Ashgourd				French bean				Pole bean				Pumpkin			
	Exch. Ca	Exch. Mg	Exch. Na	Avial. S	Exch. Ca	Exch. Mg	Exch. Na	Avial. S	Exch. Ca	Exch. Mg	Exch. Na	Avial. S	Exch. Ca	Exch. Mg	Exch . Na	Avial. S
T_1	3.38	1.99	0.15	9.9	3.88	2.22	0.21	10.05	3.07	2.09	0.20	10.28	3.18	2.38	0.32	18.4
T_2	4.18	2.44	0.16	12.1	4.95	2.47	0.22	12.43	4.30	2.72	0.22	13.33	4.37	3.00	0.34	22.8
T_3	3.59	2.12	0.23	10.7	4.10	2.29	0.27	11.52	3.39	2.55	0.32	10.89	4.04	2.55	0.45	19.6
T_4	4.42	2.57	0.16	12.8	5.25	2.55	0.23	13.13	4.68	2.90	0.23	14.28	4.70	3.18	0.35	24.1
T_5	3.47	2.06	0.22	10.2	4.04	2.26	0.26	10.31	3.21	2.19	0.31	10.41	3.36	2.47	0.44	18.9
T_6	4.30	2.51	0.17	12.4	5.10	2.51	0.23	12.77	4.47	2.81	0.24	13.84	4.53	3.09	0.36	23.4
T_7	3.82	2.25	0.25	11.1	4.48	2.37	0.28	11.34	3.74	2.44	0.35	11.86	3.84	2.73	0.48	20.8
T_8	4.62	2.70	0.19	13.4	5.55	2.62	0.24	13.73	4.97	3.07	0.27	15.29	5.03	3.35	0.39	25.2
T_9	3.69	2.19	0.23	10.8	4.34	2.33	0.27	10.96	3.54	2.36	0.33	11.38	3.69	2.64	0.46	20.1
T_{10}	4.52	2.63	0.18	13.1	5.40	2.58	0.24	13.44	4.82	2.98	0.26	14.78	4.85	3.26	0.38	24.6
T_{11}	4.03	2.38	0.26	11.8	4.80	2.44	0.29	11.99	4.07	2.63	0.37	12.84	4.20	2.91	0.51	22.0
T_{12}	4.87	2.83	0.21	14.0	5.85	2.69	0.25	14.47	5.35	3.25	0.29	16.25	5.36	3.52	0.42	26.5
T_{13}	3.95	2.32	0.25	11.5	4.65	2.40	0.28	11.72	3.93	2.54	0.36	12.36	4.03	2.82	0.50	21.5
T_{14}	4.78	2.76	0.20	13.7	5.72	2.65	0.25	14.19	5.20	3.17	0.28	15.77	5.21	3.44	0.41	26.0
S.Em ±	**0.22**	**0.12**	**0.02**	**0.6**	**0.27**	**0.24**	**0.01**	**0.61**	**0.33**	**0.16**	**0.02**	**0.89**	**0.29**	**0.16**	**0.03**	**1.2**
C.D.(P=0.05)	**0.63**	**0.34**	**0.05**	**1.6**	**0.78**	**0.71**	**0.03**	**1.78**	**0.96**	**0.48**	**0.07**	**2.59**	**0.85**	**0.46**	**0.08**	**3.4**

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

nitrogen through human urine in two split doses without gypsum (T_7). Similar trend was observed at harvest of french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown. The trend of variation in available sulfur content of soil recorded at harvest of ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

A slight increase in available sulfur content of soil was recorded after the harvest of french bean, pole bean and pumpkin crops (14.47, 16.25 and 26.5 kg ha^{-1}, respectively) due to continuous application of human urine in three split doses plus gypsum (T_{12}) followed by T_{14}, T_2, T_{11} and T_{13}. Lower available sulfur content of soil was recorded in treatment receiving farmyard manure alone (T_1) followed by T_3, T_4, T_5 and T_6 treatments.

4.6.10 DTPA Extractable iron (mg kg^{-1})

Application of human urine and cattle urine had significant influence on DTPA extractable iron content of soil at harvest of ashgourd crop (Table 4.21).

The DTPA extractable iron content of soil after the harvest of ashgourd crop varied significantly due to human urine and cattle urine and was highest in treatment receiving recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 15.48 mg kg^{-1}) and it was on par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower DTPA extractable iron was noticed with application of farm yard manure alone i.e., T_1 (11.89 mg kg^{-1}) which was on par with T_3, T_4, T_5 and T_6. Similar results were observed in french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown. The trend of variation in DTPA extractable iron content of soil recorded at harvest of ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

Continuous application of human urine in three split doses plus gypsum (T_{12}) recorded slight variation in the DTPA extractable iron content of soil after the harvest of french bean, pole bean and pumpkin crops (21.79, 19.66 and 19.82 mg kg^{-1}, respectively) followed by T_{14}, T_2, T_{11} and T_{13}. Lower DTPA extractable iron content of soil was recorded in treatment receiving farmyard manure alone (T_1) followed by T_3, T_4, T_5 and T_6 treatments.

4.6.11 DTPA Extractable manganese (mg kg^{-1})

Human urine and cattle urine application significantly influenced the DTPA extractable manganese at harvest of ashgourd crop (Table 4.21). DTPA extractable manganese was significantly higher in treatment with recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 10.44 mg kg^{-1}) and it was on par with T_{14}, T_2, T_{11}, and T_{13} but was found significantly superior over other treatments (T_1, T_3, T_4, T_5 and T_6). Significantly lower DTPA extractable manganese content in soil was recorded in farmyard manure alone treatment (T_1: 8.15 mg kg^{-1}) and it was at par with treatment receiving recommended dose of nitrogen through human urine in single dose without gypsum (T_3) and with gypsum (T_4), recommended dose of nitrogen through cattle urine in single dose without gypsum (T_5) and with gypsum (T_6). Similar trend was observed at harvest of french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown. The trend of changes in DTPA extractable manganese content of soil recorded at harvest of ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plot receiving same treatments.

A slight increase in DTPA extractable manganese content of soil was recorded after the harvest of french bean, pole bean and pumpkin crops (13.18, 14.21 and 16.51 mg kg^{-1}, respectively) due to continuous application of human urine in three split doses plus gypsum (T_{12}) followed by T_{14}, T_2, T_{11} and T_{13}. Lower DTPA extractable manganese content of soil was recorded in treatment receiving farmyard manure alone (T_1) followed by T_3, T_4, T_5 and T_6 treatments.

4.6.12 DTPA Extractable Zinc (mg kg^{-1})

DTPA extractable zinc in soil differed significantly among the treatments after harvest of ashgourd crop. DTPA extractable zinc content of soil was significantly higher in treatment receiving recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 2.11 mg kg^{-1}) and it was on par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower DTPA extractable zinc in soil was recorded with application of farmyard manure alone (T_1: 1.16 mg kg^{-1}) at harvest which was at par with T_3, T_4, T_5 and T_6. Similar results were noticed at harvest of french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown (Table 4.21). The trend of changes in DTPA extractable zinc content of soil recorded at harvest of ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in same plot receiving same treatments.

Repeated application of human urine in three split doses plus gypsum (T_{12}: 1.94, 2.38 and 2.67 mg kg^{-1}, respectively) recorded slight increase in the DTPA extractable zinc content of soil after the harvest of french bean, pole bean and pumpkin crops followed by T_{14}, T_2, T_{11} and T_{13}. Lower DTPA extractable zinc content of soil was recorded in treatment receiving farmyard manure alone (T_1) followed by T_3, T_4, T_5 and T_6 treatments.

4.6.13 DTPA Extractable copper (mg kg^{-1})

Application of human urine and cattle urine had significant influence on DTPA extractable copper content of soil at harvest of ashgourd crop (Table 4.21).

The DTPA extractable copper content of soil varied significantly due to human urine and cattle urine application and was highest in treatment receiving recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}) at harvest of ashgourd crop (1.99 mg kg^{-1}) and it was on par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower DTPA extractable copper was noticed with application of farm yard manure alone i.e., T_1 (1.32 mg kg^{-1}) which was on par with T_3, T_4, T_5 and T_6. Similar results were

Table 4.21: Effect of split application of human urine and cattle urine with and without gypsum on DTPA extractable micronutrients ($mg\ kg^{-1}$) content of soil at harvest of different vegetable crops

Treatments	Ashgourd				French bean				Pole bean				Pumpkin			
	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
T_1	11.89	8.15	1.16	1.32	13.25	8.97	1.41	1.15	13.11	9.59	1.47	1.43	14.96	9.68	1.56	1.40
T_2	14.94	10.13	1.97	1.88	21.79	12.50	1.87	1.86	18.75	13.50	2.20	1.72	19.09	15.31	2.51	1.95
T_3	12.44	8.75	1.30	1.42	14.03	9.46	1.49	1.28	14.32	10.30	1.49	1.48	15.71	10.45	1.72	1.49
T_4	13.00	9.06	1.43	1.53	15.45	10.13	1.56	1.40	15.25	11.02	1.66	1.53	16.46	11.56	1.88	1.59
T_5	12.16	8.60	1.21	1.37	13.43	9.12	1.44	1.21	13.59	9.94	1.49	1.43	15.34	9.89	1.63	1.44
T_6	12.72	8.90	1.36	1.47	14.75	11.13	1.51	1.34	14.83	10.66	1.57	1.51	16.10	11.00	1.78	1.54
T_7	13.55	9.36	1.58	1.62	16.84	10.82	1.65	1.53	16.44	11.72	1.80	1.58	17.21	12.56	2.07	1.70
T_8	13.97	9.59	1.68	1.73	17.97	11.23	1.72	1.66	17.37	12.43	1.93	1.63	17.90	13.42	2.18	1.79
T_9	13.27	9.22	1.51	1.58	16.21	10.48	1.60	1.47	15.99	11.35	1.74	1.56	16.84	12.12	1.96	1.65
T_{10}	13.83	9.52	1.65	1.71	17.61	11.15	1.69	1.60	16.92	12.08	1.90	1.61	17.59	13.21	2.15	1.75
T_{11}	14.65	9.99	1.88	1.83	19.73	12.17	1.80	1.79	18.27	13.13	2.15	1.69	18.71	14.96	2.43	1.90
T_{12}	15.48	10.44	2.11	1.99	21.79	13.18	1.94	1.99	19.66	14.21	2.38	1.77	19.82	16.51	2.67	2.05
T_{13}	14.38	9.83	1.79	1.78	18.85	11.82	1.77	1.73	17.80	12.78	2.05	1.67	18.34	14.28	2.32	1.84
T_{14}	15.21	10.29	2.13	1.93	21.35	12.84	1.89	1.92	19.21	13.85	2.33	1.74	19.45	16.17	2.59	1.99
S.Em ±	**0.54**	**0.26**	**0.13**	**0.08**	**1.00**	**0.61**	**0.06**	**0.10**	**0.63**	**0.60**	**0.08**	**0.05**	**0.64**	**0.70**	**0.13**	**0.07**
C.D.(P=0.05)	**1.58**	**0.76**	**0.39**	**0.23**	**2.90**	**1.76**	**0.18**	**0.29**	**1.82**	**1.76**	**0.24**	**0.14**	**1.85**	**2.05**	**0.37**	**0.21**

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

observed after harvest of french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in same plots after harvest of ashgourd crop. The trend of changes in DTPA extractable copper content of soil recorded at harvest of ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

The continuous application of human urine in three split doses plus gypsum (T_{12}) recorded slight variation in the DTPA extractable copper content of soil after the harvest of french bean, pole bean and pumpkin crops (1.99, 1.77 and 2.67 mg kg^{-1}, respectively) followed by T_{14}, T_2, T_{11} and T_{13}. Lower DTPA extractable copper content of soil was recorded in treatment receiving farmyard manure alone (T_1) followed by T_3, T_4, T_5 and T_6 treatments.

4.7 Soil microbial population

Soil microbial population as influenced by application of human urine and cattle urine to vegetable crops are presented in Tables 4.22a and 4.22b.

4.7.1 Soil fungi (CFUx10^4 g^{-1})

The population of soil fungi differed significantly due to application of human urine and cattle urine to ashgourd crop (Table 4.22a). The fungal population was significantly higher in treatment with recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 5.92 CFUx10^4 g^{-1}) and was on par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower soil fungal population was recorded with application of farmyard manure alone (T_1: 4.56 CFUx10^4 g^{-1}) it was on par with T_3, T_4, T_5 and T_6 during ashgourd crop.

Similar trend was continued after harvest of french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown (Tables 4.22a and 4.22b). The trend of variation in population of soil fungi recorded at harvest of ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

A slight increase in population of soil fungi was recorded after the harvest of french bean, pole bean and pumpkin crops (6.45, 7.04 and 7.26 CFUx10^4 g^{-1}, respectively) due to continuous application of human urine in three split doses plus gypsum (T_{12}) followed by T_{14}, T_2, T_{11} and T_{13}. Lowest soil fungi population was recorded in treatment receiving farmyard manure alone (T_1) followed by T_3, T_4, T_5 and T_6 treatments.

4.7.2 Soil bacteria (CFUx10^7 g^{-1})

The soil bacterial population varied significantly among the treatments after harvest of ashgourd crop due to application of human urine and cattle urine on N basis (Table 4.22a and 4.22b). Application of recommended dose of nitrogen through human urine in three split doses plus gypsum recorded significantly higher (T_{12}: 8.24 CFUx10^7 g^{-1}) number of soil bacterial population and was on par with T_{14}, T_2, T_{11}, and T_{13} but was significantly superior over rest of treatments. Significantly lower bacterial population was recorded with farmyard manure alone (T_1: 6.69 CFUx10^7 g^{-1}) and it was on par with T_3, T_4, T_5 and T_6. Similar trend was continued in french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown. The trend of changes in population of soil bacteria recorded at harvest of ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plot receiving same treatments.

The continuous application of human urine in three split doses plus gypsum (T_{12}) recorded a slight increase in the population of soil bacteria after the harvest of french bean, pole bean and pumpkin crops (8.23, 8.97 and 9.15 CFUx10^7 g^{-1}, respectively) followed by T_{14}, T_2, T_{11} and T_{13}. Lowest population of soil bacteria was recorded in treatment receiving farmyard manure alone (T_1) followed by T_3, T_4, T_5 and T_6 treatments.

4.7.3 Soil actinomycetes (CFUx10^3 g^{-1})

The soil actinomycetes population differed significantly due to supply of nitrogen through human urine and cattle urine to ashgourd crop (Table 4.22a and 4.22b).

Significantly higher soil actinomycetes population was observed in treatment receiving recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 5.26 CFUx10^3 g^{-1}) which was significantly superior over $T_{1,}$ T_3, T_4, T_5 and T_6 but was on par with T_{14}, T_2, T_{11}, and T_{13}. Similar trend was observed after the harvest of french bean, pole bean and pumpkin crops. The trend of variation in population of soil actinomycetes recorded at harvest of ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plot receiving same treatments.

A slight increase in population of soil actinomycetes was recorded after the harvest of french bean, pole bean and pumpkin crops (5.73, 6.02 and 6.32 CFUx10^3 g^{-1}, respectively) due to continuous application of human urine in three split doses plus gypsum (T_{12}) followed by T_{14}, T_2, T_{11} and T_{13}. Lowest soil actinomycetes population was recorded in treatment receiving farmyard manure alone (T_1) followed by T_3, T_4, T_5 and T_6 treatments.

4.7.4 N- fixers (CFU x 10^3 g^{-1})

There were significant differences among the treatments with respect to population of soil N-fixers in soil at harvest of ashgourd crop. Significantly higher population of N-fixers was recorded in treatment receiving recommended dose of nitrogen through human urine plus gypsum in three split doses (T_{12}: 4.32 CFUx10^3 g^{-1}) and it was at par with T_{14}, T_2, T_{11}, and T_{13}. Significantly lower number of N-fixers population was recorded with treatment receiving recommended dose nitrogen through farmyard manure (T_1: 3.28 CFUx10^3 g^{-1}) which was on par with T_3, T_4, T_5 and T_6. Similar trend was continued after harvest of french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown (Tables 4.22a and 4.22b). The trend of changes in population of soil N-fixers recorded at harvest of ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

The repeated application of human urine in three split doses plus gypsum recorded slightly increase in the population of soil N-fixers after the harvest of french bean, pole bean and pumpkin crops (T_{12}: 4.73, 5.16 and 5.62 CFUx10^3 g^{-1}, respectively) followed by T_{14}, T_2, T_{11} and T_{13}. Lowest population of soil N-fixers was recorded in treatment receiving farmyard manure alone (T_1) followed by T_3, T_4, T_5 and T_6 treatments.

4.7.5 P- Solublizers (CFU x 10^3 g^{-1})

Application of nitrogen through human urine and cattle urine showed significantly influenced the P-solublizer population in soil after harvest of ashgourd crop (Table 4.22a). Recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}) registered significantly higher P-solublizer population (3.30 CFUx10^3 g^{-1}) at harvest and was at par with T_{14}, T_2, T_{11}, and T_{13}. Application of farmyard manure alone treatment recorded lowest value (T_1: 2.30 CFUx10^3 g^{-1}). The same trend was continued after harvest of french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown (Table 4.22a and 4.22b). The trend of variation in population of soil P-solublizer recorded at harvest of ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plot receiving same treatments.

A slight increase in population of soil P-solublizer was recorded after the harvest of french bean, pole bean and pumpkin crops (3.93, 4.12 and 4.33 CFUx10^3 g^{-1}, respectively) due to continuous application of human urine in three split doses plus gypsum (T_{12}) followed by T_{14}, T_2, T_{11} and T_{13}. Lowest soil P-solublizer population was recorded in treatment receiving farmyard manure alone (T_1) followed by T_3, T_4, T_5 and T_6 treatments.

Table 4.22a: The population of different groups of microorganisms in soil after harvest of vegetables crops as influenced by split application of human urine and cattle urine with and without gypsum.

Treatments	Ashgourd					French bean				
	Fungi (CFUx10^4 g^{-1} soil)	Bacteria (CFUx10^7 g^{-1} soil)	A (CFUx10^3 g^{-1} soil)	N- fixers (CFUx10^3 g^{-1} soil)	P-S (CFUx10^3 g^{-1}soil)	Fungi (CFUx10^4 g^{-1} soil)	Bacteria (CFUx10^7 g^{-1} soil)	A (CFUx10^3 g^{-1} soil)	N- fixers (CFUx10^3 g^{-1} soil)	P-S (CFUx10^3 g^{-1}soil)
T_1	4.56	6.69	3.10	3.28	2.30	4.97	6.34	3.38	2.89	2.74
T_2	5.59	7.79	5.02	4.16	3.18	6.10	7.77	5.47	4.52	3.78
T_3	4.72	6.76	3.36	3.31	2.27	5.14	6.56	3.66	3.02	2.71
T_4	4.72	7.17	3.49	3.23	2.37	5.14	6.56	3.81	3.14	2.82
T_5	4.64	6.67	3.11	3.29	2.40	5.06	6.45	3.39	2.86	2.86
T_6	4.33	7.15	3.39	3.28	2.37	4.72	6.02	3.69	3.05	2.82
T_7	4.93	7.19	3.83	3.30	2.47	5.37	6.85	4.18	3.45	2.94
T_8	4.85	7.27	4.23	3.43	2.61	5.29	6.75	4.61	3.81	3.10
T_9	4.81	7.07	3.63	3.39	2.46	5.24	6.68	3.96	3.27	2.93
T_{10}	4.93	7.17	4.00	3.26	2.51	5.38	6.86	4.36	3.60	2.99
T_{11}	5.37	7.66	4.90	4.08	3.12	5.86	7.47	5.34	4.41	3.71
T_{12}	5.92	8.24	5.26	4.32	3.30	6.45	8.23	5.73	4.73	3.93
T_{13}	5.28	7.55	4.90	4.00	3.06	5.76	7.34	5.34	4.41	3.64
T_{14}	5.79	7.95	5.17	4.24	3.24	6.31	8.04	5.63	4.65	3.86
S.Em ±	**0.31**	**0.27**	**0.33**	**0.25**	**0.22**	**0.32**	**0.39**	**0.35**	**0.26**	**0.25**
C.D.(P=0.05)	**0.90**	**0.79**	**0.96**	**0.73**	**0.65**	**0.94**	**1.15**	**1.01**	**0.76**	**0.72**

Legend:

T_1	:	FYM (Farmyard manure) alone	T_8	:	RDN through human urine in two split doses+ gypsum
T_2	:	Recommended dose of fertilizer + Farmyard manure	T_9	:	RDN through cattle urine in two split doses
T_3	:	RDN through human urine in single dose	T_{10}	:	RDN through cattle urine in two split doses+ gypsum
T_4	:	RDN through human urine in single dose + gypsum	T_{11}	:	RDN through human urine in three split doses
T_5	:	RDN through cattle urine in single dose	T_{12}	:	RDN through human urine in three split doses+ gypsum
T_6	:	RDN through cattle urine in single dose+ gypsum	T_{13}	:	RDN through cattle urine in three split doses
T_7	:	RDN through human urine in two split doses	T_{14}	:	RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen; **A-** Actinomycetes**: PS-** P-Solubilizers

Table 4.22b: The population of different groups of microorganisms in soil after harvest of vegetables crops as influenced by split application of human urine and cattle urine with and without gypsum.

Treatments	Pole bean					Pumpkin				
	Fungi (CFUx10^4 g^{-1} soil)	Bacteria (CFUx10^7 g^{-1} soil)	A (CFUx10^3 g^{-1} soil)	N- fixers (CFUx10^3 g^{-1} soil)	P-S (CFUx10^3 g^{-1}soil)	Fungi (CFUx10^4 g^{-1} soil)	Bacteria (CFUx10^7 g^{-1} soil)	A (CFUx10^3 g^{-1} soil)	N- fixers (CFUx10^3 g^{-1} soil)	P-S (CFUx10^3 g^{-1}soil)
T_1	5.43	6.91	3.55	3.04	2.87	5.59	7.05	3.73	3.31	3.02
T_2	6.66	8.47	5.75	4.92	3.97	6.86	8.64	6.03	5.37	4.17
T_3	5.62	7.15	3.85	3.30	2.84	5.79	7.29	4.04	3.59	2.98
T_4	5.62	7.15	4.00	3.43	2.96	5.79	7.29	4.20	3.74	3.11
T_5	5.52	7.03	3.56	3.05	3.00	5.69	7.17	3.73	3.32	3.15
T_6	5.16	6.57	3.88	3.32	2.96	5.31	6.70	4.07	3.62	3.11
T_7	5.86	7.46	4.39	3.76	3.08	6.04	7.61	4.61	4.10	3.24
T_8	5.78	7.35	4.85	4.15	3.26	5.95	7.50	5.09	4.53	3.42
T_9	5.72	7.28	4.16	3.56	3.07	5.89	7.43	4.37	3.89	3.23
T_{10}	5.87	7.47	4.58	3.92	3.14	6.05	7.62	4.81	4.28	3.30
T_{11}	6.39	8.14	5.61	4.81	3.90	6.59	8.30	5.89	5.24	4.09
T_{12}	7.04	8.97	6.02	5.16	4.12	7.26	9.15	6.32	5.62	4.33
T_{13}	6.28	8.00	5.61	4.81	3.82	6.47	8.16	5.89	5.24	4.01
T_{14}	6.89	8.77	5.91	5.07	4.05	7.09	8.94	6.21	5.52	4.25
S.Em ±	**0.34**	**0.40**	**0.33**	**0.23**	**0.24**	**0.29**	**0.43**	**0.30**	**0.22**	**0.28**
C.D.(P=0.05)	**0.98**	**1.16**	**0.95**	**0.68**	**0.70**	**0.85**	**1.25**	**0.87**	**0.64**	**0.82**

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen; A- Actinomycetes**: PS-** P-Solubilizers

Table 4.23a: Nitrogen balance (kg ha^{-1}) in soil as influenced by split application of human urine and cattle urine with and without gypsum after harvest of vegetable crops

Treatments	Ashgourd							French bean						
	IAN (1)	N- FYM/F/ HU/CU (2)	TN 3(1+2)	C U 4	E B 5(3-4)	A B (6)	G/L 7(6-5)	IAN (1)	N- FYM/F/ HU/CU (2)	TN 3(1+2)	CU 4	EB 5(3-4)	AB (6)	G/L 7(6-5)
T_1	285.5	63.7	349.2	60.3	288.9	269.6	-19.3	269.6	115.8	385.4	64.6	320.8	266.5	-54.4
T_2	285.5	86.6	372.1	101.2	270.9	288.0	17.1	288.0	141.8	429.8	123.4	306.4	285.5	-20.8
T_3	285.5	106.3	391.8	74.8	317.0	272.7	-44.3	272.7	175.5	448.2	74.1	374.1	270.6	-103.5
T_4	285.5	106.3	391.8	80.3	311.5	273.4	-38.2	273.4	175.5	448.9	84.1	364.8	270.6	-94.2
T_5	285.5	106.3	391.8	72.5	319.3	271.8	-47.5	271.8	175.5	447.3	68.8	378.5	267.8	-110.7
T_6	285.5	106.3	391.8	77.1	314.7	273.2	-41.4	273.2	175.5	448.7	78.8	369.9	275.4	-94.5
T_7	285.5	106.3	391.8	85.4	306.4	275.1	-31.3	275.1	175.5	450.6	94.8	355.8	277.0	-78.8
T_8	285.5	106.3	391.8	90.2	301.6	276.8	-24.8	276.8	175.5	452.3	103.4	348.9	278.0	-70.9
T_9	285.5	106.3	391.8	82.7	309.1	273.6	-35.5	273.6	175.5	449.1	89.5	359.6	276.1	-83.5
T_{10}	285.5	106.3	391.8	88.9	302.9	275.4	-27.5	275.4	175.5	450.9	100.1	350.8	277.0	-73.8
T_{11}	285.5	106.3	391.8	98.3	293.4	283.6	-9.8	283.6	175.5	459.1	118.4	340.7	282.7	-58.0
T_{12}	285.5	106.3	391.8	108.9	282.8	290.9	8.1	290.9	175.5	466.4	134.3	332.1	291.3	-40.8
T_{13}	285.5	106.3	391.8	95.9	295.9	281.0	-14.9	281.0	175.5	456.5	112.5	344.0	281.0	-63.0
T_{14}	285.5	106.3	391.8	104.5	287.3	287.0	-0.3	287.0	175.5	462.5	130.8	331.7	288.4	-43.3

Note: **IAN -** Initial available nitrogen **N -** Nitrogen added through **FYM**, Fertilizer (**F**), Human urine (**HU**) and Cattle urine (**CU**)
TN - Total available nitrogen **CU -** Crop uptake **EB -** Expected balance **AB** - Actual balance **G/L** - Net gain (+) / net loss (-)

T_1- FYM (Farmyard manure) alone
T_2- Recommended dose of fertilizer + Farmyard manure
T_3- RDN through human urine in single dose
T_4- RDN through human urine in single dose + gypsum
T_5- RDN through cattle urine in single dose
T_6- RDN through cattle urine in single dose+ gypsum
T_7- RDN through human urine in two split doses
T_8- RDN through human urine in two split doses+ gypsum
T_9- RDN through cattle urine in two split doses
T_{10}- RDN through cattle urine in two split doses+ gypsum
T_{11}- RDN through human urine in three split doses
T_{12}- RDN through human urine in three split doses+ gypsum
T_{13}- RDN through cattle urine in three split doses
T_{14}- RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

Table 4.23b: Nitrogen balance (kg ha^{-1}) in soil as influenced by split application of human urine and cattle urine with and without gypsum after harvest of vegetable crops

Treatments	Pole bean							Pumpkin						
	IAN (1)	N- FYM/F/ HU/CU (2)	TN 3(1+2)	CU 4	EB 5(3-4)	AB (6)	G/L 7(6-5)	IAN (1)	N- FYM/F/ HU/CU (2)	TN 3(1+2)	CU 4	EB 5(3-4)	AB (6)	G/L 7(6-5)
T_1	266.5	131.6	398.1	77.5	320.6	256.2	-64.4	256.2	191.2	447.3	67.7	379.6	261.0	-118.6
T_2	285.5	158.6	444.2	142.1	302.1	289.9	-12.2	289.9	206.9	496.8	146.1	350.7	292.5	-58.1
T_3	270.6	175.5	446.1	86.6	359.5	264.1	-95.4	264.1	212.5	476.6	77.1	399.6	265.6	-133.9
T_4	270.6	175.5	446.1	97.2	348.9	267.5	-81.4	267.5	212.5	480.0	91.5	388.5	269.3	-119.2
T_5	267.8	175.5	443.3	82.6	360.7	259.7	-101.0	259.7	212.5	472.2	70.7	401.5	264.4	-137.1
T_6	275.4	175.5	450.9	94.9	356.0	265.2	-90.8	265.2	212.5	477.7	83.9	393.8	266.6	-127.2
T_7	277.0	175.5	452.5	107.6	344.9	273.2	-71.7	273.2	212.5	485.7	106.0	379.7	276.2	-103.5
T_8	278.0	175.5	453.5	117.5	336.0	274.1	-61.9	274.1	212.5	486.6	118.2	368.4	281.8	-86.7
T_9	276.1	175.5	451.6	102.4	349.2	268.8	-80.4	268.8	212.5	481.3	99.4	381.9	271.5	-110.4
T_{10}	277.0	175.5	452.5	113.0	339.5	273.9	-65.6	273.9	212.5	486.4	113.2	373.2	279.4	-93.8
T_{11}	282.7	175.5	458.2	131.4	326.8	281.1	-45.7	281.1	212.5	493.6	139.0	354.6	289.0	-65.6
T_{12}	291.3	175.5	466.8	148.8	318.0	298.2	-19.8	298.2	212.5	510.7	162.8	347.9	302.2	-45.7
T_{13}	281.0	175.5	456.5	125.0	331.5	280.1	-51.4	280.1	212.5	492.6	130.9	361.7	286.7	-75.0
T_{14}	288.4	175.5	463.9	144.2	319.7	294.0	-25.7	294.0	212.5	506.5	154.2	352.3	295.6	-56.7

Note: **IAN -**Initial available nitrogen **N -** Nitrogen added through **FYM**, Fertilizer (**F**), Human urine (**HU**) and Cattle urine (**CU**)
TN - Total available nitrogen **CU -** Crop uptake **EB -** Expected balance **AB -** Actual balance **G/L** - Net gain (+) / net loss (-)

T_1- FYM (Farmyard manure) alone
T_2- Recommended dose of fertilizer + Farmyard manure
T_3- RDN through human urine in single dose
T_4- RDN through human urine in single dose + gypsum
T_5- RDN through cattle urine in single dose
T_6- RDN through cattle urine in single dose+ gypsum
T_7- RDN through human urine in two split doses
T_8- RDN through human urine in two split doses+ gypsum
T_9- RDN through cattle urine in two split doses
T_{10}- RDN through cattle urine in two split doses+ gypsum
T_{11}- RDN through human urine in three split doses
T_{12}- RDN through human urine in three split doses+ gypsum
T_{13}- RDN through cattle urine in three split doses
T_{14}- RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

Table 4.24a: Phosphorus balance (kg ha^{-1}) in soil as influenced by split application of human urine and cattle urine with and without gypsum after harvest of vegetable crops

Treatments	Ashgourd							French bean						
	IAN (1)	N- FYM/F/ HU/CU (2)	TN 3(1+2)	CU 4	EB 5(3-4)	AB (6)	G/L 7(6-5)	IAN (1)	N- FYM/F/ HU/CU (2)	TN 3(1+2)	CU 4	EB 5(3-4)	AB (6)	G/L 7(6-5)
T_1	27.6	28.3	56.0	4.7	51.3	25.3	-26.0	25.3	51.5	76.8	4.8	72.0	24.5	-47.5
T_2	27.6	65.0	92.6	9.0	83.7	30.1	-53.6	30.1	133	163.1	9.7	153.4	30.6	-122.8
T_3	27.6	75.0	102.6	5.8	96.8	26.7	-70.1	26.7	150	176.7	5.6	171.1	26.2	-144.9
T_4	27.6	75.0	102.6	6.5	96.2	27.4	-68.7	27.4	150	177.4	6.4	171.1	27.2	-143.9
T_5	27.6	75.0	102.6	5.6	97.1	26.3	-70.7	26.3	150	176.3	5.2	171.1	25.8	-145.4
T_6	27.6	75.0	102.6	6.1	96.5	27.1	-69.4	27.1	150	177.1	6.0	171.0	26.7	-144.3
T_7	27.6	75.0	102.6	7.2	95.5	28.2	-67.3	28.2	150	178.2	7.2	171.0	28.2	-142.8
T_8	27.6	75.0	102.6	7.8	94.8	28.9	-65.9	28.9	150	178.9	7.9	171.0	29.1	-141.9
T_9	27.6	75.0	102.6	6.8	95.8	27.8	-68.0	27.8	150	177.8	6.9	171.0	27.7	-143.3
T_{10}	27.6	75.0	102.6	7.5	95.1	28.6	-66.5	28.6	150	178.6	7.7	170.9	28.7	-142.2
T_{11}	27.6	75.0	102.6	8.7	93.9	29.4	-64.5	29.4	150	179.4	9.1	170.3	29.7	-140.6
T_{12}	27.6	75.0	102.6	9.9	92.8	31.4	-61.4	31.4	150	181.4	10.7	170.7	32.3	-138.4
T_{13}	27.6	75.0	102.6	8.5	94.1	29.3	-64.8	29.3	150	179.3	8.7	170.7	29.6	-141.1
T_{14}	27.6	75.0	102.6	9.5	93.1	30.5	-62.7	30.5	150	180.5	10.2	170.2	31.1	-139.2

Note: **IAN -** Initial available nitrogen **N -** Nitrogen added through **FYM**, Fertilizer (**F**), Human urine (**HU**) and Cattle urine (**CU**)
TN - Total available nitrogen **CU -** Crop uptake **EB -** Expected balance **AB -** Actual balance **G/L -** Net gain (+) / net loss (-)

T_1- FYM (Farmyard manure) alone
T_2- Recommended dose of fertilizer + Farmyard manure
T_3- RDN through human urine in single dose
T_4- RDN through human urine in single dose + gypsum
T_5- RDN through cattle urine in single dose
T_6- RDN through cattle urine in single dose+ gypsum
T_7- RDN through human urine in two split doses
T_8- RDN through human urine in two split doses+ gypsum
T_9- RDN through cattle urine in two split doses
T_{10}- RDN through cattle urine in two split doses+ gypsum
T_{11}- RDN through human urine in three split doses
T_{12}- RDN through human urine in three split doses+ gypsum
T_{13}- RDN through cattle urine in three split doses
T_{14}- RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

Table 4.24b: Phosphorus balance (kg ha^{-1}) in soil as influenced by split application of human urine and cattle urine with and without gypsum after harvest of vegetable crops

Treatments	Pole bean							Pumpkin						
	IAN (1)	N- FYM/F/ HU/CU (2)	TN 3(1+2)	CU 4	EB 5(3-4)	AB (6)	G/L 7(6-5)	IAN (1)	N- FYM/F/ HU/CU (2)	TN 3(1+2)	CU 4	EB 5(3-4)	AB (6)	G/L 7(6-5)
T_1	24.5	58.5	83.0	5.3	77.7	23.3	-54.4	23.3	75.5	98.8	5.7	93.1	22.9	-70.2
T_2	30.6	137.5	168.1	10.4	157.7	30.0	-127.7	30.0	137.5	167.5	14.6	152.9	30.0	-122.9
T_3	26.2	150.0	176.2	6.1	170.1	25.2	-144.9	25.2	150.0	175.2	7.1	168.1	24.9	-143.2
T_4	27.2	150.0	177.2	6.9	170.3	26.3	-144.0	26.3	150.0	176.3	8.7	167.6	26.0	-141.6
T_5	25.8	150.0	175.8	5.7	170.0	24.8	-145.3	24.8	150.0	174.8	6.3	168.4	24.4	-144.0
T_6	26.7	150.0	176.7	6.6	170.1	25.8	-144.3	25.8	150.0	175.8	7.9	167.9	25.5	-142.4
T_7	28.2	150.0	178.2	7.7	170.5	27.4	-143.1	27.4	150.0	177.4	10.3	167.1	27.2	-139.9
T_8	29.1	150.0	179.1	8.4	170.7	28.4	-142.3	28.4	150.0	178.4	11.8	166.6	28.2	-138.3
T_9	27.7	150.0	177.7	7.3	170.4	26.8	-143.5	26.8	150.0	176.8	9.5	167.4	26.6	-140.7
T_{10}	28.7	150.0	178.7	8.1	170.5	27.9	-142.6	27.9	150.0	177.9	11.1	166.8	27.7	-139.0
T_{11}	29.7	150.0	179.7	9.5	170.2	29.1	-141.2	29.1	150.0	179.1	13.8	165.2	29.0	-136.2
T_{12}	32.3	150.0	182.3	11.1	171.2	31.8	-139.4	31.8	150.0	181.8	16.5	165.3	31.9	-133.4
T_{13}	29.6	150.0	179.6	9.0	170.6	28.9	-141.7	28.9	150.0	178.9	12.9	166.0	28.9	-137.2
T_{14}	31.1	150.0	181.1	10.5	170.5	30.6	-140.0	30.6	150.0	180.6	15.8	164.7	30.6	-134.2

Note: **IAN -** Initial available nitrogen   **N -** Nitrogen added through **FYM**, Fertilizer (**F**), Human urine (**HU**) and Cattle urine (**CU**)
TN - Total available nitrogen   **CU -** Crop uptake   **EB -** Expected balance   **AB -** Actual balance   **G/L -** Net gain (+) / net loss (-)

T_1- FYM (Farmyard manure) alone
T_2- Recommended dose of fertilizer + Farmyard manure
T_3- RDN through human urine in single dose
T_4- RDN through human urine in single dose + gypsum
T_5- RDN through cattle urine in single dose
T_6- RDN through cattle urine in single dose+ gypsum
T_7- RDN through human urine in two split doses
T_8- RDN through human urine in two split doses+ gypsum
T_9- RDN through cattle urine in two split doses
T_{10}- RDN through cattle urine in two split doses+ gypsum
T_{11}- RDN through human urine in three split doses
T_{12}- RDN through human urine in three split doses+ gypsum
T_{13}- RDN through cattle urine in three split doses
T_{14}- RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

Table 4.25a: Potassium balance (kg ha^{-1}) in soil as influenced by split application of human urine and cattle urine with and without gypsum after harvest of vegetable crops

Treatments	Ashgourd							French bean						
	IAN (1)	N- FYM/F/ HU/CU (2)	TN 3(1+2)	CU 4	EB 5(3-4)	AB (6)	G/L 7(6-5)	IAN (1)	N- FYM/F/ HU/CU (2)	TN 3(1+2)	CU 4	EB 5(3-4)	AB (6)	G/L 7(6-5)
T_1	312.25	49.6	361.8	64.2	297.6	274.0	-23.6	274.0	90.1	364.1	59.1	305.0	265.9	-39.1
T_2	312.25	56.3	368.5	96.2	272.3	316.2	43.8	316.2	132.8	448.9	110.4	338.5	314.5	-24.0
T_3	312.25	30.0	342.3	72.8	269.5	277.4	8.0	277.4	162.5	439.9	66.3	373.6	283.4	-90.2
T_4	312.25	30.0	342.3	78.1	264.1	284.3	20.2	284.3	162.5	446.8	74.5	372.3	293.1	-79.2
T_5	312.25	32.0	344.3	70.5	273.8	275.7	1.9	275.7	162.5	438.2	62.4	375.8	279.0	-96.8
T_6	312.25	32.0	344.3	75.2	269.0	280.6	11.6	280.6	162.5	443.1	70.6	372.5	288.2	-84.3
T_7	312.25	30.0	342.3	82.8	259.4	291.0	31.5	291.0	162.5	453.5	83.9	369.6	296.5	-73.0
T_8	312.25	30.0	342.3	87.0	255.2	303.1	47.9	303.1	162.5	465.6	90.0	375.6	297.0	-78.6
T_9	312.25	32.0	344.3	80.2	264.0	284.9	20.9	284.9	162.5	447.4	79.0	368.4	293.6	-74.8
T_{10}	312.25	32.0	344.3	85.9	258.4	297.8	39.4	297.8	162.5	460.3	87.9	372.4	296.9	-75.5
T_{11}	312.25	30.0	342.3	94.3	247.9	313.8	65.9	313.8	162.5	476.3	102.8	373.5	306.5	-67.1
T_{12}	312.25	30.0	342.3	102.0	240.3	319.9	79.6	319.9	162.5	482.4	117.4	365.0	324.2	-40.8
T_{13}	312.25	32.0	344.3	91.9	252.4	310.2	57.8	310.2	162.5	472.7	97.4	375.3	300.3	-75.0
T_{14}	312.25	32.0	344.3	99.3	245.0	317.8	72.8	317.8	162.5	480.3	112.2	368.1	321.0	-47.1

Note: **IAN -** Initial available nitrogen **N -** Nitrogen added through **FYM**, Fertilizer (**F**), Human urine (**HU**) and Cattle urine (**CU**)
TN - Total available nitrogen **CU -** Crop uptake **EB -** Expected balance **AB** - Actual balance **G/L -** Net gain (+) / net loss (-)

T_1- FYM (Farmyard manure) alone
T_2- Recommended dose of fertilizer + Farmyard manure
T_3- RDN through human urine in single dose
T_4- RDN through human urine in single dose + gypsum
T_5- RDN through cattle urine in single dose
T_6- RDN through cattle urine in single dose+ gypsum
T_7- RDN through human urine in two split doses
T_8- RDN through human urine in two split doses+ gypsum
T_9- RDN through cattle urine in two split doses
T_{10}- RDN through cattle urine in two split doses+ gypsum
T_{11}- RDN through human urine in three split doses
T_{12}- RDN through human urine in three split doses+ gypsum
T_{13}- RDN through cattle urine in three split doses
T_{14}- RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

Table 4.25b: Potassium balance (kg ha^{-1}) in soil as influenced by split application of human urine and cattle urine with and without gypsum after harvest of vegetable crops

Treatments	Pole bean							Pumpkin						
	IAN (1)	N- FYM/F/ HU/CU (2)	TN 3(1+2)	CU 4	EB 5(3-4)	AB (6)	G/L 7(6-5)	IAN (1)	N- FYM/F/ HU/CU (2)	TN 3(1+2)	CU 4	EB 5(3-4)	AB (6)	G/L 7(6-5)
T_1	265.9	102.4	368.3	54.2	314.1	259.0	-55.1	259.0	89.7	348.6	62.0	286.6	257.2	-29.5
T_2	314.5	140.6	455.1	102.9	352.2	314.3	-37.9	314.3	92.5	406.8	135.4	271.4	317.9	46.4
T_3	283.4	162.5	445.9	62.0	383.9	278.0	-105.9	278.0	127.5	405.5	74.9	330.6	274.9	-55.7
T_4	293.1	162.5	455.6	69.9	385.7	288.6	-97.1	288.6	127.5	416.1	86.8	329.3	286.2	-43.1
T_5	279.0	162.5	441.5	58.3	383.2	273.2	-110.0	273.2	127.5	400.7	68.8	331.9	269.8	-62.1
T_6	288.2	162.5	450.7	69.5	381.2	283.3	-98.0	283.3	127.5	410.8	81.0	329.8	280.5	-49.2
T_7	296.5	162.5	459.0	77.5	381.5	299.2	-82.3	299.2	127.5	426.7	101.1	325.6	297.5	-28.1
T_8	297.0	162.5	459.5	84.3	375.2	306.2	-69.0	306.2	127.5	433.7	113.1	320.6	299.4	-21.2
T_9	293.6	162.5	456.1	74.1	382.0	294.0	-88.0	294.0	127.5	421.5	95.1	326.4	292.0	-34.4
T_{10}	296.9	162.5	459.4	82.4	377.0	304.4	-72.6	304.4	127.5	431.9	107.4	324.5	298.8	-25.7
T_{11}	306.5	162.5	469.0	95.0	374.0	313.7	-60.3	313.7	127.5	441.2	129.7	311.5	315.5	4.1
T_{12}	324.2	162.5	486.7	109.1	377.6	323.7	-54.0	323.7	127.5	451.2	150.8	300.4	330.9	30.6
T_{13}	300.3	162.5	462.8	89.9	372.9	309.9	-63.0	309.9	127.5	437.4	121.1	316.3	314.3	-2.0
T_{14}	321.0	162.5	483.5	104.4	379.1	320.3	-58.8	320.3	127.5	447.8	144.0	303.8	324.3	20.5

Note: **IAN -** Initial available nitrogen **N -** Nitrogen added through **FYM**, Fertilizer (**F**), Human urine (**HU**) and Cattle urine (**CU**)
TN - Total available nitrogen **CU -** Crop uptake **EB -** Expected balance **AB -** Actual balance **G/L** - Net gain (+) / net loss (-)

T_1- FYM (Farmyard manure) alone
T_2- Recommended dose of fertilizer + Farmyard manure
T_3- RDN through human urine in single dose
T_4- RDN through human urine in single dose + gypsum
T_5- RDN through cattle urine in single dose
T_6- RDN through cattle urine in single dose+ gypsum
T_7- RDN through human urine in two split doses
T_8- RDN through human urine in two split doses+ gypsum
T_9- RDN through cattle urine in two split doses
T_{10}- RDN through cattle urine in two split doses+ gypsum
T_{11}- RDN through human urine in three split doses
T_{12}- RDN through human urine in three split doses+ gypsum
T_{13}- RDN through cattle urine in three split doses
T_{14}- RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown (Table 4.24a and 4.24b).

4.8.3 Potassium balance in soil

The potassium balance in soil as influenced by application of human urine and cattle urine after the harvest vegetable crops is given in Table 4.25a and 4.25b.

The initial available potassium in soil was 312.2 kg ha^{-1} (Table 4.42a). Maximum crop uptake of potassium from the soil was noticed in treatment receiving recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 102.0 kg ha^{-1}) which was followed by recommended dose of nitrogen through cattle urine in three split dose plus gypsum (T_{14}: 99.3 kg ha^{-1}) and the lowest was recorded in treatment receiving recommended dose of nitrogen through farmyard manure alone (T_1: 64.2 kg ha^{-1}). The actual balance was higher (319.9 kg ha^{-1}) with recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}) and the net positive balance was also high in the same treatment. Similar trend was also observed in pumpkin crop (Table 4.46b). Whereas, in case of french bean and pole bean crops the net negative balance was higher with recommended dose of nitrogen through cattle urine in single dose plus without gypsum (T_5).

4.9 Economics

Data on economics of cultivation of different vegetable crops (ashgourd, french bean, pole bean and pumpkin) as influenced by application of human urine and cattle urine is furnished in Tables 4.26a and 4.26b.

The highest cost of cultivation (Rs. 29,456.0, 44,388.0, 41,603.0 and 45,613.0 ha^{-1}, respectively for growing ashgourd, french bean, pole bean and pumpkin crops) was recorded with the application of nitrogen through farmyard manure alone to soil (T_1) while it was least (Rs. 23,412.0, 36,870.0, 34,440.0 and 33,844.0 ha^{-1}, respectively for ashgourd, french bean, pole bean and pumpkin crops) in treatment receiving recommended dose of nitrogen through fertilizer plus farmyard manure (T_2).

Table 4.26a: Economics of cultivation of different vegetables as influenced by split application of human and cattle urine with and without gypsum.

Treatments	Ashgourd				French bean			
	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit cost ratio	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit cost ratio
T_1	29456	59229.4	29773.0	2.01	44338	77000	32662	1.74
T_2	23412	110220.8	86808.8	4.71	36870	120000	83130	3.25
T_3	24617	66466.2	41849.6	2.70	38085	81000	42915	2.13
T_4	24961	70750.4	45789.7	2.83	38519	84000	45481	2.18
T_5	25225	63235.5	38010.5	2.51	38831	78000	39169	2.01
T_6	25638	70631.4	44993.6	2.75	39352	81000	41648	2.06
T_7	24617	86881.5	62264.9	3.53	38085	90000	51915	2.36
T_8	24961	95294.4	70333.8	3.82	38519	97000	58481	2.52
T_9	25225	83389.1	58164.1	3.31	38831	88000	49169	2.27
T_{10}	25638	90723.5	65085.7	3.54	39352	94000	54648	2.39
T_{11}	24617	109381.0	84764.4	4.44	38085	118000	79915	3.10
T_{12}	24961	117635.7	92675.0	4.71	38519	124000	85481	3.22
T_{13}	25225	106119.4	80894.4	4.21	38831	114000	75169	2.94
T_{14}	25638	113995.4	88357.6	4.45	39352	122000	82648	3.10

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen

Cost of inputs and outputs: Urea @ Rs. 5.40 kg^{-1}, SSP@ Rs. 4.0 kg^{-1}, MOP @ Rs. 4.80 kg^{-1}; Ashgourd seeds @ Rs.950.0 kg^{-1} and Price of price ashgourd fruit @ Rs.3.0 kg^{-1}; French bean seeds @ Rs.90.0 kg^{-1} and Price of French bean pods @ Rs.10.0 kg^{-1}

4.8 Nutrient balance studies in soil

The data on balance of nitrogen, phosphorus and potassium in soil as influenced by application of human urine and cattle urine to vegetable crops are given in Tables 4.22a to 4.24b.

4.8.1 Nitrogen balance in soil

The initial available nitrogen in soil was 285.5 kg ha^{-1} (Table 4.23a). Maximum crop uptake of nitrogen from the soil was noticed in treatment with recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 108.9 kg ha^{-1}) which was followed by recommended dose of nitrogen through cattle urine in three split doses plus gypsum (T_{14}: 104.5 kg ha^{-1}) and lowest was reported in recommended dose of nitrogen through farmyard manure alone (T_1: 60.3 kg ha^{-1}). The actual balance was higher (290.9 kg ha^{-1}) with recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}) and the net negative balance (- 47.5 kg ha^{-1}) was higher with recommended dose of nitrogen through cattle urine in single dose without gypsum (T_5). The same trend was recorded in french bean, pole bean and pumpkin crops which were grown sequentially in the subsequent seasons in the same plot where ashgourd crop was grown (Table 4.23a and 4.23b).

4.8.2 Phosphorus balance in soil

The initial available phosphorus in soil was 27.6 kg ha^{-1} (Table 4.24a). Maximum crop uptake of phosphorus from the soil was noticed in treatment receiving recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}: 9.9 kg ha^{-1}) which was followed by recommended dose of nitrogen through cattle urine in three split doses plus gypsum (T_{14}: 9.5 kg ha^{-1}) and lowest was reported in recommended dose of nitrogen through farmyard manure alone (T_1: 4.7 kg ha^{-1}), while actual balance was higher (31.4 kg ha^{-1}) with recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}) and the net negative balance (- 70.7 kg ha^{-1}) was higher with recommended dose of nitrogen through cattle urine in single dose without gypsum (T_5). The same trend was also continued in french bean, pole bean and pumpkin crops

Table 4.26b: Economics of cultivation of different vegetable crops as influenced by split application of human and cattle urine with and without gypsum.

Treatments	Pole bean				Pumpkin			
	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit cost ratio	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit cost ratio
T_1	41603	79200	37597	1.90	45613	68250	22637	1.50
T_2	34440	135900	101460	3.95	33844	128800	94956	3.81
T_3	35655	87300	51645	2.45	35933	76650	40717	2.13
T_4	36089	92700	56611	2.57	36621	81550	44929	2.23
T_5	36401	83700	47299	2.30	37150	72800	35650	1.96
T_6	36922	89100	52178	2.41	37976	81550	43574	2.15
T_7	35655	102600	66945	2.88	35933	100100	64167	2.79
T_8	36089	119700	83611	3.32	36621	109900	73279	3.00
T_9	36401	99000	62599	2.72	37150	96250	59100	2.59
T_{10}	36922	110700	73778	3.00	37976	104650	66674	2.76
T_{11}	35655	133200	97545	3.74	35933	126000	90067	3.51
T_{12}	36089	149400	113311	4.14	36621	135450	98829	3.70
T_{13}	36401	130500	94099	3.59	37150	122500	85350	3.30
T_{14}	36922	142200	105278	3.85	37976	131250	93274	3.46

Legend:

T_1 : FYM (Farmyard manure) alone
T_2 : Recommended dose of fertilizer + Farmyard manure
T_3 : RDN through human urine in single dose
T_4 : RDN through human urine in single dose + gypsum
T_5 : RDN through cattle urine in single dose
T_6 : RDN through cattle urine in single dose+ gypsum
T_7 : RDN through human urine in two split doses
T_8 : RDN through human urine in two split doses+ gypsum
T_9 : RDN through cattle urine in two split doses
T_{10} : RDN through cattle urine in two split doses+ gypsum
T_{11} : RDN through human urine in three split doses
T_{12} : RDN through human urine in three split doses+ gypsum
T_{13} : RDN through cattle urine in three split doses
T_{14} : RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine; **RDN**: Recommended Dose of Nitrogen
Cost of inputs and outputs: Urea @ Rs. 5.40 kg^{-1}, SSP@ Rs. 4.0 kg^{-1}, MOP @ Rs. 4.80 kg^{-1}; Pole bean seeds @ Rs.90.0 kg^{-1} and Price of price pole bean pods @ Rs.9.0 kg^{-1}; pumpkin seeds @ Rs.1200.0 kg^{-1} and Price of price pole bean pods @ Rs.3.5 kg^{-1}

Gross returns was maximum (Rs. 1,17,635.7, 124,000.0, 1,49,400.0 and 1,35,450.0 ha^{-1}, respectively for ashgourd, french bean, pole bean and pumpkin crops) in treatment receiving recommended dose of nitrogen through human urine plus gypsum in three split doses (T_{12}). The lowest gross returns (Rs 54,300.0, 69,330.0, 79,200.0 and 78,000.0 ha^{-1}, respectively for ashgourd, french bean, pole bean and pumpkin crops) was obtained with application of nitrogen through farmyard manure alone to soil (T_1).

Maximum net returns (Rs. 92675.0, 85,481.0, 1,13,311.0 and 98,829.0 ha^{-1}, respectively for ashgourd, french bean, pole bean and pumpkin crops) was recorded in treatment receiving recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}). The lowest net returns (Rs 29,773.0, 32,662.0, 37,597.0 and 22,637.0 ha^{-1}, respectively with ashgourd, french bean, pole bean and pumpkin crops) was obtained with application of nitrogen through farmyard manure alone (T_1).

Highest benefit cost ratio (B:C ratio) of 4.71, 3.22, 4.14 and 3.70, respectively was recorded for ashgourd, french bean, pole bean and pumpkin crops in treatment with recommended dose of nitrogen through human urine in three split doses plus gypsum (T_{12}). The lowest B: C ratio of 2.01, 1.74, 1.90 and 1.50 was obtained with application of nitrogen through farmyard manure alone to soil (T_1).

Experiment-III - Effect of graded levels of human and cattle urine on soil properties, growth and yield of tomato in red, laterite and black soils under green house conditions

4.10 Growth components

The data on plant height, number of branches plant^{-1}, number of leaves plant^{-1} and total dry matter accumulation of tomato as influenced by graded levels of human and cattle urine applied to red, laterite and black soils are presented in Table 4.27.

4.10.1 Plant height (cm)

The height of tomato plant grown in three different soils at harvest as influenced by graded levels of human and cattle urine in three different soils is presented in Table

4.27. The plant height differed significantly due to graded levels of human and cattle urine at harvest.

Significantly higher plant height was recorded in red soil with application of 2 times the recommended dose of nitrogen through human urine (T_6) at harvest (87.2 cm) which was on par with 2 times the recommended dose of nitrogen through cattle urine (T_9), 2 times the recommended dose of nitrogen through chemical fertilizers (T_3) and 1.5 times recommended dose of nitrogen through human urine (T_5), cattle urine (T_8) and fertilizers (T_2). The treatment receiving recommended dose of nitrogen through chemical fertilizers (T_1) recorded significantly lower plant height of 78.1 cm and it was on par with recommended dose of nitrogen through human urine (T_4) and cattle urine (T_7). Similar trend was observed at all the stages of tomato crop in laterite soil also.

In black soil, significantly higher plant height (93.9 cm) at harvest of tomato crop was recorded with application of 2 times the recommended dose of nitrogen through chemical fertilizers (T_3) and it was on par with 2 times the recommended dose of nitrogen through human urine (T_6) and cattle urine (T_9) and 1.5 times recommended dose of nitrogen through fertilizers (T_2), human urine (T_5) and cattle urine (T_8). Significantly lower plant height (85.7 cm) was recorded with recommended dose of nitrogen through cattle urine (T_7) and it was on par with recommended dose of nitrogen through human urine (T_4) and chemical fertilizer (T_1) treatments.

4.10.2 Number of branches (plant^{-1})

The data on number of branches plant^{-1} showed significant differences at harvest of tomato crop (Table 4.27).

Significantly maximum number of branches plant^{-1} (5.90 plant^{-1}) at harvest of tomato crop in red soil was recorded in treatment receiving 2 times the recommended dose of nitrogen through human urine (T_6) which was on par with T_9, T_3, T_5 T_8 and T_2. Recommended dose of nitrogen through chemical fertilizer to crop (T_1) recorded significantly lower number of branches plant^{-1} (5.15) and it was at par with T_4 and T_7. The same trend was observed at harvest of tomato crop in laterite soil also.

In case of black soil, significantly maximum number of branches plant^{-1} (6.90 plant^{-1}) at harvest of crop was recorded in treatment receiving 2 times the recommended dose of nitrogen through chemical fertilizer (T_3) which was on par with T_6, T_9, T_2, T_5 and T_8. Treatment receiving recommended dose of nitrogen through cattle urine to crop (T_7) recorded significantly lower number of branches plant^{-1} (5.13) and it was at par with T_4 and T_1.

4.10.3 Number of leaves (plant^{-1})

The number of leaves plant^{-1} showed significant differences at harvest of tomato crop (Table 4.27).

In red soil, significantly maximum number of leaves plant^{-1} (40.8) at harvest in red soil was recorded with application of 2 times the recommended dose of nitrogen through human urine (T_6) which was on par with T_9, T_3, T_5 T_8 and T_2. Application of recommended dose of nitrogen through chemical fertilizer (T_1) recorded significantly lower number of leaves plant^{-1} (29.6) and it was at par with T_4 and T_7. Similar trend was observed at harvest of tomato crop in laterite soil.

In case of black soil, significantly higher number of leaves plant^{-1} (41.5) was noticed at harvest with the application of 2 times the recommended dose of nitrogen through chemical fertilizer (T_3) and it was on par with T_6, T_9, T_2, T_5 and T_8. Application of recommended dose of nitrogen through cattle urine (T_7) recorded significantly lower number of leaves plant^{-1} (29.5) and it was at par with T_4 and T_1.

4.10.4 Total dry matter accumulation (g plant^{-1})

Total dry matter accumulation by tomato plants varied significantly due to graded levels of human urine and cattle urine application in three different soils (red, black and laterite) at harvest (Table 4.27).

Significant differences among the treatments with respect to total dry weight (g plant^{-1}) was observed at harvest of tomato crop in red soil (Table 4.27). Significantly higher total dry weight plant^{-1} was recorded in treatment with 2 times the recommended

Table 4.27: Plant height (cm), number of branches, number of leaves and total dry matter (g/plant) of tomato at harvest as influenced by graded levels of human urine, cattle urine and fertilizer in three different soils.

Treatments	Red soil				Laterite soil				Black soil			
	Plant height	No. of branches	No. of leaves	Total dry matter	Plant height	No. of branches	No. of leaves	Total dry matter	Plant height	No. of branches	No. of leaves	Total dry matter
T_1	78.1	5.15	29.6	164.5	72.6	4.16	26.3	153.5	87.3	5.43	30.3	194.5
T_2	83.1	5.60	36.7	213.3	76.8	5.15	31.7	200.1	91.9	6.30	38.0	238.7
T_3	84.8	5.74	38.0	227.3	78.0	5.47	34.3	212.3	93.9	6.90	41.5	249.8
T_4	78.3	5.23	31.2	174.0	72.9	4.33	26.8	162.2	86.5	5.17	29.7	191.9
T_5	84.5	5.70	37.3	217.6	77.6	5.35	34.0	201.4	90.8	6.24	37.2	235.7
T_6	87.2	5.90	40.8	236.7	80.2	5.80	36.2	218.6	93.3	6.60	40.3	243.5
T_7	78.2	5.18	30.6	171.6	72.8	4.23	26.4	158.9	85.7	5.13	29.5	188.5
T_8	84.3	5.67	36.5	215.7	77.0	5.27	33.7	201.0	90.1	6.05	36.7	233.0
T_9	85.3	5.82	38.9	234.6	78.8	5.60	36.0	216.4	92.4	6.41	38.3	238.2
S.Em ±	**1.11**	**0.09**	**1.04**	**6.02**	**0.86**	**0.16**	**1.10**	**4.37**	**1.15**	**0.25**	**1.28**	**4.59**
C.D. (P=0.01)	**4.57**	**0.38**	**4.28**	**24.68**	**3.54**	**0.67**	**4.52**	**17.91**	**4.71**	**1.04**	**5.27**	**18.81**

Legend :

T_1 : Control-Recommended dose of NPK

T_2 : 1.5 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_3 : 2 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_4 : Recommended dose of N through Human urine + Balance P & K

T_5 : 1.5 times the recommended dose of N through Human urine + Balance P & K

Note : -Balance P and K supplied through SSP and MOP respectively

: -Applied gypsum @ 6.45g l^{-1} urine to all urine applied treatments

T_6 : 2 times the recommended dose of N through Human urine + Balance P & K

T_7 : Recommended dose of N through Cattle urine + Balance P & K

T_8 : 1.5 times the recommended dose of N through Cattle urine + Balance P & K

T_9 : 2 times the recommended dose of N through Cattle urine + Balance P & K

RDF: 250:250:250 kg N, P_2O_5, K_2O ha^{-1}

Source of nutrients: human urine, cattle urine and chemical fertilizers

Where- N-Nitrogen**; P-**Phosphorus**; K-**Potassium**.**

dose of nitrogen through human urine (T_6: 236.7 g plant^{-1}) and it was at par with T_9, T_3, T_5, T_8 and T_2. Significantly lower total dry matter (164.5 g plant^{-1}) was recorded with application of recommended dose of nitrogen through chemical fertilizers (T_1) which was on par with T_4 and T_7. Similar result was observed at harvest of tomato crop grown in laterite soil.

Accumulation of total dry matter (g plant^{-1}) in tomato crop grown in black soil showed significant differences among the treatments at harvest (Table 4.27). Application of 2 times the recommended dose of nitrogen through chemical fertilizers (T_3) recorded significantly higher total dry weight (249.8 g plant^{-1}) and it was on par with T_6, T_9, T_2, T_5 and T_8 over recommended dose of nitrogen through chemical fertilizer (T_1: 194.5 g plant^{-1}), human urine (T_4: 191.9 g plant^{-1}) and cattle urine (T_7: 188.5 g plant^{-1}).

4.11 Yield and yield parameters of tomato

The data pertaining to yield parameters of tomato crop such as number of flower clusters plant^{-1}, number of fruits plant^{-1}, average fruit weight and fruit yield plant^{-1} as influenced by graded levels of human and cattle urine application to three different soils (red, black and laterite) are furnished in Tables 4.28 to 4.30.

4.11.1 Number of flower clusters plant^{-1}

Number of flower cluster plant^{-1} of tomato as influenced by graded levels of human and cattle urine varied significantly among three different soils (Table 4.28).

Significantly higher number of flower clusters (12.6, 15.2 and 3.78 plant^{-1}) was recorded in treatment receiving 2 times the recommended dose of nitrogen through human urine (T_6) (at 60, 90 DAT and at harvest, respectively) and it was at par with T_9, T_3, T_5, T_8 and T_2. Significantly lower number of flower clusters per plant were recorded with the application of recommended dose of nitrogen through fertilizers to soil (T_1: 9.20, 10.80 and 2.69 plant^{-1}, respectively) which was on par with T_4 and T_7. Similar results were observed at all the growth stages of tomato crop in laterite soil also.

Table 4.28: Number of flower cluster of tomato as influenced by graded levels of human urine, cattle urine and fertilizer in three different soils

Treatments	Number of flower cluster per plant								
	Red soil			Laterite soil			Black soil		
	60 DAT	90 DAT	At harvest	60 DAT	90 DAT	At harvest	60 DAT	90 DAT	At harvest
T_1	9.20	10.8	2.69	8.46	9.9	2.48	11.2	13.4	3.48
T_2	11.4	14.0	3.51	10.5	12.9	3.23	12.9	15.4	3.97
T_3	12.1	14.5	3.63	11.2	13.3	3.34	13.7	15.8	4.18
T_4	9.7	12.8	3.13	9.4	11.6	2.90	10.4	13.1	3.44
T_5	11.6	14.2	3.55	11.1	13.3	3.31	12.7	15.3	3.91
T_6	12.6	15.2	3.78	11.6	14.0	3.50	13.5	15.7	4.10
T_7	9.5	12.5	3.10	8.7	11.3	2.88	10.1	12.0	2.96
T_8	11.5	14.2	3.55	10.6	13.1	3.27	12.6	15.2	3.86
T_9	12.4	14.9	3.73	11.4	13.7	3.43	13.3	15.5	3.99
S.Em ±	**0.32**	**0.31**	**0.10**	**0.28**	**0.31**	**0.08**	**0.27**	**0.16**	**0.08**
C.D. (P=0.01)	**1.30**	**1.28**	**0.40**	**1.14**	**1.26**	**0.32**	**1.12**	**0.65**	**0.34**

Legend :

T_1 : Control-Recommended dose of NPK

T_2 : 1.5 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_3 : 2 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_4 : Recommended dose of N through Human urine + Balance P & K

T_5 : 1.5 times the recommended dose of N through Human urine + Balance P & K

Note : -Balance P and K supplied through SSP and MOP respectively

: -Applied gypsum @ 6.45g l^{-1} urine to all urine applied treatments

T_6 : 2 times the recommended dose of N through Human urine + Balance P & K

T_7 : Recommended dose of N through Cattle urine + Balance P & K

T_8 : 1.5 times the recommended dose of N through Cattle urine + Balance P & K

T_9 : 2 times the recommended dose of N through Cattle urine + Balance P & K

RDF: 250:250:250 kg N, P_2O_5, K_2O ha^{-1}

Source of nutrients: human urine, cattle urine and chemical fertilizers

Where- N-Nitrogen**; P**-Phosphorus**; K**-Potassium**.**

Number of flower clusters plant^{-1} differed significantly among the treatments in black soil at 60, 90 DAT and at harvest of tomato crop (Table 4.28). Number of flower cluster plant^{-1} was significantly higher in treatment receiving 2 times the recommended dose of nitrogen through chemical fertilizers (T_3: 13.70, 15.80 and 4.18 plant^{-1}, respectively) and it was on par with T_6, T_9, T_2, T_5 and T_8. Significantly lower number of flower clusters per plant were recorded with application of recommended dose of nitrogen through cattle urine (T_7: 11.2, 13.4 and 3.48 plant^{-1}) which was on par with T_1 and T_4.

4.11.2 Number of fruits plant^{-1}

The data on number of fruits plant^{-1} of tomato as influenced by graded levels of human and cattle urine are presented in Table 4.29. Number of fruits plant^{-1} varied significantly among the treatments in three different soils also.

Number of fruits plant^{-1} recorded at 60, 90 DAT and at harvest, was significantly higher in 2 times the recommended dose of nitrogen through human urine (T_6: 45.9, 52.5 and 52.7 plant-1, respectively) and it was at par with T_9, T_3, T_5, T_8 and T_2 but was found significantly superior over rest of the treatments (T_1, T_4 and T_7). Significantly lower number of fruits plant^{-1} was recorded with application of recommended dose of nitrogen through chemical fertilizers to soil (T_1: 32.6, 39.9 and 42.6 plant^{-1}) and it was at par with T_4 and T_7. Similar trend was observed in laterite soil.

In case of black soil, number of fruits plant^{-1} varied significantly among the treatments at 60, 90 DAT and at harvest of tomato crop (Table 4.29). Significantly higher number of fruits plant^{-1} was recorded with 2 times the recommended dose of nitrogen through chemical fertilizers (T_3: 50.3, 57.5 and 57.7 plant^{-1}, respectively) and it was on par with T_6, T_9, T_2, T_5 and T_8. Significantly lower number of fruits plant^{-1} was recorded with application of recommended dose of nitrogen through cattle urine to soil (T_7: 35.9, 43.9 and 53.7 plant^{-1}) which was on par with T_1 and T_4.

Table 4.29: Number of fruits of tomato as influenced by graded levels of human urine, cattle urine and fertilizer in three different soils.

Treatments	Number of fruits per plant								
	Red soil			Laterite soil			Black soil		
	60 DAT	90 DAT	At harvest	60 DAT	90 DAT	At harvest	60 DAT	90 DAT	At harvest
T_1	32.6	39.9	42.6	30.0	36.7	37.5	37.6	45.7	48.3
T_2	42.8	48.1	48.8	39.4	44.3	44.9	46.4	52.9	54.5
T_3	44.4	51.2	52.2	40.8	47.1	48.0	50.3	57.5	57.7
T_4	34.2	41.5	43.9	31.4	38.2	37.9	36.9	44.2	47.8
T_5	43.3	48.5	49.8	40.3	44.9	47.8	47.2	52.4	54.0
T_6	45.9	52.5	52.7	44.4	49.1	51.8	50.1	56.6	56.9
T_7	33.5	40.2	43.4	30.8	37.0	37.7	35.9	43.9	46.9
T_8	42.9	48.4	49.4	39.5	44.5	45.8	47.1	52.2	53.7
T_9	45.5	52.3	52.5	43.8	48.0	49.6	48.8	56.3	55.3
S.Em ±	**0.94**	**1.13**	**1.49**	**1.27**	**1.52**	**1.74**	**0.82**	**1.17**	**1.21**
C.D. (P=0.01)	**3.85**	**4.63**	**6.13**	**5.21**	**6.23**	**7.15**	**3.37**	**4.80**	**4.94**

Legend :

T_1 : Control-Recommended dose of NPK

T_2 : 1.5 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_3 : 2 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_4 : Recommended dose of N through Human urine + Balance P & K

T_5 : 1.5 times the recommended dose of N through Human urine + Balance P & K

T_6 : 2 times the recommended dose of N through Human urine + Balance P & K

T_7 : Recommended dose of N through Cattle urine + Balance P & K

T_8 : 1.5 times the recommended dose of N through Cattle urine + Balance P & K

T_9 : 2 times the recommended dose of N through Cattle urine + Balance P & K

Note : -Balance P and K supplied through SSP and MOP respectively

: -Applied gypsum @ 6.45g l^{-1} urine to all urine applied treatments

RDF: 250:250:250 kg N, P_2O_5, K_2O ha^{-1}

Source of nutrients: human urine, cattle urine and chemical fertilizers

Where- N-Nitrogen**; P-**Phosphorus**; K-**Potassium**.**

4.11.3 Fresh weight (g fruit^{-1})

The data on fruit fresh weight as influenced by graded levels of human urine and cattle urine in three different soils are presented in Table 4.30.

Fruit weight of tomato differed significantly among the treatments. Fruit weight at harvest, was significantly higher in treatment receiving 2 times the recommended dose of nitrogen through human urine (T_6: 76.3 g fruit^{-1}) and it was on par with T_9, T_3, T_5, T_8 and T_2. Significantly lower fruit (58.3 g) weight was recorded with recommended dose of nitrogen through chemical fertilizers (T_1) which was at par with T_4 and T_7. Similar results were also observed in laterite soil also.

In black soil, application of 2 times the recommended dose of nitrogen through chemical fertilizers (T_3) showed significantly higher fruit weight (81.5 g fruit^{-1}) which was at par with T_6, T_9, T_2, T_5 and T_8. Recommended dose of nitrogen through cattle urine to crop (T_7) recorded significantly lower fruit weight (67.2 g fruit^{-1}) and it was at par with T_4 and T_1.

4.11.4 Fruit weight (kg plant^{-1})

The fruits weight plant^{-1} recorded at harvest varied significantly among the treatments (Table 4.30).

Application of 2 times the recommended dose of nitrogen through human urine (T_6) recorded significantly higher mean fruit weight (3.6 kg) plant^{-1} in red soil condition and it was significantly superior over recommended dose of nitrogen through chemical fertilizers (T_1) and cattle urine (T_7) to soil (2.2 kg) but it was at par with T_9, T_3, T_5, T_8 and T_2. Similar trend was also noticed in tomato crop grown in laterite soil also.

In black soil, fruit weight varied significantly due to graded levels of human, cattle urine and fertilizer. Significantly higher fruit weight was recorded in 2 times the recommended dose of nitrogen through chemical fertilizers (T_3: 3.67 kg), which was significantly superior over T_1, T_4 and T_7 but was on par with rest of the treatments.

Table 4.30: Yield of tomato as influenced by graded levels of human urine, cattle urine and fertilizer in three different soils

Treatments	Red soil		Laterite soil		Black soil	
	Fresh weight (g $fruit^{-1}$)	Fruit yield (kg $plant^{-1}$)	Fresh weight (g $fruit^{-1}$)	Fruit yield (kg $plant^{-1}$)	Fresh weight (g $fruit^{-1}$)	Fruit yield (kg $plant^{-1}$)
T_1	50.8	2.2	50.1	1.97	60.4	2.24
T_2	62.2	3.0	59.8	2.86	66.9	3.36
T_3	66.3	3.5	63.8	3.21	72.2	3.67
T_4	51.8	2.3	50.6	2.17	59.5	2.10
T_5	63.2	3.1	62.6	3.14	68.1	3.30
T_6	68.8	3.6	68.3	3.45	71.9	3.53
T_7	51.0	2.2	50.3	2.01	57.9	2.03
T_8	62.9	3.1	60.5	3.05	67.3	3.27
T_9	68.4	3.6	65.9	3.32	71.5	3.45
S.Em ±	**3.24**	**0.17**	**2.19**	**0.15**	**1.38**	**0.16**
C.D. (P=0.01)	**13.29**	**0.70**	**8.97**	**0.62**	**5.67**	**0.68**

Legend :

T_1 : Control-Recommended dose of NPK

T_2 : 1.5 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_3 : 2 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_4 : Recommended dose of N through Human urine + Balance P & K

T_5 : 1.5 times the recommended dose of N through Human urine + Balance P & K

Note : -Balance P and K supplied through SSP and MOP respectively

: -Applied gypsum @ 6.45g l^{-1} urine to all urine applied treatments

T_6 : 2 times the recommended dose of N through Human urine + Balance P & K

T_7 : Recommended dose of N through Cattle urine + Balance P & K

T_8 : 1.5 times the recommended dose of N through Cattle urine + Balance P & K

T_9 : 2 times the recommended dose of N through Cattle urine + Balance P & K

RDF: 250:250:250 kg N, P_2O_5, K_2O ha^{-1}

Source of nutrients: human urine, cattle urine and chemical fertilizers

Where- N-Nitrogen**; P**-Phosphorus**; K**-Potassium**.**

4.12 Quality parameters

The data on quality parameters such as Juice (%), titrable acidity (% of citric acid), ascorbic acid and total soluble solids of tomato crop grown in red, laterite and black soils as influenced by graded levels of human and cattle urine at harvest are presented in Table 4.31.

4.12.1 Per cent Juice

The per cent juice of tomato fruit was significantly influenced by application of different rates of application of human and cattle urine to soils among the treatments (Table 4.30). Application of 2 times the recommended dose of N through human urine (T_6) recorded significantly highest value (79.5 per cent) over recommended dose of N through cattle urine (T_7: 68.9 per cent) and recommended dose of N through chemical fertilizers (T_1: 68.3 per cent) but rest of treatments were on par with T_6. Similar trend was also observed in tomato grown in laterite soil.

Fruit juice per cent varied significantly among the treatments in black soil also. Fruit juice yield was significantly higher in treatment receiving 2 times the recommended dose of N through chemical fertilizers (T_3: 84.3 per cent) and it was on par with T_6, T_9, $T_{2,}$ T_5 and $T_{8.}$ Significantly lower juice percent was recorded with treatment receiving recommended dose of N through cattle urine (T_7: 72.4 per cent) which was at par with T_4 and T_1.

4.12.2 Titratable acidity (%)

Titrable acidity expressed in terms of % of citric acid of tomato fruit grown under red soil as influenced by graded levels of human urine and cattle urine is presented in Table 4.31. Titrable acidity (% of citric acid) varied significantly due to rate of application of human and cattle urine and higher content (0.72 %) was noticed in 2 times the recommended dose of N through human urine (T_6) which was significantly superior over T_7, T_4 and T_1, but on par with rest of the treatments. Similar trend was observed in the tomato crop grown in laterite soil.

In black soil also, titratable acidity of tomato fruits varied significantly due to grade levels of human and cattle urine (Table 4.30). Application of 2 times the recommended dose of nitrogen through chemical fertilizers showed significantly higher values (T_3: 0.64 per cent) and it was on par with 2 times the recommended dose of nitrogen through human urine (T_6: 0.63 per cent) and 2 times the recommended dose of nitrogen through cattle urine (T_9: 0.61 t ha^{-1}). Significantly lower titratable acidity was recorded with recommended dose of nitrogen through cattle urine (T_7: 0.51per cent) which was at par with T_4 (0.51 per cent) and T_1 (0.54 per cent) treatments.

4.12.3 Ascorbic acid content (%)

The ascorbic acid content of tomato fruits varied significantly among the treatments under red soil situation (Table 4.31). Application of 2 times the recommended N dose of through human urine (T_6) recorded significantly higher ascorbic content (24.81 %) followed by treatment receiving recommended dose of N through human urine (T_4: 17.90 %), recommended dose of N through cattle urine (T_7: 16.93 %) and recommended dose of N through chemical fertilizers (T_1: 16.60 %) but rest of treatments were on par with T_6. Similar trend was also observed in tomato crop grown in laterite soil.

In case of black soil also, the ascorbic acid content of tomato fruits varied significantly due to graded levels of human and cattle urine (Table 4.31). Ascorbic acid content of fruits was higher in 2 times the recommended dose of N through chemical fertilizers (T_3: 25.43 %), which was significantly superior over T_7, T_4 and T_7 but on par with rest of the treatments.

4.12.4 Total soluble solids (^{0}Brix)

The data on total soluble solids (TSS) as influenced by application of graded levels of human and cattle urine is presented in Table 4.31. At harvest, TSS differed significantly among the treatments. Application of 2 times of recommended dose of N through human urine (T_6) recorded significantly higher TSS (4.9 ^{0}Brix) in red soil and it was significantly superior over recommended dose of nitrogen through human urine (T_4: 3.93 ^{0}Brix), recommended dose of nitrogen through cattle urine (T_7: 3.86 ^{0}Brix) and

Table 4.31: Quality parameters of tomato fruits as influenced by graded levels of human urine, cattle urine and fertilizer in three different soils.

Treatments	Red soil				Laterite soil				Black soil			
	Juice (%)	Acidity (%)	Ascorbic acid (%)	TSS (^{0}Brix)	Juice (%)	Acidity (%)	Ascorbic acid (%)	TSS (^{0}Brix)	Juice (%)	Acidity (%)	Ascorbic acid (%)	TSS (^{0}Brix)
T_1	68.3	0.72	24.81	3.77	66.5	0.58	22.45	3.42	74.4	0.54	18.35	4.03
T_2	74.2	0.68	22.63	4.46	71.8	0.55	20.48	4.05	80.0	0.59	22.78	4.71
T_3	78.1	0.62	17.90	4.73	74.2	0.50	16.20	4.29	84.3	0.51	16.93	5.02
T_4	69.3	0.70	22.95	3.93	67.3	0.57	20.77	3.57	72.6	0.63	24.24	3.97
T_5	75.5	0.66	22.33	4.60	72.5	0.54	20.21	4.17	79.7	0.60	22.99	4.65
T_6	79.5	0.57	16.60	4.90	75.5	0.46	15.02	4.44	83.5	0.51	17.39	4.92
T_7	68.9	0.71	23.60	3.86	67.0	0.57	21.36	3.50	72.4	0.54	18.35	3.84
T_8	75.2	0.68	22.39	4.53	72.0	0.55	20.26	4.11	79.2	0.61	23.20	4.55
T_9	78.8	0.60	16.93	4.79	74.9	0.48	15.32	4.35	82.8	0.61	23.41	4.82
S.Em ±	**1.40**	**0.02**	**0.98**	**0.11**	**1.07**	**0.02**	**0.88**	**0.10**	**1.06**	**0.02**	**1.00**	**0.11**
C.D. (P=0.01)	**5.75**	**0.08**	**4.00**	**0.44**	**4.40**	**0.06**	**3.62**	**0.40**	**4.33**	**0.07**	**4.09**	**0.45**

Legend :

T_1 : Control-Recommended dose of NPK

T_2 : 1.5 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_3 : 2 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_4 : Recommended dose of N through Human urine + Balance P & K

T_5 : 1.5 times the recommended dose of N through Human urine + Balance P & K

Note : -Balance P and K supplied through SSP and MOP respectively

: -Applied gypsum @ 6.45g l^{-1} urine to all urine applied treatments

T_6 : 2 times the recommended dose of N through Human urine + Balance P & K

T_7 : Recommended dose of N through Cattle urine + Balance P & K

T_8 : 1.5 times the recommended dose of N through Cattle urine + Balance P & K

T_9 : 2 times the recommended dose of N through Cattle urine + Balance P & K

RDF: 250:250:250 kg N, P_2O_5, K_2O ha^{-1}

Source of nutrients: human urine, cattle urine and chemical fertilizers

Where- N-Nitrogen**; P**-Phosphorus**; K**-Potassium**.**

recommended dose of nitrogen through chemical fertilizers (T_1: 3.77 ^{0}Brix) but it was at par with T_9, T_3, $T_{5,}$ T_8 and T_2. Similar results were observed in tomato crop grown in laterite soil also.

In black soil also total soluble solids content of fruits differed significantly among the treatments. It was significantly higher in treatment receiving 2 times the recommended dose of N through chemical fertilizers (T_3: 5.02 ^{0}brix) and it was on par with T_6, T_9, $T_{2,}$ T_5 and $T_{8.}$ Significantly lower TSS content of fruit (3.84 ^{0}brix) was recorded with recommended dose of N through cattle urine (T_7) which was at par with T_4 and T_1 treatments.

4.13 Nutrients content

The data on nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, zinc and copper content in tomato fruits as influenced by graded levels of human and cattle urine applied to three different soils are presented in Tables 4.31 to 4.33.

4.13.1 Nitrogen content (%)

Nitrogen content in tomato fruits as influenced by graded levels of human and cattle urine applied to three different soils are presented in Table 4.32.

Nitrogen content in tomato fruits differed significantly due to graded levels of human urine and cattle urine in red soil. Significantly higher nitrogen content in fruits was registered in 2 times the recommended dose of nitrogen through human urine (T_6: 3.67 %) and it was on par with T_9, T_3, T_5 T_8 and T_2. Significantly lower nitrogen content was recorded with recommended dose of nitrogen through chemical fertilizer (T_1: 3.13 %) and it was at par with T_4 and T_7. The same trend was observed at harvest of crop grown in laterite soil.

In black soil also, nitrogen content in fruits differed significantly due to graded levels of human urine and cattle urine. Significantly higher nitrogen content in fruit was registered in 2 times recommended dose of nitrogen through chemical fertilizer (T_3: 3.78

%) which was on par with T_6, T_9, $T_{2,}$ T_5 and T_8. Recommended dose of nitrogen through cattle urine (T_7) recorded significantly lower nitrogen content (3.32 %) and it was at par with T_4 and T_1 treatments.

4.13.2 Phosphorus content (%)

The phosphorus content in tomato fruit as influenced by application of graded levels of human urine and cattle urine to different soils are furnished in Table 4.32.

The phosphorus content of fruit (Table 4.32) was significantly higher in treatment receiving 2 times recommended dose of nitrogen through human urine (T_6: 0.33 %) which was on par with T_9, T_3, T_5 T_8 and T_2. Application of recommended dose of nitrogen through chemical fertilizer (T_1) recorded significantly lower phosphorus content (0.25 %) and it was on par with T_4 and T_7. Similar trend of results was observed in case of tomato fruits grown in laterite soil also.

In case of black soil, the phosphorus content in fruits differed significantly due to application of graded levels of human urine and cattle urine. Significantly higher phosphorus content in fruit was registered in 2 times recommended dose of nitrogen through chemical fertilizer (T_3: 0.34 %) which was on par with T_6, T_9, $T_{2,}$ T_5 and T_8. Recommended dose of nitrogen through cattle urine (T_7) recorded significantly lower nitrogen content (0.26 %) and it was at par with T_4 and T_1.

4.13.3 Potassium content (%)

Potassium content in fruits of tomato grown in different soils as influenced by application of graded levels of human urine and cattle urine is given in Table 4.32.

Potassium content in tomato fruits grown in red soil was significantly higher (3.66 %) in treatment receiving 2 times the recommended dose of N through human urine (T_6) which was significantly superior over T_7, T_4 and T_1, but was on par with rest of the treatments. Lowest potassium content was recorded in treatment receiving recommended dose of N through chemical fertilizers (T_1). The similar trend was observed in the tomato crop grown in laterite soil also.

Table 4.32: Nitrogen (N), phosphorus (P) and potassium (K) content (%) in tomato fruits as influenced by graded levels of human urine, cattle urine and fertilizer in three different soils at harvest.

Treatments	Red soil			Laterite soil			Black soil		
	N	P	K	N	P	K	N	P	K
T_1	3.13	0.25	2.87	2.83	0.23	2.59	3.44	0.27	2.34
T_2	3.27	0.29	3.29	3.07	0.26	2.88	3.64	0.31	2.76
T_3	3.53	0.31	3.51	3.29	0.28	3.14	3.78	0.34	2.89
T_4	3.08	0.26	3.03	2.86	0.24	2.69	3.35	0.26	2.33
T_5	3.40	0.30	3.40	3.19	0.27	3.05	3.62	0.31	2.73
T_6	3.67	0.33	3.66	3.41	0.29	3.28	3.75	0.34	2.88
T_7	3.03	0.26	2.94	2.82	0.24	2.61	3.32	0.26	2.30
T_8	3.37	0.29	3.29	3.13	0.26	2.95	3.58	0.31	2.68
T_9	3.57	0.32	3.63	3.32	0.29	3.26	3.71	0.32	2.82
S.Em±	**0.10**	**0.01**	**0.09**	**0.08**	**0.01**	**0.11**	**0.07**	**0.01**	**0.08**
C.D. (P=0.01)	**0.41**	**0.05**	**0.38**	**0.34**	**0.03**	**0.44**	**0.31**	**0.04**	**0.31**

Legend :

T_1 : Control-Recommended dose of NPK

T_2 : 1.5 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_3 : 2 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_4 : Recommended dose of N through Human urine + Balance P & K

T_5 : 1.5 times the recommended dose of N through Human urine + Balance P & K

Note : -Balance P and K supplied through SSP and MOP respectively

: -Applied gypsum @ 6.45g l^{-1} urine to all urine applied treatments

T_6 : 2 times the recommended dose of N through Human urine + Balance P & K

T_7 : Recommended dose of N through Cattle urine + Balance P & K

T_8 : 1.5 times the recommended dose of N through Cattle urine + Balance P & K

T_9 : 2 times the recommended dose of N through Cattle urine + Balance P & K

RDF: 250:250:250 kg N, P_2O_5, K_2O ha^{-1}

Source of nutrients: human urine, cattle urine and chemical fertilizers

Where- N-Nitrogen; **P**-Phosphorus; **K**-Potassium.

Potassium content in fruits grown in black soil differed significantly due to treatments. It was significantly higher (2.89 %) in treatment receiving 2 times the recommended dose of N through chemical fertilizers (T_3) and it was on par with T_6, T_9, $T_{2,}$ T_5 and $T_{8.}$ Significantly lower potassium content (2.30 %) was recorded with recommended dose of N through cattle urine (T_7) which was at par with T_4 and T_1.

4.13.4 Calcium content (%)

Calcium content in tomato fruits grown in red soil differed significantly due to application of graded levels of human urine and cattle urine (Table 4.33). Significantly higher calcium content (0.95 %) in fruit was recorded in application of 2 times the recommended of N through human urine (T_6) over recommended dose of N through human urine (T_4: 0.78 %), recommended dose of N through cattle urine (T_7: 0.76 %) and recommended dose of N through chemical fertilizers (T_1: 0.75 %) but rest of treatments were on par with T_6. Similar trend was observed in tomato crop grown in laterite soil also.

In case of black soil, the calcium content of fruits varied significantly due to application of graded levels of human and cattle urine. Calcium content of fruits was higher (0.99 %) in treatment receiving 2 times the recommended dose of N through chemical fertilizers (T_3), which was significantly superior over T_7, T_4 and T_7 but was on par with rest of the treatments.

4.13.5 Magnesium content (%)

Magnesium content in tomato fruits as influenced by application of graded levels of human urine and cattle urine are presented in Table 4.33.

Magnesium content in fruits differed significantly due to application of human urine and cattle urine at different rates to red soil. Significantly higher magnesium content in fruit was registered in 2 times recommended dose of nitrogen through human urine (T_6: 0.40 %) and it was on par with T_9, T_3, T_5 T_8 and T_2. Significantly lower magnesium content was recorded with recommended dose of nitrogen through chemical fertilizer (T_1: 0.34 %) and it was at par with T_4 and T_7. The same trend was observed in laterite soil also.

In black soil also, magnesium content in tomato fruits differed significantly due to application of graded levels of human urine and cattle urine. Significantly higher magnesium content in leaf, stem and fruit was registered in 2 times recommended dose of nitrogen through chemical fertilizer (T_3: 0.44 %) which was on par with T_6, T_9, $T_{2,}$ T_5 and T_8. Treatment receiving recommended dose of nitrogen through cattle urine (T_7) recorded significantly lower magnesium content (0.33 %) and it was at par with T_4 and T_1.

4.13.6 Sulfur content (%)

Sulfur content in tomato fruit grown in different soils with application of graded levels of human urine and cattle urine to different soils are furnished in Table 4.33.

The sulfur content of fruit (Table 4.33) was significantly higher (0.33 %) due to application of 2 times recommended dose of nitrogen through human urine (T_6) which was on par with T_9, T_3, T_5 T_8 and T_2. Application of recommended dose of nitrogen through chemical fertilizer (T_1) recorded significantly lower sulfur content (0.27 %) and it was on par with T_4 and T_7. Similar trend was observed at harvest of crop in laterite soil also.

In case of black soil, the sulfur content in tomat fruits differed significantly due to application of graded levels of human urine and cattle urine. Significantly higher sulfur content in tomato fruit was registered in 2 times recommended dose of nitrogen through chemical fertilizer (T_3: 0.36 %) which was on par with T_6, T_9, $T_{2,}$ T_5 and T_8. Treatment receiving recommended dose of nitrogen through cattle urine (T_7) recorded significantly lower sulfur content (0.27 %) and it was at par with T_4 and T_1.

4.13.7 Iron content (ppm)

Human urine and cattle urine application significantly influenced the iron content in tomato fruits grown in red soil (Table 4.34).

Table 4.33: Calcium (Ca), magnesium (Mg) and sulfur (S) content (%) in tomato fruits as influenced by graded levels of human urine, cattle urine and fertilizer at harvest in three different soils

Treatments	Red soil			Laterite soil			Black soil		
	Ca	Mg	S	Ca	Mg	S	Ca	Mg	S
T_1	0.75	0.34	0.27	0.67	0.29	0.26	0.90	0.35	0.30
T_2	0.84	0.36	0.29	0.77	0.32	0.29	0.95	0.41	0.33
T_3	0.92	0.39	0.32	0.84	0.35	0.30	0.99	0.44	0.36
T_4	0.78	0.34	0.28	0.70	0.30	0.26	0.88	0.34	0.29
T_5	0.89	0.37	0.31	0.81	0.34	0.29	0.95	0.40	0.33
T_6	0.95	0.40	0.33	0.88	0.36	0.31	0.98	0.43	0.36
T_7	0.76	0.34	0.27	0.69	0.29	0.26	0.87	0.33	0.27
T_8	0.86	0.37	0.30	0.79	0.33	0.29	0.93	0.40	0.33
T_9	0.95	0.39	0.32	0.87	0.36	0.30	0.97	0.42	0.34
S.Em±	**0.04**	**0.01**	**0.01**	**0.03**	**0.01**	**0.01**	**0.02**	**0.01**	**0.01**
C.D. (P=0.01)	**0.15**	**0.04**	**0.03**	**0.13**	**0.06**	**0.03**	**0.08**	**0.05**	**0.04**

Legend :

T_1 : Control-Recommended dose of NPK

T_2 : 1.5 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_3 : 2 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_4 : Recommended dose of N through Human urine + Balance P & K

T_5 : 1.5 times the recommended dose of N through Human urine + Balance P & K

Note : -Balance P and K supplied through SSP and MOP respectively

: -Applied gypsum @ 6.45g l^{-1} urine to all urine applied treatments

T_6 : 2 times the recommended dose of N through Human urine + Balance P & K

T_7 : Recommended dose of N through Cattle urine + Balance P & K

T_8 : 1.5 times the recommended dose of N through Cattle urine + Balance P & K

T_9 : 2 times the recommended dose of N through Cattle urine + Balance P & K

RDF: 250:250:250 kg N, P_2O_5, K_2O ha^{-1}

Source of nutrients: human urine, cattle urine and chemical fertilizers

Where- N-Nitrogen**; P**-Phosphorus**; K**-Potassium**.**

Iron content in fruit was significantly higher in treatment receiving 2 times the recommended dose of N through human urine (T_6: 95.9 ppm) which was significantly superior over T_7, T_4 and T_1, but was on par with rest of the treatments. Similar trend was observed in the iron content of tomato fruits grown in laterite soil.

Iron content in tomato fruit grown in black soil differed significantly due to the treatments. It was significantly higher in treatment receiving application 2 times the recommended dose of N through chemical fertilizers (T_3: 94.3 ppm) and it was on par with T_6, T_9, $T_{2,}$ T_5 and $T_{8.}$ Significantly lower iron content (74.9 ppm) was recorded with recommended dose of N through cattle urine (T_7) which was at par with T_4 and T_1.

4.13.8 Manganese content (ppm)

The manganese content in different parts of tomato fruits as influenced by graded levels of human urine and cattle urine applied to different soils are presented in Table 4.34.

Manganese content in fruits differed significantly due to application of graded levels of human urine and cattle urine (Table 4.33). Significantly higher manganese content in fruit was recorded in treatment receiving 2 times the recommended dose N through human urine (T_6: 61.9 ppm) over recommended dose of N through human urine (T_4: 50.4 ppm), recommended dose of N through cattle urine (T_7: 49.2 ppm, respectively) and recommended dose of N through chemical fertilizers (T_1: 48.2, 38.9 and 21.4 ppm) but rest of treatments were on par with T_6. Similar trend was also observed in tomato crop grown in laterite soil.

In black soil, the manganese content of tomato fruits was higher in 2 times the recommended dose of N through chemical fertilizers (T_3: 63.4 ppm), which was significantly superior over T_7, T_4 and T_7 but was on par with rest of the treatments.

4.13.9 Zinc content (ppm)

Zinc content in tomato fruits as influenced by application of graded levels of human urine and cattle urine to different soils are furnished in Table 4.34.

The zinc content of tomato fruits was significantly higher in tomato grown in red soil with application of 2 times the recommended dose of nitrogen through human urine (T_6: 18.4 ppm) which was on par with T_9, T_3, T_5 T_8 and T_2. Application of recommended dose of nitrogen through chemical fertilizer (T_1) recorded significantly lower zinc content (15.0 ppm) and it was on par with T_4 and T_7. Similar trend was observed at harvest of crop grown in laterite soil also.

In case of black soil, the zinc content of fruits differed significantly due to application of graded levels of human urine and cattle urine. Significantly higher zinc content in leaf, stem and fruits was registered in 2 times recommended dose of nitrogen through chemical fertilizer (T_3: 20.1 ppm) which was on par with T_6, T_9, $T_{2,}$ T_5 and T_8. Treatment receiving recommended dose of nitrogen through cattle urine (T_7) recorded significantly lower zinc content (15.0 ppm) and it was at par with T_4 and T_1.

4.13.10 Copper content (ppm)

Copper content of tomato fruits as influenced by application of graded levels of human urine and cattle urine are presented in Table 4.34.

Human urine and cattle urine application significantly influenced the copper content of tomato fruits grown in red soil (Table 4.34). Copper content in fruit was significantly higher in treatment receiving 2 times the recommended dose of N through human urine (T_6: 10.2 ppm) which was significantly superior over T_7, T_4 and T_1 treatments, but was on par with rest of the treatments. The similar trend was observed with respect to copper content of tomato fruits grown in laterite soil also.

Copper content in fruit grown in black soil differed significantly among the treatments. It was significantly higher due to application of 2 times the recommended dose of N through chemical fertilizers (T_3: 11.4 ppm) and it was on par with T_6, T_9, $T_{2,}$ T_5 and $T_{8.}$ Significantly lower copper content (9.5 ppm) was recorded with recommended dose of N through cattle urine (T_7) which was at par with T_4 and T_1.

Table 4.34: Iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) content (ppm) in tomato fruits as influenced by graded levels of human urine, cattle urine and fertilizer in three different soils at harvest.

Treatments	Red soil				Laterite soil				Black soil			
	Fe	**Mn**	**Zn**	**Cu**	**Fe**	**Mn**	**Zn**	**Cu**	**Fe**	**Mn**	**Zn**	**Cu**
T_1	75.7	48.2	15.0	8.8	73.4	43.9	11.7	8.14	76.9	54.4	16.1	9.6
T_2	84.1	54.3	16.4	9.1	79.5	48.8	13.2	9.04	89.8	59.4	18.9	10.7
T_3	91.6	59.3	17.6	9.9	85.1	53.1	14.4	9.88	94.3	63.4	20.1	11.4
T_4	78.7	50.4	15.3	8.6	74.1	45.6	12.2	8.45	75.8	53.5	15.5	9.6
T_5	89.0	57.4	17.1	9.5	82.5	51.6	14.0	9.57	88.9	58.7	18.6	10.6
T_6	95.9	61.9	18.4	10.2	88.3	55.6	15.0	10.30	93.7	61.4	19.8	11.1
T_7	76.3	49.2	15.1	8.5	73.1	44.3	11.9	8.20	74.9	53.1	15.0	9.5
T_8	86.3	55.7	16.6	9.4	81.1	50.1	13.5	9.28	87.3	57.4	18.3	10.4
T_9	95.2	61.4	18.3	10.0	85.9	55.2	14.9	10.23	92.0	59.9	19.3	10.8
S.Em±	**3.1**	**2.2**	**0.5**	**0.3**	**2.16**	**1.81**	**0.54**	**0.39**	**2.22**	**1.59**	**0.44**	**0.3**
C.D. (P=0.01)	**12.8**	**9.1**	**2.1**	**1.1**	**8.85**	**7.44**	**2.21**	**1.59**	**9.10**	**54.4**	**1.80**	**1.2**

Legend :

T_1 : Control-Recommended dose of NPK

T_2 : 1.5 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_3 : 2 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_4 : Recommended dose of N through Human urine + Balance P & K

T_5 : 1.5 times the recommended dose of N through Human urine + Balance P & K

Note : -Balance P and K supplied through SSP and MOP respectively

: -Applied gypsum @ 6.45g l^{-1} urine to all urine applied treatments

T_6 : 2 times the recommended dose of N through Human urine + Balance P & K

T_7 : Recommended dose of N through Cattle urine + Balance P & K

T_8 : 1.5 times the recommended dose of N through Cattle urine + Balance P & K

T_9 : 2 times the recommended dose of N through Cattle urine + Balance P & K

RDF: 250:250:250 kg N, P_2O_5, K_2O ha^{-1}

Source of nutrients: human urine, cattle urine and chemical fertilizers

Where- N-Nitrogen; **P**-Phosphorus; **K**-Potassium.

4.14 Nutrients uptake by tomato crop

The data on nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, zinc and copper uptake by tomato plant as influenced by graded levels of human urine and cattle urine under different soil are presented in Tables 4.35 to 4.37.

4.14.1 Nitrogen uptake (kg ha^{-1})

Nitrogen uptake by tomato plant as influenced by application of graded levels of human urine and cattle urine are presented in Table 4.35.

Nitrogen uptake by tomato grown in red soil differed significantly due to application of graded levels of human urine and cattle urine. Significantly higher nitrogen uptake by leaf, stem and fruit was registered in treatment receiving 2 times recommended dose of nitrogen through human urine (T_6: 186.3 kg ha^{-1}) and it was on par with T_9, T_3, T_5 T_8 and T_2. Significantly lower nitrogen uptake was recorded with recommended dose of nitrogen through chemical fertilizer (T_1: 104.8 kg ha^{-1}, respectively) and it was at par with T_4 and T_7. Similar trend was observed at all the stages of crop grown in laterite soil also.

In black soil, nitrogen uptake by tomato crop differed significantly due to application of graded levels of human urine and cattle urine. Significantly higher nitrogen uptake was registered in 2 times the recommended dose of nitrogen through chemical fertilizer (T_3: 197.6 kg ha^{-1}) which was on par with T_6, T_9, $T_{2,}$ T_5 and T_8. Recommended dose of nitrogen through cattle urine to crop (T_7) recorded significantly lower nitrogen uptake (123.2 kg ha^{-1}) and it was at par with T_4 and T_1 treatments.

4.14.2 Phosphorus uptake (kg ha^{-1})

Phosphorus uptake by tomato plant grown in different soils as influenced by application of graded levels of human urine and cattle urine are furnished in Table 4.35.

The phosphorus uptake by tomato plant was significantly higher (9.82 kg ha^{-1}) in treatment with 2 times the recommended dose of nitrogen through human urine under red soil (T_6) which was on par with T_9, T_3, T_5 T_8 and T_2. Application of recommended dose of nitrogen through chemical fertilizer (T_1) recorded significantly lower phosphorus uptake (5.19 kg ha^{-1}) and it was on par with T_4 and T_7. Similar trend was observed in laterite soil.

In case of black soil, phosphorus uptake differed significantly due to application of graded levels of human urine and cattle urine. Significantly higher phosphorus uptake by tomato crop was registered with 2 times recommended dose of nitrogen through chemical fertilizer (T_3: 11.28 kg ha^{-1}) which was on par with T_6, T_9, $T_{2,}$ T_5 and T_8. Recommended dose of nitrogen through cattle urine to crop (T_7) recorded significantly lower phosphorus uptake (6.12 kg ha^{-1}) and it was at par with T_4 and T_1.

4.14.3 Potassium uptake (kg ha^{-1})

Potassium uptake by plant as influenced by application of graded levels of human urine and cattle urine are given in Table 4.35.

Potassium uptake by tomato crop grown in red soil was significantly influenced due to graded levels of application of human urine and cattle urine. Potassium uptake was significantly higher in 2 times the recommended dose of N through human urine (T_6: 173.9 kg ha^{-1}) which was significantly superior over T_7, T_4 and T_1, but was on par with rest of the treatments. A similar trend of potassium uptake by tomato plant was observed in laterite soil.

Potassium uptake in black soil differed significantly due to application of graded levels of human and cattle urine. It was significantly higher in treatment receiving 2 times the recommended dose of N through chemical fertilizer (T_3: 190.4 kg ha^{-1}) and it was on par with T_6, T_9, $T_{2,}$ T_5 and $T_{8.}$ Significantly lower potassium uptake (110.9 kg ha^{-1}) was recorded with recommended dose of N through cattle urine (T_7) which was at par with T_4 and T_1.

4.14.4 Calcium uptake (kg ha^{-1})

Calcium uptake by tomato crop as influenced by application of graded levels of human urine and cattle urine are presented in Table 4.36.

Table 4.35: Nitrogen, phosphorus and potassium uptake (kg ha^{-1}) by tomato crop as influenced by graded levels of human urine, cattle urine and fertilizer at harvest in three different soils

Treatments	Red soil			Laterite soil			Black soil		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
T_1	104.8	5.19	97.7	87.3	4.70	84.9	130.7	6.70	120.0
T_2	150.6	7.86	139.4	126.5	7.02	121.7	177.6	9.80	166.2
T_3	171.9	9.11	160.2	143.7	7.97	140.6	197.6	11.28	190.4
T_4	113.9	5.77	105.7	95.2	5.19	92.2	126.6	6.37	116.6
T_5	159.1	8.38	148.6	131.8	7.39	129.2	174.0	9.57	161.9
T_6	186.3	9.82	173.9	153.8	8.60	150.7	194.6	11.06	186.1
T_7	109.3	5.56	101.7	91.1	4.96	88.2	123.2	6.12	110.9
T_8	153.7	8.06	143.6	127.9	7.11	125.8	169.2	9.37	158.4
T_9	178.8	9.58	170.0	149.1	8.66	147.2	188.2	10.52	177.1
S.Em±	**9.2**	**0.52**	**8.3**	**6.6**	**0.44**	**8.2**	**7.4**	**0.49**	**8.5**
C.D. (P=0.01)	**37.7**	**2.11**	**34.1**	**27.3**	**1.79**	**33.7**	**30.1**	**2.02**	**34.7**

Legend :

T_1 : Control-Recommended dose of NPK

T_2 : 1.5 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_3 : 2 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_4 : Recommended dose of N through Human urine + Balance P & K

T_5 : 1.5 times the recommended dose of N through Human urine + Balance P & K

Note : -Balance P and K supplied through SSP and MOP respectively

: -Applied gypsum @ 6.45g l^{-1} urine to all urine applied treatments

T_6 : 2 times the recommended dose of N through Human urine + Balance P & K

T_7 : Recommended dose of N through Cattle urine + Balance P & K

T_8 : 1.5 times the recommended dose of N through Cattle urine + Balance P & K

T_9 : 2 times the recommended dose of N through Cattle urine + Balance P & K

RDF: 250:250:250 kg N, P_2O_5, K_2O ha^{-1}

Source of nutrients: human urine, cattle urine and chemical fertilizers

Where- N-Nitrogen**; P-**Phosphorus**; K-**Potassium**.**

Calcium uptake by tomato crop grown in red soil differed significantly due to application of graded levels of human urine and cattle urine (Table 4.35). Significantly higher calcium uptake was registered in treatment receiving 2 times the recommended of N through human urine (T_6: 27.0 kg ha^{-1}) over recommended dose of N through human urine (T_4: 16.2 kg ha^{-1}), recommended dose of N through cattle urine (T_7: 15.5 kg ha^{-1}) and recommended dose of N through chemical fertilizers (T_1: 14.8 kg ha^{-1}) but rest of treatments were on par with T_6. Similar trend was observed in tomato crop grown in laterite soil also.

In case of black soil, the calcium uptake differed significantly due to application of graded levels of human and cattle urine. Calcium uptake was higher in 2 times the recommended dose of N through chemical fertilizers (T_3: 32.24 kg ha^{-1}), which was significantly superior over T_7, T_4 and T_7 but on par with rest of the treatments.

4.14.5 Magnesium uptake (kg ha^{-1})

Magnesium uptake by tomato crop as influenced by application of graded levels of human urine and cattle urine are presented in Table 4.36.

In red soil, magnesium uptake by tomato crop in differed significantly due to application of graded levels of human urine and cattle urine (Table 4.35). Significantly higher magnesium uptake by tomato crop was registered in 2 times recommended dose of nitrogen through human urine (T_6: 11.06 kg ha^{-1}) and it was on par with T_9, T_3, T_5 T_8 and T_2. Significantly lower magnesium uptake was recorded with recommended dose of nitrogen through chemical fertilizer (T_1: 6.06 kg ha^{-1}) and it was at par with T_4 and T_7. The same trend was observed at all the stages of crop in laterite soil also.

In black soil, the magnesium uptake differed significantly due to application of graded levels of human urine and cattle urine. Significantly higher magnesium uptake was registered in 2 times recommended dose of nitrogen through chemical fertilizer (T_3: 15.08 kg ha^{-1}) which was on par with T_6, T_9, $T_{2,}$ T_5 and T_8. Recommended dose of nitrogen through cattle urine to crop (T_7) recorded significantly lower magnesium uptake (8.28 kg ha^{-1}) and it was at par with T_4 and T_1 treatments.

Table 4.36: Calcium, magnesium and sulfur uptake (kg ha^{-1}) by tomato crop as influenced by graded levels of human urine, cattle urine and fertilizer at harvest in three different soils

Treatments	Red soil			Laterite soil			Black soil		
	Calcium	Magnesium	Sulfur	Calcium	Magnesium	Sulfur	Calcium	Magnesium	Sulfur
T_1	14.8	6.06	5.36	11.8	5.62	5.19	20.35	9.11	6.95
T_2	21.8	8.92	7.76	18.3	8.36	7.91	28.43	13.24	9.96
T_3	25.2	10.36	8.95	21.0	9.54	8.90	32.24	15.08	11.49
T_4	16.2	6.58	5.80	13.2	6.17	5.76	19.50	8.64	6.61
T_5	23.1	9.44	8.21	19.4	8.79	8.19	27.99	12.93	9.73
T_6	27.0	11.06	9.60	22.6	10.28	9.55	31.84	14.70	11.27
T_7	15.5	6.41	5.64	12.6	5.87	5.49	18.96	8.28	6.30
T_8	22.4	9.17	7.98	18.6	8.49	7.96	27.44	12.55	9.53
T_9	26.4	10.73	9.28	21.8	10.00	9.23	30.50	14.11	10.80
S.Em±	**1.5**	**0.53**	**0.47**	**0.9**	**0.53**	**0.55**	**1.36**	**0.72**	**0.57**
C.D. (P=0.01)	**6.0**	**2.17**	**1.92**	**3.8**	**2.18**	**2.25**	**5.58**	**2.94**	**2.33**

Legend :

T_1 : Control-Recommended dose of NPK

T_2 : 1.5 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_3 : 2 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_4 : Recommended dose of N through Human urine + Balance P & K

T_5 : 1.5 times the recommended dose of N through Human urine + Balance P & K

Note : -Balance P and K supplied through SSP and MOP respectively

: -Applied gypsum @ 6.45g l^{-1} urine to all urine applied treatments

T_6 : 2 times the recommended dose of N through Human urine + Balance P & K

T_7 : Recommended dose of N through Cattle urine + Balance P & K

T_8 : 1.5 times the recommended dose of N through Cattle urine + Balance P & K

T_9 : 2 times the recommended dose of N through Cattle urine + Balance P & K

RDF: 250:250:250 kg N, P_2O_5, K_2O ha^{-1}

Source of nutrients: human urine, cattle urine and chemical fertilizers

Where- N-Nitrogen**; P-**Phosphorus**; K-**Potassium**.**

4.14.6 Sulfur uptake (kg ha^{-1})

Sulfur uptake by tomato crop grown in different soil differed significantly due to application of graded levels of human urine and cattle urine under different soil are furnished in Table 4.36.

The sulfur uptake by tomato in red soil was significantly higher due to application of 2 times recommended dose of nitrogen through human urine (T_6: 9.60 kg ha^{-1}) which was on par with T_9, T_3, T_5 T_8 and T_2. Application of recommended dose of nitrogen through chemical fertilizer (T_1) recorded significantly lower sulfur uptake (5.36 kg ha^{-1}) and it was at par with T_4 and T_7 treatments. Similar trend was observed in laterite soil also.

In case of black soil, sulfur uptake differed significantly due to application of graded levels of human urine and cattle urine. Significantly higher sulfur uptake was registered in 2 times recommended dose of nitrogen through chemical fertilizer (T_3: 11.49 kg ha^{-1}) which was on par with T_6, T_9, $T_{2,}$ T_5 and T_8. Recommended dose of nitrogen through cattle urine to crop (T_7) recorded significantly lower sulfur content (6.30 kg ha^{-1}) and it was at par with T_4 and T_1 treatments.

4.14.7 Iron uptake (g ha^{-1})

Iron uptake by tomato crop as influenced by application of graded levels of human urine and cattle urine are given in Table 4.37.

Iron uptake by tomato crop grown in red soil was significantly influenced by application of graded levels of human urine and cattle urine. Iron uptake was significantly higher in 2 times the recommended dose of N through human urine (T_6: 329.5 g ha^{-1}) which was significantly superior over T_7, T_4 and T_1, but was on par with rest of the treatments. Similar trend was observed in the tomato crop grown in laterite soil also.

Iron uptake by tomato crop grown in black soil differed significantly among the treatments. It was significantly higher in treatment receiving 2 times the recommended dose of N through chemical fertilizers (T_3: 356.6 g ha^{-1}) and it was on par with T_6, T_9, $T_{2,}$

T_5 and T_8 treatments. Significantly lower iron uptake (203.0 g ha^{-1}) was recorded with recommended dose of N through cattle urine (T_7) which was at par with T_4 and T_1.

4.14.8 Manganese uptake (g ha^{-1})

Manganese uptake by tomato crop grown in three soils as influenced by application of graded levels of human urine and cattle urine are presented in Table 4.37.

Manganese uptake by tomato crop grown in red soil differed significantly due to application of graded levels of human urine and cattle urine (Table 4.37). Significantly higher manganese uptake was registered in treatment receiving 2 times the recommended of N through human urine (T_6: 221.3 g ha^{-1}) over recommended dose of N through human urine (T_4: 132.4 g ha^{-1}), recommended dose of N through cattle urine (T_7: 127.4 g ha^{-1}) and recommended dose of N through chemical fertilizers (T_1: 121.2 g ha^{-1}) but rest of treatments were on par with T_6 treatment. Similar trend was observed in tomato crop grown in laterite soil also.

In case of black soil, the manganese uptake varied significantly due to application of graded levels of human and cattle urine. Manganese uptake was significantly higher in treatment receiving 2 times the recommended dose of N through chemical fertilizers (T_3: 256.0 g ha^{-1}), which was significantly superior over T_7, T_4 and T_7 but on par with rest of the treatments.

4.14.9 Zinc uptake (g ha^{-1})

Zinc uptake by tomato crop grown in different soils as influenced by application of graded levels of human urine and cattle urine applied to three different soil are furnished in Table 4.37.

The zinc uptake by tomato crop grown in red soil was significantly higher (79.4 g ha^{-1}) in treatment receiving 2 times recommended dose of nitrogen through human urine (T_6) which was on par with T_9, T_3, T_5 T_8 and T_2 treatments. Application of recommended dose of nitrogen through chemical fertilizer (T_1) recorded significantly lower zinc uptake

(43.3 g ha^{-1}) and it was at par with T_4 and T_7 treatments. Similar trend was observed in laterite soil also (Table 4.37).

In case of black soil, zinc uptake by tomato crop differed significantly due to application of graded levels of human urine and cattle urine. Significantly higher zinc uptake by plant was registered in 2 times recommended dose of nitrogen through chemical fertilizer (T_3: 90.9 g ha^{-1}) which was on par with T_6, T_9, T_2, T_5 and T_8 treatments. Recommended dose of nitrogen through cattle urine (T_7) recorded significantly lower zinc content (51.1 g ha^{-1}) and it was at par with T_4 and T_1.

4.14.10 Copper uptake (g ha^{-1})

Copper uptake by tomato crop as influenced by application of graded levels of human urine and cattle urine are given in Table 4.37.

Copper uptake by tomato crop grown in red soil was significantly influenced by application of graded levels of human urine and cattle urine (Table 4.37). Copper uptake was significantly higher in treatment receiving 2 times the recommended dose of N through human urine (T_6: 41.1 g ha^{-1}) which was significantly superior over T_7, T_4 and T_1, but was on par with rest of the treatments. Similar trend was observed in the tomato crop grown in laterite soil also.

Copper uptake by tomato crop grown in black soil was significantly influenced by application of graded levels of human and cattle urine. It was significantly higher (49.6 g ha^{-1}) in application of 2 times the recommended dose of N through chemical fertilizers (T_3) and it was on par with T_6, T_9, T_2, T_5 and T_8 treatments. Significantly lower copper uptake (30.4 g ha^{-1}) was recorded with recommended dose of N through cattle urine (T_7) which was at par with T_4 and T_1.

4.15 Chemical properties of soil

The data on pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, and potassium, exchangeable calcium, magnesium and sodium available sulfur, and DTPA extractable iron, manganese, zinc and copper content of three different

Table 4.37: Iron, manganese, zinc and copper uptake (g ha^{-1}) by tomato crop as influenced by graded levels of human urine, cattle urine and fertilizer at harvest in three different soils

Treatments	Red soil				Laterite soil				Black soil			
	Iron	Manganese	Zinc	Copper	Iron	Manganese	Zinc	Copper	Iron	Manganese	Zinc	Copper
T_1	176.1	121.2	43.3	23.9	162.3	107.5	36.3	21.3	219.0	159.0	55.1	31.9
T_2	264.2	176.9	63.3	32.9	239.7	156.7	52.8	29.7	318.0	226.4	79.3	44.0
T_3	304.6	205.0	73.2	37.8	267.4	178.9	61.4	34.5	356.6	256.0	90.9	49.6
T_4	197.3	132.4	47.3	25.3	177.2	116.9	39.5	22.8	210.5	153.3	52.9	31.3
T_5	281.4	188.9	67.7	35.0	250.7	165.1	56.1	31.5	310.9	221.0	77.2	42.9
T_6	329.5	221.3	79.4	41.1	291.8	192.8	65.6	36.9	353.3	249.6	89.3	48.4
T_7	189.5	127.4	45.9	24.4	170.5	111.8	38.0	21.9	203.0	148.1	51.1	30.4
T_8	270.4	182.7	65.0	34.0	244.6	159.1	54.3	30.5	302.5	214.8	75.6	41.3
T_9	323.3	216.1	77.9	39.9	282.8	187.5	64.3	37.7	338.6	226.3	84.1	45.9
S.Em±	**17.1**	**11.7**	**4.8**	**2.1**	**12.9**	**10.8**	**3.2**	**2.0**	**14.0**	**12.5**	**3.8**	**2.1**
C.D. (P=0.01)	**70.0**	**47.9**	**19.8**	**8.4**	**52.7**	**44.1**	**13.2**	**8.2**	**57.4**	**51.2**	**15.5**	**8.5**

Legend :

T_1 : Control-Recommended dose of NPK

T_2 : 1.5 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_3 : 2 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_4 : Recommended dose of N through Human urine + Balance P & K

T_5 : 1.5 times the recommended dose of N through Human urine + Balance P & K

Note : -Balance P and K supplied through SSP and MOP respectively

: -Applied gypsum @ 6.45g l^{-1} urine to all urine applied treatments

T_6 : 2 times the recommended dose of N through Human urine + Balance P & K

T_7 : Recommended dose of N through Cattle urine + Balance P & K

T_8 : 1.5 times the recommended dose of N through Cattle urine + Balance P & K

T_9 : 2 times the recommended dose of N through Cattle urine + Balance P & K

RDF: 250:250:250 kg N, P_2O_5, K_2O ha^{-1}

Source of nutrients: human urine, cattle urine and chemical fertilizers

Where- N-Nitrogen**; P**-Phosphorus**; K**-Potassium**.**

soils (red, laterite and black) as influenced by application of graded levels of human and cattle urine are presented in Table 4.38 to 4.41.

4.15.1 Soil pH

The data on soil pH after harvest of tomato crop differed significantly due to application of graded levels of human urine, cattle urine and fertilizer to three different soils (Table 4.38).

The soil pH differed significantly due to rate of application of human urine, cattle urine and fertilizer at harvest of tomato crop.

Significantly higher soil pH was recorded in red soil with application of 2 times recommended dose of nitrogen through human urine (T_6: 7.54) which was on par with 2 times recommended dose of nitrogen through cattle urine (T_9), 2 times recommended dose of nitrogen through chemical fertilizers (T_3) and 1.5 times recommended dose of nitrogen through human urine (T_5), cattle urine (T_8) and fertilizers (T_2). Recommended dose of nitrogen through chemical fertilizers (T_1) recorded significantly lower soil pH (6.26) and it was on par with recommended dose of nitrogen through human urine (T_4) and cattle urine (T_7). Similar trend was observed after harvest of tomato crop in laterite soil also.

In black soil, significantly higher soil pH was recorded with application of 2 times the recommended dose of nitrogen through chemical fertilizers (T_3: 9.07) and it was on par with 2 times the recommended dose of nitrogen through human urine (T_6) and cattle urine (T_9) and 1.5 times recommended dose of nitrogen through fertilizers (T_2), human urine (T_5) and cattle urine (T_8). Significantly lower pH was recorded with recommended dose of nitrogen through cattle urine (T_7: 8.33) and it was on par with recommended dose of nitrogen through human urine (T_4) and chemical fertilizer (T_1).

4.15.2 Electrical conductivity (dS m^{-1})

Data on electrical conductivity (EC) of soil showed significant difference due to treatments after the harvest of tomato crop (Table 4.38).

Table 4.38: Effect of graded levels of human urine, cattle urine and fertilizer application on soil pH and electrical conductivity ($dS\ m^{-1}$) at harvest of the tomato in three different soils.

Treatments	Red soil		Laterite soil		Black soil	
	pH	EC	pH	EC	pH	EC
T_1	6.26	0.13	5.14	0.12	8.33	0.36
T_2	6.75	0.17	5.54	0.16	8.48	0.42
T_3	7.45	0.24	6.11	0.23	9.02	0.44
T_4	6.41	0.14	5.25	0.14	8.39	0.37
T_5	7.00	0.22	5.74	0.21	8.84	0.43
T_6	7.54	0.28	6.18	0.27	9.07	0.45
T_7	6.30	0.14	5.16	0.13	8.33	0.37
T_8	6.79	0.19	5.57	0.18	8.52	0.43
T_9	7.48	0.28	6.16	0.26	9.03	0.45
S.Em±	**0.25**	**0.03**	**0.22**	**0.03**	**0.13**	**0.01**
C.D.(P=0.01)	**1.02**	**0.12**	**0.92**	**0.12**	**0.51**	**0.06**

Legend :

T_1 : Control-Recommended dose of NPK

T_2 : 1.5 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_3 : 2 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_4 : Recommended dose of N through Human urine + Balance P & K

T_5 : 1.5 times the recommended dose of N through Human urine + Balance P & K

Note : -Balance P and K supplied through SSP and MOP respectively

: -Applied gypsum @ 6.45g l^{-1} urine to all urine applied treatments

T_6 : 2 times the recommended dose of N through Human urine + Balance P & K

T_7 : Recommended dose of N through Cattle urine + Balance P & K

T_8 : 1.5 times the recommended dose of N through Cattle urine + Balance P & K

T_9 : 2 times the recommended dose of N through Cattle urine + Balance P & K

RDF: 250:250:250 kg N, P_2O_5, K_2O ha^{-1}

Source of nutrients: human urine, cattle urine and chemical fertilizers

Where- N-Nitrogen**; P**-Phosphorus**; K**-Potassium**.**

Significantly higher EC at harvest of tomato crop in red soil was recorded in treatment receiving 2 times recommended dose of nitrogen through human urine (T_6: 0.28 dS m^{-1}) which was on par with T_9, T_3, T_5 T_8 and T_2. Recommended dose of nitrogen through chemical fertilizer (T_1) recorded significantly lower EC (0.13 dS m^{-1}) and it was at par with T_4 and T_7. The same trend was observed at harvest of tomato crop in laterite soil also.

Where as in case of black soil, significantly higher EC at harvest of the crop was recorded in treatment receiving 2 times recommended dose of nitrogen through chemical fertilizer (T_3: 9.07 dS m^{-1}) which was on par with T_6, T_9, $T_{2,}$ T_5 and T_8. Recommended dose of nitrogen through cattle urine to crop (T_7) recorded significantly lower EC (8.33 dS m^{-1}) and it was at par with T_4 and T_1.

4.15.3 Available nitrogen (kg ha^{-1}) in soil

Application of different rates of human urine and cattle urine to three different soils had significant influence on available N content of soil at harvest of tomato crop (Table 4.39).

The available nitrogen content of red soil varied significantly due to application of graded levels of human urine and cattle urine and was highest in treatment receiving 2 times recommended dose of nitrogen through human urine (T_6: 262.1 kg ha^{-1}) and it was on par with T_9, T_3, T_5 T_8 and T_2. Significantly lower available nitrogen was noticed with treatment receiving recommended dose of nitrogen through chemical fertilizer (T_1: 231.9 kg ha^{-1}). Similar results were observed in laterite soil also.

In black soil, the available nitrogen content varied significantly due to application of graded levels of human urine and cattle urine and was highest in treatment receiving 2 times recommended dose of nitrogen through chemical fertilizers (T_3: 412.0 kg ha^{-1}), it was on par with T_6, T_9, $T_{2,}$ T_5 and T_8. Significantly lower available nitrogen was noticed with recommended dose of nitrogen through cattle urine (T_7) is 341.9 kg $ha^{-1}$and it was on par with T_4 and T_1 treatments.

4.15.4 Available phosphorus (kg ha^{-1})

The data on available P_2O_5 content of soil differed significantly due to the application of different quanties of human urine and cattle urine to tomato crop (Table 4.39).

In red soil, application of 2 times recommended dose of nitrogen through human urine (T_6) registered significantly higher available phosphorus (32.0 kg ha^{-1}) and it was on par with T_9, T_3, $T_{5,}$ T_8 and T_2 treatments. Same trend was noticed in laterite soil also at harvest.

In black soil, the available phosphorus content varied significantly due to application of graded levels of human urine and cattle urine and was highest in treatment receiving 2 times recommended dose of nitrogen through chemical fertilizers (T_3: 21.5 kg ha^{-1}), it was on par with T_6, T_9, $T_{2,}$ T_5 and T_8. Significantly lower available phosphorus was noticed with recommended dose of nitrogen through cattle urine (T_7) and it was on par with T_4 and T_1 treatments.

4.15.5 Available potassium (kg ha^{-1})

Application of graded levels of human urine and cattle urine had significant influence on available K_2O content of soil at harvest of tomato crop grown in different soils (Table 4.39).

The available potassium content of red soil varied significantly due to application of graded levels of human urine and cattle urine and was highest in treatment receiving 2 times recommended dose of nitrogen through human urine (T_6: 355.7 kg ha^{-1}) and was on par with T_9, T_3, T_5 T_8 and T_2 treatments. Significantly lower available nitrogen (316.1 kg ha^{-1}) was noticed with recommended dose of nitrogen through chemical fertilizers to soil (T_1). Similar results were observed in laterite soil also.

In black soil, the available nitrogen content varied significantly due to application of different quantities of human urine and cattle urine and was highest in treatments receiving 2 times recommended dose of nitrogen through chemical fertilizers (T_3: 556.9

Table 4.39: Effect of graded levels of human urine, cattle urine and fertilizer application on available nitrogen, phosphorus and potassium (kg ha^{-1}) at harvest of the tomato in three different soils.

Treatments	Red soil			Laterite soil			Black soil		
	Avail. N	Avail. P_2O_5	Avail. K_2O	Avail. N	Avail. P_2O_5	Avail. K_2O	Avail. N	Avail. P_2O_5	Avail. K_2O
T_1	231.9	24.5	316.1	207.3	11.0	104.3	356.3	17.8	502.8
T_2	241.7	28.1	330.7	216.1	12.6	109.1	392.4	20.4	529.0
T_3	261.5	30.7	344.7	225.6	13.8	119.6	412.0	21.5	556.9
T_4	227.7	25.5	309.9	203.5	11.5	102.3	348.0	17.5	498.7
T_5	251.8	29.7	345.5	225.1	13.4	114.0	388.6	20.2	522.3
T_6	262.1	32.0	355.7	228.6	14.4	123.6	409.4	21.5	549.0
T_7	224.5	25.2	309.0	200.6	11.3	102.0	341.9	17.2	486.7
T_8	249.1	28.8	340.4	222.7	13.0	112.3	380.8	19.9	519.6
T_9	262.0	31.8	349.1	226.3	14.3	120.0	402.2	20.9	543.3
S.Em±	**6.65**	**1.3**	**10.3**	**5.8**	**0.5**	**3.4**	**12.2**	**0.5**	**11.7**
C.D. (P=0.01)	**27.25**	**5.4**	**42.1**	**23.8**	**2.2**	**14.0**	**50.0**	**1.9**	**48.0**

Legend :

T_1 : Control-Recommended dose of NPK

T_2 : 1.5 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_3 : 2 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_4 : Recommended dose of N through Human urine + Balance P & K

T_5 : 1.5 times the recommended dose of N through Human urine + Balance P & K

T_6 : 2 times the recommended dose of N through Human urine + Balance P & K

T_7 : Recommended dose of N through Cattle urine + Balance P & K

T_8 : 1.5 times the recommended dose of N through Cattle urine + Balance P & K

T_9 : 2 times the recommended dose of N through Cattle urine + Balance P & K

Note : -Balance P and K supplied through SSP and MOP respectively

: -Applied gypsum @ 6.45g l^{-1} urine to all urine applied treatments

RDF: 250:250:250 kg N, P_2O_5, K_2O ha^{-1}

Source of nutrients: human urine, cattle urine and chemical fertilizers

Where- N-Nitrogen**; P**-Phosphorus**; K**-Potassium**.**

kg ha^{-1}) it was on par with T_6, T_9, $T_{2,}$ T_5 and T_8 treatments. Significantly lower available potassium (486.7 kg ha^{-1}) was noticed with recommended dose of nitrogen through cattle urine (T_7) and it was at par with T_4 and T_1.

4.15.6 Exchangeable calcium (cmol (p^+) kg^{-1})

The data on exchangeable calcium content of red soil showed significant differences after harvest of tomato crop (Table 4.40). Exchangeable calcium content of soil was significantly higher in treatment receiving 2 times the recommended dose of nitrogen through human urine (T_6: 4.30 cmol (p^+) kg^{-1}) and it was on par with T_9, T_3, $T_{5,}$ T_8 and T_2 treatments. Significantly lower exchangeable calcium (3.73 cmol (p^+) kg^{-1}) was recorded with application of recommended dose of nitrogen through chemical fertilizers (T_1) and it was on par with T_4 and T_7 treatments. Similar results were recorded at harvest of tomato crop in laterite soil also.

In black soil, the exchangeable calcium content at harvest of tomato crop was significantly higher (32.70 cmol (p^+) kg^{-1}) with application of 2 times recommended dose of nitrogen through chemical fertilizers (T_3) and it was at par with T_6, T_9, $T_{2,}$ T_5 and T_8 treatments. Significantly lower exchangeable calcium was recorded with recommended dose of nitrogen through cattle urine (T_7: 27.45 cmol (p^+) kg^{-1}) and it was on par with T_4 and T_1 treatments.

4.15.7 Exchangeable magnesium (cmol (p^+) kg^{-1})

Exchangeable magnesium content of red soil after harvest of tomato crop varied significantly due to different levels of human urine and cattle urine (Table 4.40). Exchangeable magnesium was significantly higher in treatment receiving 2 times recommended dose of nitrogen through human urine (T_6: 1.85 cmol (p^+) kg^{-1}) and it was on par with T_9, T_3, $T_{5,}$ T_8 and T_2 treatments. Significantly lower exchangeable magnesium was recorded with application of recommended dose of nitrogen through chemical fertilizers (T_1: 1.65 cmol (p^+) kg^{-1}) and it was on par with T_4 and T_7 treatment. Similar results were recorded at harvest of tomato crop in laterite soil also.

In black soil, the exchangeable magnesium content at harvest of tomato crop was significantly higher (11.77 cmol (p^+) kg^{-1}) with 2 times the recommended dose of nitrogen through chemical fertilizers (T_3) and it was ar par with T_6, T_9, $T_{2,}$ T_5 and T_8. Significantly lower exchangeable magnesium (10.24 cmol (p^+) kg^{-1}) was noticed with recommended dose of nitrogen through cattle urine applied to soil (T_7) and it was on par with T_4 and T_1 treatments.

4.15.8 Available sulfur (kg ha^{-1})

Data on available S content of soil as influenced by application of graded levels of human urine and cattle urine is presented in Table 4.40.

Application of 2 times the recommended dose of nitrogen through human urine recorded highest available sulfur (T_6: 11.15 kg ha^{-1}) in soil and it was on par with T_9, T_3, $T_{5,}$ T_8 and T_2 treatments but was found to be significantly superior over rest of the treatments ($T_{1,}$ T_4 and T_7). Significantly lower available S content (9.79 kg ha^{-1}) was recorded with the application of recommended dose of nitrogen through chemical fertilizers to soil (T_1) and it was at par with recommended dose of nitrogen through human urine (T_4) and cattle urine (T_7). Similar trend was observed at harvest of tomato crop in laterite soil also.

Significantly higher available sulfur (13.89 kg ha^{-1}) at harvest of tomato crop in black soil was recorded with 2 times the recommended dose of nitrogen through chemical fertilizers (T_3) which was on par with T_6, T_9, $T_{2,}$ T_5 and T_8 treatments. Recommended dose of nitrogen through cattle urine (T_7) recorded significantly lower available sulfur (12.09 kg ha^{-1}) and it was at par with T_4 and T_7 treatments.

4.15.9 Exchangeable sodium (cmol (p^+) kg^{-1}) in soil

The data on exchangeable sodium content of soil as influenced by application of graded levels of human urine and cattle urine are presented in Table 4.40. Exchangeable sodium content of soil varied significantly among the treatments in all the three soils.

Table 4.40: Effect of graded levels human urine, cattle urine and fertilizer application on exchangeable calcium [cmol (p+) kg^{-1}], magnesium [cmol (p+) kg^{-1}], sodium [cmol (p+) kg^{-1}] and available sulphur (kg ha^{-1}) content in three different soils at harvest of the tomato.

Treatments	Red soil				Laterite soil				Black soil			
	Exch. Ca	Exch. Mg	Exch. Na	Avial. S	Exch. Ca	Exch. Mg	Exch. Na	Avial. S	Exch. Ca	Exch. Mg	Exch. Na	Avial. S
T_1	3.73	1.65	0.12	9.79	3.73	1.65	0.10	5.45	28.34	10.18	0.66	12.01
T_2	4.01	1.74	0.17	10.45	4.02	1.74	0.17	6.25	30.33	10.92	0.68	12.89
T_3	4.18	1.82	0.21	10.87	4.18	1.82	0.20	6.67	32.70	11.77	0.73	13.89
T_4	3.77	1.68	0.14	9.96	3.77	1.68	0.12	5.76	27.84	10.08	0.66	11.90
T_5	4.08	1.79	0.19	10.65	4.08	1.79	0.18	6.45	29.65	10.68	0.71	12.60
T_6	4.30	1.85	0.25	11.15	4.30	1.85	0.24	6.95	31.59	11.37	0.76	13.42
T_7	3.73	1.66	0.13	9.78	3.73	1.66	0.11	5.58	27.45	10.24	0.65	12.09
T_8	4.03	1.76	0.17	10.46	4.03	1.76	0.17	6.26	29.02	10.45	0.69	12.33
T_9	4.21	1.85	0.25	11.10	4.21	1.85	0.23	6.90	31.18	11.23	0.74	13.25
S.Em±	**0.08**	**0.04**	**0.02**	**0.18**	**0.12**	**0.04**	**0.02**	**0.27**	**1.03**	**0.36**	**0.03**	**0.42**
C.D. (P=0.01)	**0.32**	**0.15**	**0.08**	**0.73**	**0.51**	**0.16**	**0.07**	**1.10**	**4.23**	**1.47**	**0.13**	**1.74**

Legend :

T_1 : Control-Recommended dose of NPK

T_2 : 1.5 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_3 : 2 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_4 : Recommended dose of N through Human urine + Balance P & K

T_5 : 1.5 times the recommended dose of N through Human urine + Balance P & K

Note : -Balance P and K supplied through SSP and MOP respectively

: -Applied gypsum @ 6.45g l^{-1} urine to all urine applied treatments

T_6 : 2 times the recommended dose of N through Human urine + Balance P & K

T_7 : Recommended dose of N through Cattle urine + Balance P & K

T_8 : 1.5 times the recommended dose of N through Cattle urine + Balance P & K

T_9 : 2 times the recommended dose of N through Cattle urine + Balance P & K

RDF: 250:250:250 kg N, P_2O_5, K_2O ha^{-1}

Source of nutrients: human urine, cattle urine and chemical fertilizers

Where- N-Nitrogen**; P**-Phosphorus**; K**-Potassium**.**

Exchangeable sodium content of soil at harvest, was significantly higher in treatment receiving 2 times the recommended dose of nitrogen through human urine (T_6: 0.25 cmol (p^+) kg^{-1}) and it was at par with T_9, T_3, T_5, T_8 and T_2 treatment but was found to be significantly superior over rest of the treatments (T_1, T_4 and T_7). Significantly lower exchangeable sodium content (0.12 cmol (p^+) kg^{-1}) was recorded with application of recommended dose of nitrogen through chemical fertilizers to soil (T_1) and it was at par with T_4 and T_7 treatments. Similar trend was observed in laterite soil also.

In case of black soil, exchangeable sodium varied significantly among the treatments at harvest of tomato crop (Table 4.72). Significantly higher exchangeable sodium was registered in treatment receiving 2 times the rate of recommended dose of nitrogen through chemical fertilizers (T_3: 0.76 cmol (p^+) kg^{-1}) and it was on par with T_6, T_9, T_2, T_5 and T_8 treatments. Significantly lower exchangeable sodium (0.66 cmol (p^+) kg^{-1}) was recorded with application of recommended dose of nitrogen through cattle urine to soil (T_7) which was on par with T_1 and T_4.

4.15.10 DTPA Extractable iron (mg kg^{-1})

DTPA-Fe content of soil was significantly influenced by rate of application of human urine and cattle urine to tomato crop in three different soils (Table 4.41). DTPA-Fe was significantly higher in treatment receiving 2 times the recommended dose of nitrogen through human urine under red soil (T_6: 33.42 mg kg^{-1}) and it was on par with T_9, T_3, T_5, T_8 and T_2 treatments. Significantly lower DTPA-Fe was recorded with recommended dose of nitrogen through chemical fertilizers (T_1: 30.01 mg kg^{-1}) which was at par with T_4 and T_7 treatments. Similar results were observed in laterite soil also.

In black soil, application of 2 times the recommended dose of nitrogen through chemical fertilizers recorded significantly higher DTPA-Fe (T_3: 13.99 mg kg^{-1}) which was at par with T_6, T_9, T_2, T_5 and T_8 treatments. Recommended dose of nitrogen through cattle urine to crop (T_7) recorded significantly lower DTPA-Fe (12.60 mg kg^{-1}) and it was at par with T_4 and T_1 treatments.

4.15.11 DTPA Extractable manganese (mg kg^{-1})

Data on DTPA extractable manganese content of soil as influenced by application of graded levels of human urine and cattle urine to tomato crop in different soil is presented in Table 4.41.

Application of 2 times the recommended dose of nitrogen through human urine (T_6) recorded significantly higher DTPA extractable manganese (18.42 mg kg^{-1}) in red soil and it was significantly superior over recommended dose of nitrogen through chemical fertilizers (T_1: 15.01 mg kg^{-1}), human urine (T_4: 15.26 mg kg^{-1}) and cattle urine (T_7: 15.07 mg kg^{-1}) but it was at par with T_9, T_3, T_5, T_8 and T_2 treatments. Similar trend was noticed at harvest of tomato crop in laterite soil also.

In black soil, DTPA extractable manganese content varied significantly due to application of graded levels of human and cattle urine and was higher (10.00 mg kg^{-1}) with 2 times the recommended dose of nitrogen through chemical fertilizers (T_3), which was significantly superior over T_1, T_4 and T_7 but was on par with rest of the treatments.

4.15.12 DTPA Extractable zinc (mg kg^{-1})

DTPA-Zn was significantly influenced by application of graded levels of human urine and cattle urine to tomato crop in three different soils (Table 4.41). DTPA- Zn content of soil was significantly higher in treatment receiving 2 times the recommended dose of nitrogen through human urine in red soil (T_6: 3.01 mg kg^{-1}) and it was on par with T_9, T_3, T_5, T_8 and T_2 treatments. Significantly lower DTPA- Zn was recorded with recommended dose of nitrogen through chemical fertilizers (T_1: 1.48 mg kg^{-1}) which was at par with T_4 and T_7 treatments. Similar results were observed in laterite soil also.

In black soil, application of 2 times the recommended dose of nitrogen through chemical fertilizers recorded significantly higher DTPA- Zn (T_3: 1.68 mg kg^{-1}) which was at par with T_6, T_9, T_2, T_5 and T_8 treatments. Recommended dose of nitrogen through cattle urine to crop (T_7) recorded significantly lower DTPA- Zn (1.35 mg kg^{-1}) and it was at par with T_4 and T_1 treatments.

Table 4.41: Effect of graded levels of human urine, cattle urine and fertilizer application on DTPA extractable micronutrients (mg kg^{-1}) content in three different soils at harvest of the tomato.

Treatments	Red soil				Laterite soil				Black soil			
	DTPA-Fe	DTPA-Mn	DTPA-Zn	DTPA-Cu	DTPA-Fe	DTPA-Mn	DTPA-Zn	DTPA-Cu	DTPA-Fe	DTPA-Mn	DTPA-Zn	DTPA-Cu
T_1	30.01	15.01	1.48	1.45	35.71	19.06	1.56	1.52	12.52	8.62	1.39	1.24
T_2	31.35	16.35	2.37	2.25	37.31	20.77	2.49	2.41	13.43	9.28	1.60	1.43
T_3	32.60	17.60	2.80	2.67	38.79	22.35	2.94	2.86	13.99	10.00	1.68	1.50
T_4	30.26	15.26	1.80	1.76	36.01	19.38	1.89	1.88	12.40	8.57	1.37	1.22
T_5	32.11	17.11	2.55	2.45	38.21	21.73	2.68	2.63	13.13	9.07	1.59	1.42
T_6	33.42	18.42	3.01	2.95	39.77	23.40	3.16	3.12	13.97	9.66	1.67	1.49
T_7	30.07	15.07	1.61	1.58	35.78	19.13	1.69	1.68	12.60	8.70	1.35	1.21
T_8	31.59	16.59	2.39	2.26	37.59	21.06	2.51	2.42	12.85	8.87	1.56	1.39
T_9	33.29	18.29	2.96	2.90	39.61	23.22	3.10	3.11	13.81	9.54	1.64	1.47
S.Em±	**0.51**	**0.66**	**0.16**	**0.18**	**0.77**	**0.97**	**0.18**	**0.18**	**0.47**	**0.33**	**0.06**	**0.04**
C.D. (P=0.01)	**2.11**	**2.71**	**0.67**	**0.73**	**3.15**	**3.98**	**0.73**	**0.72**	**1.92**	**1.34**	**0.24**	**0.16**

Legend :

T_1 : Control-Recommended dose of NPK

T_2 : 1.5 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_3 : 2 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_4 : Recommended dose of N through Human urine + Balance P & K

T_5 : 1.5 times the recommended dose of N through Human urine + Balance P & K

Note : -Balance P and K supplied through SSP and MOP respectively

: -Applied gypsum @ 6.45g l^{-1} urine to all urine applied treatments

T_6 : 2 times the recommended dose of N through Human urine + Balance P & K

T_7 : Recommended dose of N through Cattle urine + Balance P & K

T_8 : 1.5 times the recommended dose of N through Cattle urine + Balance P & K

T_9 : 2 times the recommended dose of N through Cattle urine + Balance P & K

RDF: 250:250:250 kg N, P_2O_5, K_2O ha^{-1}

Source of nutrients: human urine, cattle urine and chemical fertilizers

Where- N-Nitrogen**; P-**Phosphorus**; K-**Potassium**.**

4.15.13 DTPA Extractable copper (mg kg^{-1})

Data on DTPA extractable copper content of soil in different soils as influenced by application of human urine and cattle urine to tomato crop is given in Table 4.41.

Application of 2 times the recommended dose of nitrogen through human urine (T_6) recorded significantly higher DTPA extractable copper (2.95 mg kg^{-1}) in red soil and it was significantly superior over recommended dose of nitrogen through chemical fertilizers (T_1: 1.45 mg kg^{-1}), human urine (T_4: 1.76 mg kg^{-1}) and cattle urine (T_7: 1.58 mg kg^{-1}) but it was at par with T_9, T_3, T_5, T_8 and T_2 treatments. Similar trend was noticed at harvest of tomato crop in laterite soil also.

In black soil, DTPA extractable copper content of soil varied significantly due to application of graded levels of human and cattle urine and was higher in treatment receiving 2 times recommended dose of nitrogen through chemical fertilizers (T_3: 1.49 mg kg^{-1}), which was significantly superior over T_1, T_4 and T_7 treatments but was on par with rest of the treatments.

4.16 Soil microbial population

The data on soil microbial population as influenced by rate of application of human urine and cattle urine to tomato crop grown in three different soils is presented in Table 4.42a and 4.42b.

4.16.1 Soil fungi (CFUx10^4 g^{-1} soil)

The population of soil fungi differed significantly due to application of human urine and cattle urine to tomato crop in red soil (Table 4.42a). Application of 2 times the recommended dose of N through human urine (T_6) recorded significantly higher soil fungi population (7.83 CFUx10^4 g^{-1} soil) over recommended dose of N through cattle urine (T_7: 6.29 CFUx10^4 g^{-1} soil) and recommended dose of N through chemical fertilizers (T_1: 6.16 CFUx10^4 g^{-1} soil) but rest of the treatments were on par with T_6 treatment. Similar trend of results was also observed in tomato crop grown in laterite soil also.

The data on population of soil fungi in black soil at harvest of tomato crop as influenced by application of graded levels of human and cattle urine is presented in Table 4.42b. Soil fungi population varied significantly among the treatments. Population of soil fungi was significantly higher in treatment receiving 2 times the recommended dose of N through chemical fertilizers (T_3: 10.30 CFUx10^4 g^{-1} soil) and it was on par with T_6, T_9, T_2, T_5 and T_8 treatments. Significantly lower soil fungi population was recorded with recommended dose N through cattle urine (T_7: 8.27 CFUx10^4 g^{-1} soil) which was at par with T_4 and T_1 treatments.

4.16.2 Soil bacteria (CFUx10^7 g^{-1} soil)

The data on soil bacterial population as influenced by application of graded levels of human urine and cattle urine to tomato crop grown in red soil are presented in Table 4.42a. The soil bacterial population varied significantly among the treatments in rhizosphere soil of tomato crop.

Soil bacterial population varied significantly due to application of graded levels of human and cattle urine and higher population (9.40 CFUx10^7 g^{-1} soil) was recorded in treatment receiving 2 times the recommended dose of N through human urine (T_6) which was significantly superior over T_7, T_4 and T_1 treatments, but was on par with rest of the treatments. Similar trend was observed in the laterite soil also.

In black soil, the bacterial population varied significantly due to application of graded levels of human and cattle urine (Table 4.42b.). Application of 2 times the recommended dose of nitrogen through chemical fertilizers showed significantly higher bacterial population (T_3: 7.95 CFUx10^7 g^{-1} soil) and it was on par with 2 times the recommended dose of nitrogen through human urine (T_6: 7.90 CFUx10^7 g^{-1} soil) and 2 times the recommended dose of nitrogen through cattle urine (T_9: 7.76 CFUx10^7 g^{-1} soil). Significantly lower bacterial population (6.38 CFUx10^7 g^{-1} soil) was recorded with recommended dose of nitrogen through cattle urine (T_7) which was at par with T_4 (6.47 CFUx10^7 g^{-1} soil) and T_1 (6.59 CFUx10^7 g^{-1} soil) treatments.

4.16.3 Soil actinomycetes (CFUx10^3 g^{-1} soil)

The population of soil actinomycetes was significantly influenced by application of graded levels of human urine and cattle urine to grow tomato crop in red and laterite soils (Table 4.42a).

Application of 2 times the recommended dose of N through human urine (T_6) recorded significantly maximum population of soil actinomycetes (8.61 CFUx10^3 g^{-1} soil) over recommended dose of N through human urine (T_4: 7.14 CFUx10^3 g^{-1} soil), recommended dose of N through cattle urine (T_7: 6.92 CFUx10^3 g^{-1} soil) and recommended dose of N through chemical fertilizers (T_1: 6.76 CFUx10^3 g^{-1} soil) but rest of treatments were on par with T_6 treatment. Similar trend was observed in laterite soil also.

In case of black soil, actinomycetes population varied significantly due to application of graded levels of human and cattle urine (Table 4.42b). Population of soil actinomycetes was higher in treatment receiving 2 times the recommended dose of N through chemical fertilizers (T_3: 9.54 CFUx10^3 g^{-1}), which was significantly superior over T_1, T_4 and T_7 treatment but on par with rest of the treatments.

4.16.4 N- fixers (CFU x 10^3 g^{-1} soil)

There were significant differences among the treatments with respect to population of N-fixers in soil at harvest of tomato crops (Table 4.42a). At harvest, N-fixers population differed significantly among the treatments in red soil. Among the treatments, application of 2 times of recommended dose of N through human urine (T_6) recorded significantly higher population (5.59 CFUx10^3 g^{-1}) and it was significantly superior over recommended dose of nitrogen through human urine (T_4: 4.56 CFUx10^3 g^{-1}), recommended dose of nitrogen through cattle urine (T_7: 4.49 CFUx10^3 g^{-1}) and recommended dose of nitrogen through chemical fertilizers (T_1: 4.64 CFUx10^3 g^{-1}) but it was at par with T_9, T_3, T_5, T_8 and T_2 treatments. Similar results were observed in laterite soil also.

Table 4.42a: The population of different groups of microorganisms in different soils at harvest of the tomato as influenced by graded levels of human urine, cattle urine and fertilizers.

Treatments	Red Soil					Laterite Soil				
	Fungi ($CFUx10^4$ g^{-1} soil)	Bacteria ($CFUx10^7$ g^{-1} soil)	A ($CFUx10^3$ g^{-1} soil)	N- fixers ($CFUx10^3$ g^{-1} soil)	PS ($CFUx10^3$ g^{-1} soil)	Fungi ($CFUx10^4$ g^{-1} soil)	Bacteria ($CFUx10^7$ g^{-1} soil)	A ($CFUx10^3$ g^{-1} soil)	N- fixers ($CFUx10^3$ g^{-1} soil)	PS ($CFUx10^3$ g^{-1} soil)
T_1	6.16	7.38	6.76	4.64	4.12	9.22	5.73	6.09	4.03	3.67
T_2	7.04	8.45	7.75	5.33	4.86	10.33	6.55	6.97	4.63	4.32
T_3	7.54	9.01	8.26	5.56	5.07	11.27	7.01	7.43	4.83	4.51
T_4	6.49	7.79	7.14	4.56	4.10	9.74	6.04	6.43	3.96	3.65
T_5	7.27	8.73	8.00	5.28	4.81	10.91	6.76	7.20	4.59	4.28
T_6	7.83	9.40	8.61	5.59	5.10	11.74	7.28	7.75	4.87	4.54
T_7	6.29	7.54	6.92	4.49	4.05	9.43	5.85	6.22	3.91	3.61
T_8	7.05	8.46	7.76	5.18	4.72	10.58	6.56	6.98	4.50	4.20
T_9	7.78	9.33	8.57	5.46	4.98	11.66	7.23	7.70	4.75	4.42
S.Em±	**0.24**	**0.27**	**0.22**	**0.12**	**0.13**	**0.37**	**0.13**	**0.21**	**0.11**	**0.14**
C.D. (P=0.01)	**1.00**	**1.11**	**0.90**	**0.50**	**0.55**	**1.50**	**0.54**	**0.85**	**0.44**	**0.58**

Legend :

T_1 : Control-Recommended dose of NPK

T_2 : 1.5 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_3 : 2 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_4 : Recommended dose of N through Human urine + Balance P & K

T_5 : 1.5 times the recommended dose of N through Human urine + Balance P & K

Note : -Balance P and K supplied through SSP and MOP respectively

: -Applied gypsum @ 6.45g l^{-1} urine to all urine applied treatments

T_6 : 2 times the recommended dose of N through Human urine + Balance P & K

T_7 : Recommended dose of N through Cattle urine + Balance P & K

T_8 : 1.5 times the recommended dose of N through Cattle urine + Balance P & K

T_9 : 2 times the recommended dose of N through Cattle urine + Balance P & K

RDF: 250:250:250 kg N, P_2O_5, K_2O ha^{-1}

Source of nutrients: human urine, cattle urine and chemical fertilizers

Where- N-Nitrogen; **P**-Phosphorus; **K**-Potassium; **A**-Actinomyceetes and **PS-** P-Solubilisers

Table 4.42b: The population of different groups of microorganisms in different soil at harvest of the tomato as influenced by graded levels of human urine, cattle urine and fertilizers.

Treatments	Black Soil				
	Fungi ($CFUx10^4$ g^{-1} soil)	Bacteria ($CFUx10^7$ g^{-1} soil)	Actinomycetes ($CFUx10^3$ g^{-1} soil)	N- fixers ($CFUx10^3$ g^{-1} soil)	P- solubalizers ($CFUx10^3$ g^{-1} soil)
T_1	8.54	6.59	7.91	4.13	3.20
T_2	9.81	7.57	9.08	4.74	3.68
T_3	10.30	7.95	9.54	4.98	3.86
T_4	8.39	6.47	7.77	4.05	3.14
T_5	9.72	7.50	9.00	4.69	3.64
T_6	10.24	7.90	9.48	4.95	3.83
T_7	8.27	6.38	7.66	4.00	3.10
T_8	9.54	7.36	8.81	4.57	3.57
T_9	10.06	7.76	9.31	4.86	3.77
S.Em±	**0.23**	**0.17**	**0.25**	**0.15**	**0.08**
C.D. (P=0.01)	**0.93**	**0.72**	**1.03**	**0.60**	**0.35**

Legend :

T_1 : Control-Recommended dose of NPK

T_2 : 1.5 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_3 : 2 times the recommended dose of N through fertilizer + Recom. dose of P and K

T_4 : Recommended dose of N through Human urine + Balance P & K

T_5 : 1.5 times the recommended dose of N through Human urine + Balance P & K

Note : -Balance P and K supplied through SSP and MOP respectively

: -Applied gypsum @ 6.45g l^{-1} urine to all urine applied treatments

T_6 : 2 times the recommended dose of N through Human urine + Balance P & K

T_7 : Recommended dose of N through Cattle urine + Balance P & K

T_8 : 1.5 times the recommended dose of N through Cattle urine + Balance P & K

T_9 : 2 times the recommended dose of N through Cattle urine + Balance P & K

RDF: 250:250:250 kg N, P_2O_5, K_2O ha^{-1}

Source of nutrients: human urine, cattle urine and chemical fertilizers

Where- **N-**Nitrogen**;** **P-**Phosphorus**;** **K-**Potassium**;** **A-**Actinomyceetes and **PS-** P-Solubilisers

In black soil the N-fixers population varied significantly due to application of human and cattle urine applied at different rates (Table 4.42b). It was significantly higher due to application 2 times the recommended dose of N through chemical fertilizers (T_3: 4.98 CFUx10^3 g^{-1}) and it was on par with T_6, T_9, T_2, T_5 and T_8 treatments. Significantly lower soil N-fixers population (4.00 CFUx10^3 g^{-1}) was recorded with recommended dose of N through cattle urine (T_7) which was at par with T_4 and T_1 treatments.

4.16.5 P- Solublizers (CFU x 10^3 g^{-1})

Population of P- Solublizers after harvest of tomato crop grown in red soil was influenced by application of graded levels of human urine and cattle urine (Table 4.42a). P- Solublizers population varied significantly due to rate of application of human and cattle urine and higher value (4.54 CFUx10^3 g^{-1}) was noticed in treatment receiving 2 times the recommended dose of N through human urine (T_6) which was significantly superior over T_7, T_4 and T_1 treatments, but on par with rest of the treatments. Similar trend was observed after the harvest of tomato crop grown in laterite soil also.

In black soil, P- Solublizers population varied significantly due to application of graded levels of human and cattle urine (Table 4.42b). Application of 2 times the recommended dose of nitrogen through chemical fertilizers showed significantly higher values (T_3: 3.86 CFUx10^3 g^{-1}) and it was on par with 2 times the recommended dose of nitrogen through human urine (T_6: 3.83 CFUx10^3 g^{-1}) and 2 times the recommended dose of nitrogen through cattle urine (T_9:3.77 CFUx10^3 g^{-1}). Significantly lower P- Solublizers population was recorded with recommended dose of nitrogen through cattle urine (T_7: 3.10 CFUx10^3 g^{-1}) which was at par with T_4 (3.14 CFUx10^3 g^{-1}) and T_1 (3.20 CFUx10^3 g^{-1}) treatments.

DISCUSSION

V DISCUSSION

The alarming depletion of fossil fuel resources, continuing energy crises, growing ecological concern, escalation of fertilizer prices, pollution hazards and soil ill health necessitates the use of alternate sources of nutrients, Anthropogenic liquid waste has been recognised as a promising alternate nutrient source for sustaining the productivity of agricultural crops especially vegetables. The results of the laboratory incubation experiment to study the changes in chemical composition of urine and the field experiments to "study the effect of repeated application of human urine and cattle urine with and without gypsum on soil properties, growth and yield of vegetable crops" conducted during 2009 to 2011 in a farmer's field, at Nagasandra, Doddaballapur taluk, Bangalore rural district located in Eastern Dry Zone of Karnataka and the green house experiment conducted at GKVK with tomato as test crop to study the impact of graded levels of human urine, cattle urine and fertilizers on soil properties, growth, yield and quality of tomato are discussed in this chapter justifying the trend of results variations among treatments with scientific reasoning and in comparison with the research results reported by the past researchers elsewhere in the field of waste utilization in agriculture.

5.1 Characteristics of human urine and cattle urine.

The chemical composition of human urine samples from ten persons each of vegetarian and non-vegetarian diet belonging to <20, 20 to 40 and >40 years age group and also cattle urine samples of HF (Holstein Friesian) , local cow, ox and buffalo was found to vary to some extent (Tables 4.1 to 4.7b).

The pH, soluble salts and nutrient composition of human urine samples from persons of vegetarian diet was found to vary slightly among the age group. The human urine was slightly acidic in reaction (5.73, 5.56 and 5.59, from persons of <20, 20 to 40 and >40 years age group, respectively), and has appreciable amount of salts (6.36, 7.50 and 7.24 dS m^{-1})in case of samples from <20, 20-40 and >40 years age group. Similar results were reported by Jonsson *et al*. (2004). Human urine has appreciable quantity of nitrogen and it varied slightly with age (0.30, 0.33 and 0.33 per cent N in urine samples collected from persons of < 20, 20-40 and >40 years age group, respectively). The P and

K content was almost half of that of nitrogen and varied slightly with age (0.19, 0.17 and 0.16 per cent P_2O_5 and 0.16, 0.17 and 0.19 per cent K_2O, in urine from persons of < 20, 20 to 40 and >40 year age group, respectively). Similar observations were recorded by Jonsson (1997) and Shayo (2003).

The concentration of calcium (11.80, 12.60 and 17.00 meql^{-1}) and magnesium (23.70, 29.23 and 36.94 meqL^{-1}) was found to be substantial. This might be due to discharge of salts through urine during purification of the blood in the body. The concentration of magnesium was almost double the concentration of calcium in human urine. This trend of lower calcium may be due to better utilization of calcium by the human body than magnesium. Similar results were reported by Altman and Dittmer (1994). Human urine had anions like sulphate (0.12, 0.14 and 0.12 per cent), bicarbonate (9.09, 10.37 and 9.60 meqL^{-1}) and chloride (28.65, 32.66 and 31.41 meqL^{-1}). In fresh human urine, the carbonate was absent as the fresh urine is acidic in reaction whereas concentration of bicarbonates varied slightly in the urine samples of different age groups. Similar findings were also reported by Kirchmann and Pettersson (1995). Human urine also contained appreciable amount of micronutrients (zinc, iron, manganese and copper) and the concentration varied slightly with age. This might be due to variation in the intake of salts and minerals through food (Schouwz *et al.*, 2002) (Table 4.1).

The urine samples from non-vegetarian diet persons of different age groups also had appreciable amount of nutrients. Fresh urine was more acidic than urine samples of vegetarian diet persons. Also the concentration of salts was found to be slightly higher in urine from persons of non-vegetarian diet which may be due to variations in food habit. It also had higher nitrogen content (0.40, 0.39 and 0.40 per cent, respectively) when compared to urine from vegetarian diet persons. This may be due to the fact that non-vegetarian diet has more protein and after assimilation, some quantity of protein will be discharged through urine as nitrogen compound. Phosphorus and potassium contents varied slightly in urine samples of non-vegetarian diet persons compared to vegetarian diet urine samples. Human urine samples from non-vegetarian diet persons also had high amount of sodium and chloride when compared to urine from vegetarian diet persons which may be due to consumption of more salts through food (Table 4.2).

In case of cattle urine there was slight variation in the chemical composition of different types of cattle. The pH was slightly acidic in nature and the electrical conductivity was higher (7.65, 7.36, 7.55 and 7.58 dS m^{-1}, HF (Holstein Friesian), cow, ox and buffalo's urine samples, respectively) which is due to the presence of more salts in the grasses they consume (Table 4.3).

There was slight difference in the concentration of nitrogen among the different types of cattle (0.28, 0.26, 0.28 and 0.28 per cent, in urine from HF (Holstein Friesian), cow, ox and buffalo's, respectively) whereas the phosphorus (0.17, 0.18, 0.18 and 0.17 per cent) and potassium content (0.22, 0.21, 0.22 and 0.22 per cent) in urine samples were not found to differ much among the types of cattle. Similar findings were also observed by Hoogendoorn *et al*. (2010) and Yawalkar *et al*. (2002). The calcium content was slightly more in urine samples of HF (Holstein Friesian) and buffalo (22.80 and 22.60 meqL^{-1}) when compared to cow and ox (19.60 and 20.60 meqL^{-1}). This might be due to the quantity of food consumed by these animals. It also contains high amount of magnesium (49.78, 43.26, 31.19 and 48.40 meqL^{-1}, respectively) and sodium (0.19, 0.20, 0.19 and 0.13 per cent, respectively). The cattle urine had appreciable amount of anions like sulphate, carbonate, bicarbonate and chloride. The concentration of micronutrients like zinc, manganese, iron and copper were also found to be in appreciable quantity which may be because of consumption of mineral salts along with the feed and excess of which was discharged through urine but lesser than the human urine.

5.1.2 Changes in chemical composition of human urine and cattle urine incubated under open condition

5.1.2.1 Human urine

There was slight variation in the chemical composition of human urine samples from persons of vegetarian diet persons of < 20 years age groups, when incubated under open condition. There was increase in pH of urine with time and had turned to slightly alkaline pH. This might be due to hydrolysis of urea leading to formation of ammonia during incubation (Jonsson, 1997) (Tables 4.4).

In open condition, the nitrogen content was slightly less compared to initial value which might be due to loss of nitrogen as NH_3 due to volatilization at high pH during incubation. Similar findings were reported by Blouin (1979), Hellstrom *et al*. (1999) and Kirchmann and Pettersson (1995). There was no variation in the phosphorus and potassium content of urine samples incubated under open condition. Similar results were recorded by Jonsson *et al*. (2004). The concentration of carbonates and bicarbonates has increased appreciably. Increase in concentration of carbonates and bicarbonates may be because of diffusion of atmospheric carbon dioxide into urine samples and its conversion to carbonates and bicarbonates. The micronutrients like zinc, manganese, iron and copper were found to decrease with time. This may be because of increase of pH of urine to the alkaline range and the conversion of Zn, Fe, Mn and Cu to insoluble carbonate salts (Blouin, 1979, and Kirchmann and Pettersson, 1995).

The urine samples of non-vegetarian diet persons also turned to alkaline side upon incubation. Similar findings were reported by Jensen *et al*. (2009).

The nitrogen content of urine samples from persons of vegetarian and non-vegetarian diet was found to decrease slightly upon incubation under open condition at 30 and it further decreased at 60 days. Similar findings were also observed by Jonsson *et al*. (2005), Lentner *et al*. (1981) and Vinneras *et al*. (2006). While the phosphorus and potassium content did not change much with incubation and it remained almost same in samples at 30 and 60 days after incubation (Larsen and Gujer (1996) and Anon. (1977)) showed more or less similar trend as that of vegetarian diet persons (Carlander *et al.*, 2001).

The fresh urine samples from vegetarian and non-vegetarian diet persons were having only bicarbonate not any carbonates. But appreciable amount of carbonate also was found at 30 days after incubation and it increased further at 60 days after incubation under open condition. This might be due to diffusion of carbon dioxide from the atmosphere into incubated urine samples. The conversion of both CO_3 and HCO_3 content were slightly higher when samples were incubated under open condition at 30 and 60 days compared to closed condition.

Micronutrients concentration showed little variation with the diet of the persons and it decreased with time it might be due to conversion of Fe, Mn, Zn and Cu to respective insoluble carbonate compounds at higher pH of incubated samples (Schouwz *et al*., 2002).

5.1.2.2 Cattle urine

The pH of urine samples from different categories of cattle *viz.* HF (Holstein Friesian), cow, ox and buffalo has increased slightly and was alkaline in reaction. There was a gradual increase in pH of urine samples with increase in duration of incubation. This may be due to conversion of uric acid to ammonia during incubation and also formation of carbonate compounds. Similar findings were reported by Haneaus *et al*. (1996) (Table 4.6a and 4.6b).

The changes in nitrogen content of urine samples followed a similar trend as that of human urine samples. Similarly there was no much variation in the phosphorus and potassium content of cattle urine samples at 30 and 60 days of incubation under open condition.

The concentration of anions viz., carbonate and bicarbonate was found to increase slightly when incubated under open condition with time and the reasons for such increase has been discussed in earlier paragraphs. As in case of human urine samples a similar trend of decrease in concentration of micronutrients was observed with time when incubated under open condition at 30 and 60 days after incubation due to increase in the alkalinity of urine with time. Similar findings were reported by Hoogendoorn (2010) and Yawalkar *et al*. (2002).

5.1.3 Changes in chemical composition of human urine and cattle urine incubated under closed condition

5.1.3.1 Human urine

The human urine samples with different diet incubated under closed condition recorded slightly lower pH value compared to that the samples under open condition as there was little or no scope for diffusion of carbon dioxide from the atmosphere (Tables 4.4 to 4.6b)

Nitrogen concentration in cattle urine samples kept in open condition was slightly lower when compared to samples kept under closed condition this might be due to loss of N as ammonia gas during incubation under open condition at higher pH (Majumdar *et al.*, 2006), phosphorus and potassium content did not show much variation with time.

The loss of nitrogen was found to be slightly less in samples incubated under closed condition than open condition as there was less chance for hydrolysis reactions. There was no much variation in phosphorus and potassium content in urine samples of different age group incubated under both open and closed condition at 30 and 60 days. Similar results observed by Feachem *et al*. (1983).

The carbonates and bicarbonates content was found to increase with time of incubation but the values were less when kept under closed condition compared to open condition as there was less scope for diffusion of carbon dioxide into urine and its conversion to carbonates and bicarbonates.

5.1.3.2 Cattle urine

Similar trend of results were observed even in cattle urine samples incubated under closed condition at 30 and 60 days as that of human urine samples incubated in a similar way and the reasons haven been discussed earlier paragraphs in this chapter, section 5.1.3.1 (Tables 4.7a and 4.7b).

Experiment–II : Field experiment to study on the effect of repeated application of human urine and cattle urine on soil properties, crop growth and yield

5.2 Weather conditions during experimentation.

Environment is a basic and fundamental factor determining the growth of plants. Thus, the fluctuation in weather conditions directly affect crop growth development and yield. Eghball *et al.* (1995) reported that the management practices may in some cases

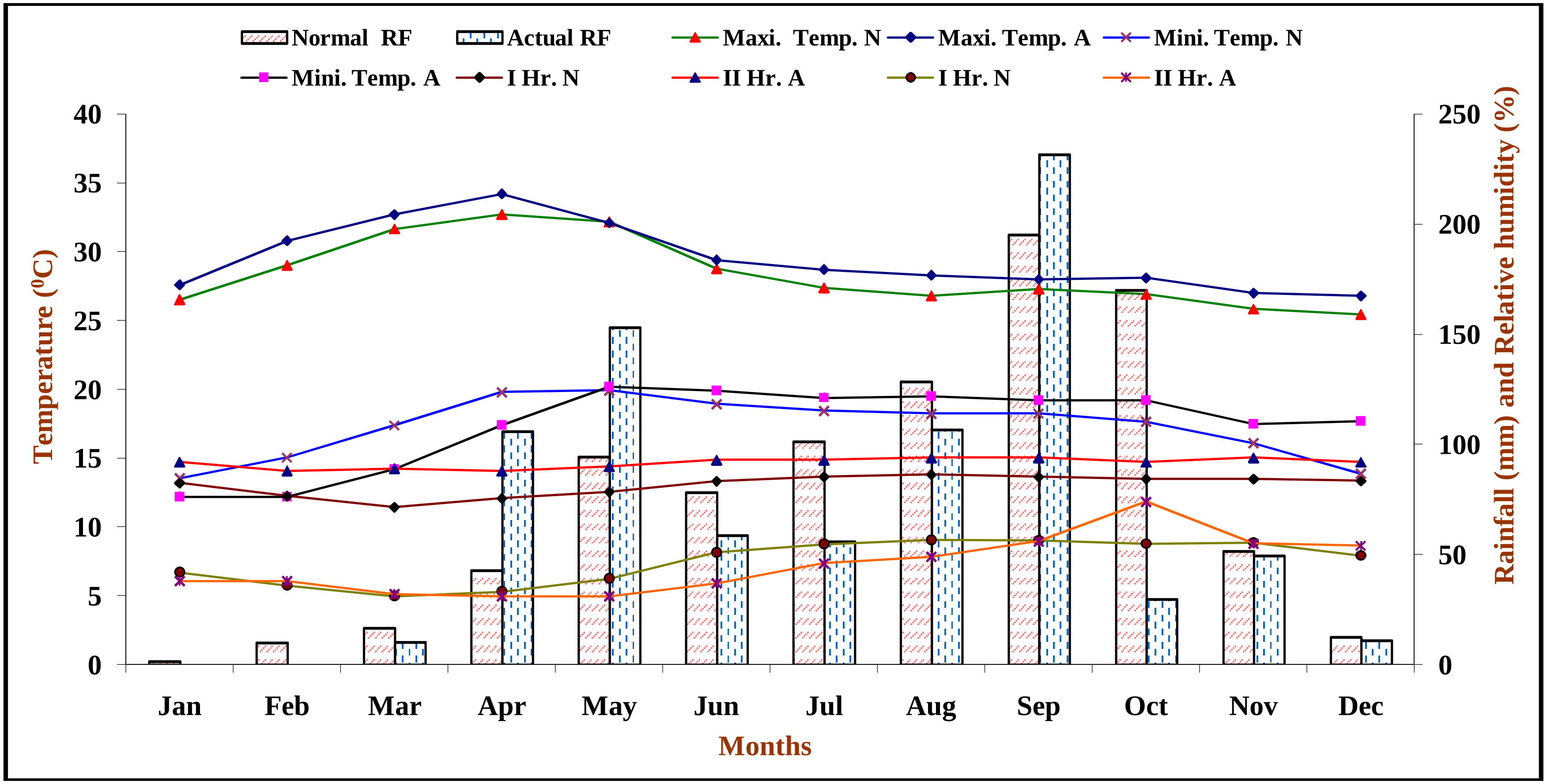


Fig. 5.1: Meteorological data indicating (1976-2009) monthly normal, actual (2009) and deviation from normal during experimental period at Krishi Vigyana Kendra, Hadonahalli, Doddaballapur taluk, Bengaluru rural district.

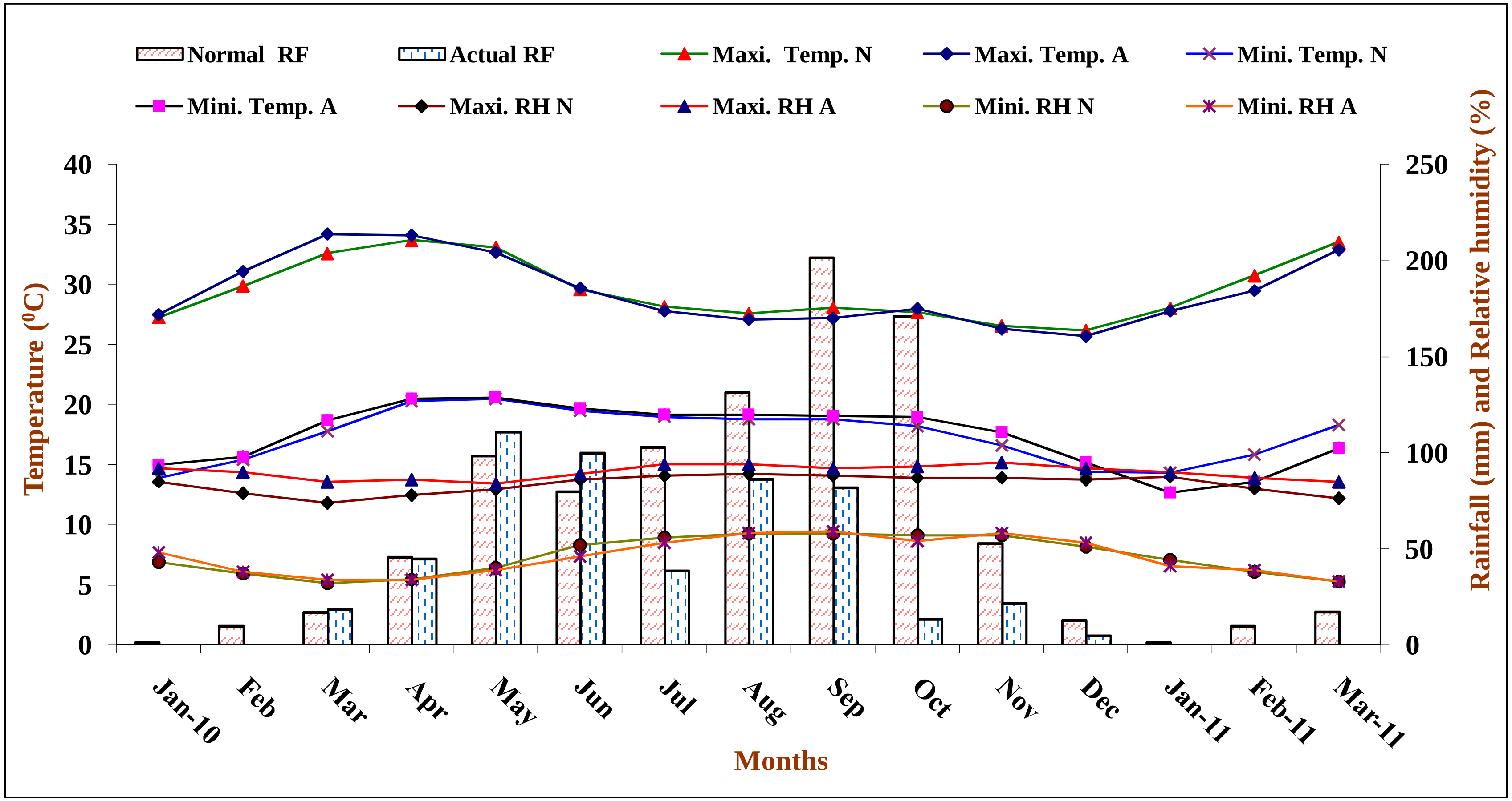


Fig. 5.2: Meteorological data indicating (1976-2010) monthly normal, actual (2010) and deviation from normal during experimental period at Krishi Vigyana Kendra, Hadonahalli, Doddaballapur taluk, Bengaluru rural district.

reduce temporal variability but in other cases have little effect on the year to year variability of crop yields. The year to year fluctuation is primarily a result of variable weather conditions that prevail in a given agro-climatic situation. In this context, the weather conditions prevailed during the period of experimentation would definitely have a direct bearing on the potentiality of any crop in general and vegetable crops in particular. The crop at the experimental location experienced favourable weather conditions during growth period as indicated by the climatic data presented in Tables 3.3 and 3.4 and depicted in Fig. 5.1 and 5.2. The weather parameters such as rainfall, maximum and minimum temperature and relative humidity were conducive to the crop during the growth period and there was no incidence of any major pest or disease during the growth period.

During the experimentation period, the vegetable crops experienced favourable weather conditions (Table 3.4). The maximum and minimum temperatures and relative humidity were conducive for crop growth. The crop also experienced optimum temperature especially during grand growth stages, which determine the yield and quality. There was no rain during December (2009), but rainfall was scanty during February and March (2010) months, the water requirement of the crop was met through irrigation and crop did not experience any water stress. The total rainfall during the experimentation period was less than the normal rainfall.

5.3 Effect of application of human urine and cattle urine on growth and yield components and yield of vegetable crops

Many factors both externally and internally influence the crop growth and productivity. Nutrient management is one such important factor which largely decides the size of the crop produced. The economic yield of a plant is an outcome of a series of integrated interactions of various biological events involving biochemical, physiological and morphological changes which take place during its development in accordance with the supply of light, water, temperature and nutrients (Donald, 1962). Yield maximization in crops and improvement in its quality can be achieved by required amount of nutrients. Nitrogen improves plant growth and productivity by having direct effect on the metabolism of plants. Nitrogen is usually applied through organic or inorganic sources. In addition, majority of crops consume the highest amount of nitrogen when compared to other major nutrients, as it is essential for almost all the metabolic processes. The time of application as well as the stage of plant growth determines the uptake and translocation of nutrients. Nutrients supply in early vegetative stage has greater influence on yield of crops. The major nutrients in particular play a vital role in growth, yield and quality of crops.

Fruit yield of vegetable crops differed significantly with respect to application of human urine and cattle urine. Application of recommended dose of N through human urine in three split dose plus gypsum recorded maximum yield (39.2, 14.2, 17.4 and 38.7 t ha^{-1}, of ashgourd, french bean, pole bean and pumpkin crops, respectively) followed by recommended dose of N through cattle urine in three split dose plus gypsum (T_{14}: 38.0, 14.1, 16.6 and 37.5 t ha^{-1}, of ashgourd, french bean, pole bean and pumpkin, respectively), and recommended dose of fertilizers. The lowest yield was recorded with application of farmyard manure alone (19.7, 8.7, 9.2 and 19.5 t ha^{-1}, of ashgourd, french bean, pole bean and pumpkin, respectively).

Higher ashgourd equivalent yield for french bean, pole bean and pumpkin was registered in recommended dose of nitrogen through human urine plus gypsum in three split doses (T_{12}: 40.2, 46.4 and 45.2 t ha^{-1}, equivalent yield of ashgourd for french bean, pole bean and pumpkin, respectively) followed by T_{14}, T_2, T_{11}, and $T_{13.}$ Lower equivalent yield of ashgourd for french bean was reported with application of farm yard manure alone (T_1: 24.7, 24.5 and 22.8 t ha^{-1}, equivalent yield of ashgourd for french bean, pole bean and pumpkin, respectively) (Table 4.11).

The reduction in yield of vegetable crops with recommended dose of N through farmyard manure (T_1: 19.7, 8.7, 9.2 and 19.5 t ha^{-1}, of ashgourd, french bean, pole bean and pumpkin, respectively), recommended dose of N through cattle urine in single dose without gypsum (T_5: 21.1, 8.9, 9.8 and 20.8 t ha^{-1}, of ashgourd, french bean, pole bean and pumpkin, respectively) and recommended dose of N through human urine in single dose plus without gypsum (T_3: 22.2, 9.3, 10.2 and 21.9 t ha^{-1}, for ashgourd, french bean, pole bean and pumpkin, respectively) could be due to decreased individual plant performance characters in terms of plant height, number of branches, number of leaves, length of fruits, diameter of fruit, fresh fruit weight, mean fruit weight, number of fruits per plant and total dry matter accumulation at harvest. The yield is final expression of growth attained by individual plant during the course of its development. Therefore, the poor growth components recorded in this particular treatment had contributed to lower yields.

Higher yield recorded with recommended dose of N through human urine in three split doses plus gypsum was attributed to better root development and higher availability of nutrients to the crops. These results are in agreement with the findings of Peter Morgan (2004) and Kedar and Deepak (2003) who used source separated human urine as the nutrient source for the vegetable plants particularly broadbean, blackgram and green pea.

Increase in dry matter production per unit area is a first step in achieving higher yield. Dry matter production and its accumulation in different parts of plants during various growth phases of life cycle of any crop is an important pre-requisite for higher yields as it signifies photosynthetic ability of the crop and also indicates other synthetic processes during developmental sequences. Maintenance of higher total dry matter at harvest was established with application of recommended dose of N through human urine in three split doses plus gypsum (701.7, 26.2, 156.8 and 719.3 g plant^{-1}, for ashgourd, french bean, pole bean and pumpkin crops, respectively) followed by application of recommended dose of N through cattle urine in three split doses plus gypsum (691.1, 22.8, 150.2 and 711.4 g plant^{-1}, for ashgourd, french bean, pole bean and pumpkin crops, respectively), compared to application of recommended dose of N through farmyard manure alone (518.9, 19.6, 113.6 and 522.3 g plant^{-1}, for ashgourd, french bean, pole bean and pumpkin crops, respectively) (Table 4.9 and Fig. 5.3)

The higher yield of vegetable crops with application of recommended dose of N through human urine in three split doses plus gypsum was favorably influenced by higher ashgourd, french bean, pole bean and pumpkin crop plants (590.8, 52.5, 452.0 and 537.1 cm, respectively) and had more number of branches (4.99, 25.3, 9.60 and 4.73,

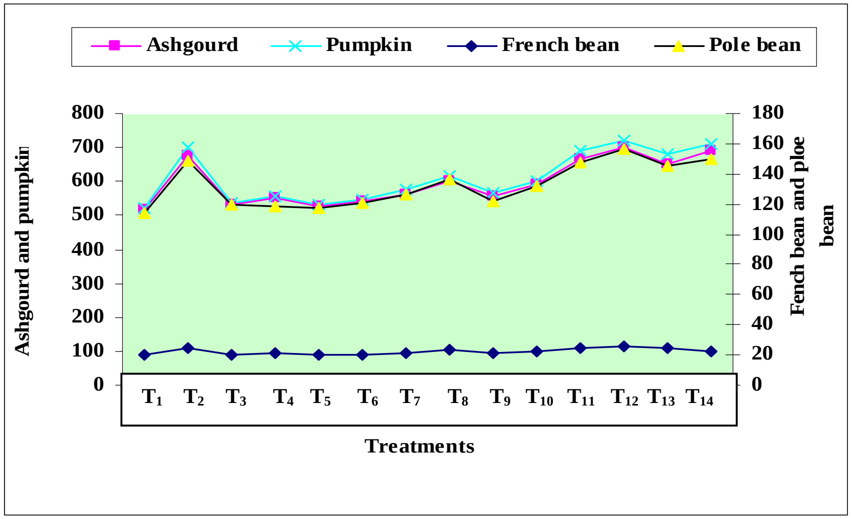


Fig.5.3: Total dry weight (g plant^{-1}) at harvest of vegetable crops as influenced by split application of human urine and cattle urine with and without gypsum.

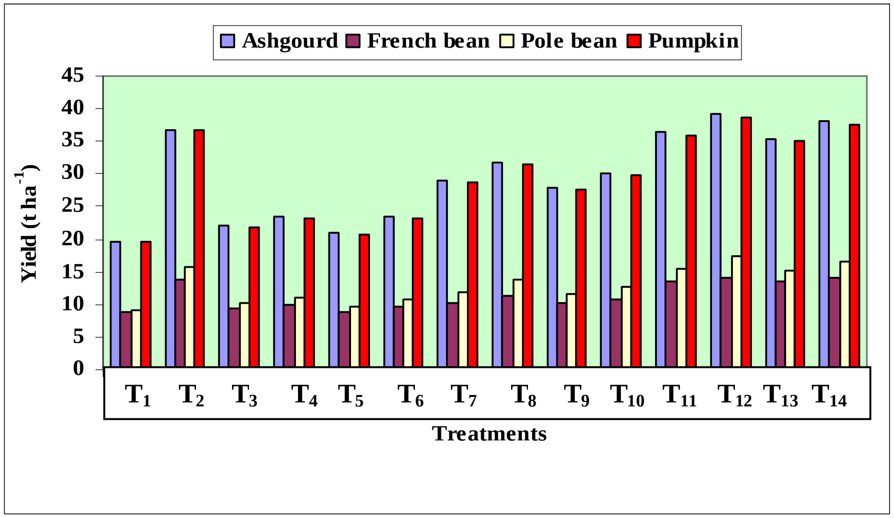


Fig. 5.4: Fresh yield (t ha^{-1}) for different vegetable crops as influenced by split application of human urine and cattle urine with and without gypsum.

Legend	
T_1 :	FYM (Farmyard Manure) alone
T_2 :	Recommended dose of fertilizer + Farmyard manure
T_3 :	RDN through human urine in single dose
T_4 :	RDN through human urine in single dose + gypsum
T_5 :	RDN through cattle urine in single dose
T_6 :	RDN through cattle urine in single dose+ gypsum
T_7 :	RDN through human urine in two split doses
T_8 :	RDN through human urine in two split doses+ gypsum
T_9 :	RDN through cattle urine in two split doses
T_{10} :	RDN through cattle urine in two split doses+ gypsum
T_{11} :	RDN through human urine in three split doses
T_{12} :	RDN through human urine in three split doses+ gypsum
T_{13} :	RDN through cattle urine in three split doses
T_{14} :	RDN through cattle urine in three split doses+ gypsum

respectively) at harvest, more number of leaves (55.5, 20.7, 58.9 and 53.0, respectively), LAI (0.29, 1.36, 0.45 and 0.56, respectively) at harvest of ashgourd, french bean, pole bean and pumpkin crops (Tables 4.8a to 4.8b). This has been the consequence of continuous and better availability of nutrients and nutrient uptake due to application of human urine in three split doses during the crop growth period in addition to the presence of all essential nutrients in human urine and cattle urine which might have stimulated the growth of vegetable crops. Hoglund (2001) and Simons and Clemens (2004) recorded similar observations on improved yield and yield attributing characters due to human urine application in rice, barley and vegetable crops like chard, turnip, carrot and fruit crops like banana, orange showed a good response and yield.

Increased yield due to application of recommended dose of N through human urine in three split doses plus gypsum could also be attributed to the significant improvement in yield parameters like number of fruits plant^{-1} (2.1, 12.4, 94.1 and 4.7), fruit length (23.7, 15.8, 19.0 and 14.2 cm), fruit diameter (17.5 and 13.5 cm, for ashgourd and pumpkin crops, respectively) and fresh weight of fruit (4510, 7.5, 11.6 and 863.6 g) of ashgourd, french bean, pole bean and pumpkin crops, respectively (Tables 4.10a and 4.10b and Fig. 5.4).

5.4 Effect of human urine and cattle urine on nutrient content and uptake of nutrients by vegetable crops

Nutrient content and uptake by ashgourd, french bean, pole bean and pumpkin crop at harvest increased with the application of human urine and cattle urine (Table 4.12 to 4.17) and graphically illustrated in Fig.5.5 to 5.10.

5.4.1 Nitrogen

The highest nitrogen content (4.09, 4.49, 4.01 and 4.33 % in fruits for ashgourd, french bean, pole bean and pumpkin crop, respectively) and highest total nitrogen uptake (108.92, 134.3, 148.8 and 162.8 kg ha^{-1}) by these crops was recorded with application of recommended dose of N through human urine in three split doses plus gypsum (Table 4.15 and Fig. 5.5). The least concentration of nitrogen in fruit and total uptake by vegetable crops was recorded with application of N through farmyard manure alone (60.33, 64.6, 77.5 and 67.7 kg ha^{-1}, for ashgourd, french bean, pole bean and pumpkin crops, respectively). This may be due to increase in the availability of nutrients to the crop from human urine, accumulating more nitrogen in the leaves and nitrogen is evenly distributed throughout the plant and the highest proportion being found in the fruits (Jean Emmanuel Ndzana and Ralf Otterpohl, 2009 and Sridevi *et al*., 2009). Nitrogen being a structural component of proteins either as storage protein or proteins as such involved in various biological functions. Increase in uptake of N was also due to increase in dry matter production and content. Split application of urine helped in providing all the nutrient elements throughout the crop growth period and contributed for higher nitrogen content in vegetable crops

Increased nitrogen content and uptake in treatment receiving human urine in three split doses might be due to split application of N through urine which resulted in decreased loss of N from soil and maintained higher N potential throughout the plant growth period. Similar observations were made by Guzha (2004) and Mnkeni *et al*. (2005) and Guadarrama *et al*. (2001) who opined that the best yield of lettuce was due to high availability of nitrogen. Anthropogenic liquid waste is a soluble liquid fertilizer, which mean that nitrogen is more rapidly available and effective even in dry season (Jonsson *et al*., 2004)

Many researchers have reported improved availability of N in soil with application of human urine (Malkki,1999, Kirchmann and Pettersson, 1995 and Powell *et al*., 1998).

5.4.2 Phosphorus

Increased phosphorus content in fruit (Table 4.12 and Fig. 5.5) and uptake by plant (Table 4.15 and Fig. 5.8) due to application of recommended dose of N through human urine in three split doses plus gypsum, recommended dose of N through cattle urine in three split doses plus gypsum and recommended dose of fertilizer plus farmyard manure could be attributed to conversion of fixed phosphorus into readily available form by organic acids released during decomposition of organic manure, applied urine and consequent improvement in the available P content of soil and also due to slow release of nutrients through the application of human urine and cattle urine to soil during crop growth period. These results corroborate with the findings of Mussie *et al*. (2006) who reported higher organic carbon, available N, P and K with the usage of dairy waste for five years. Apart, from higher availability, improved nitrogen management and higher nitrogen accumulation in plant might have enhanced the phosphorus concentration. Similar results were reported by Mnkeni *et al*. (2006).

5.4.3 Potassium

The K concentration in fruit increased with application of human urine and cattle urine (Table 4.12 and Fig. 5.5). Highest potassium content and uptake (Table 4.15 and Fig. 5.8) was noticed in treatment receiving recommended dose of N through human urine in three split doses plus gypsum along with balanced phosphorus and potassium supplied through chemical fertilizers. This might be due to better root growth and higher absorption capacity resulting in increased assimilation of potassium in plant tissue which in turn improved the absorption and translocation of elements in plant system. Hellstrom (1999) observed that the nutrients in anthropogenic liquid waste were water soluble and were easily available to the plants for uptake and are easily transported into plant parts.

5.4.4 Calcium, magnesium and sulphur

Calcium concentration in fruit of ashgourd, french bean, pole bean and pumpkin crops differed significantly due to application of human urine and cattle urine (Table 4.13 and Fig. 5.6). Calcium concentration was highest with recommended dose of N through human urine in three split doses plus gypsum followed by recommended dose of N through cattle urine in three split doses plus gypsum and the least content and uptake of calcium was recorded with recommended dose of N through farmyard manure. This might be due to the presence of appreciable amount of Ca in human urine and cattle urine, which enhanced the crop uptake and accumulation.

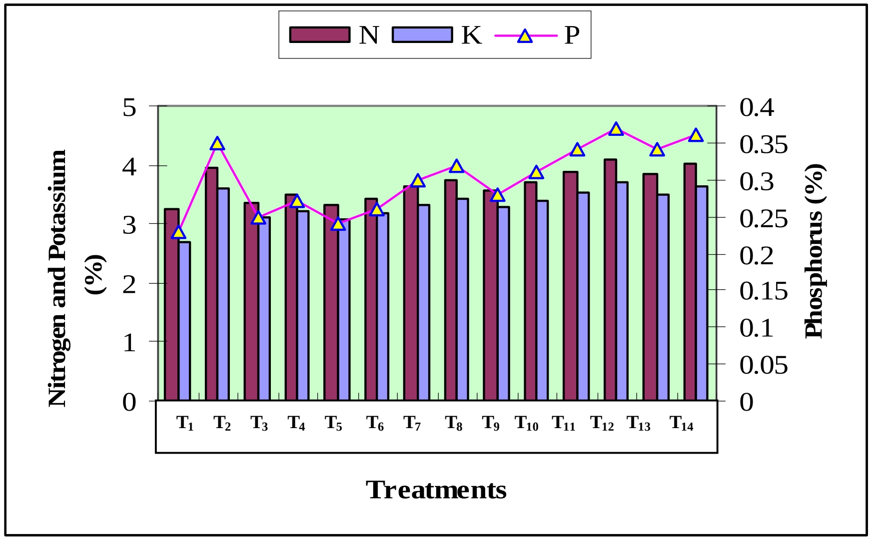
Similar trend of results were observed in magnesium concentration of crops highest Mg in treatment receiving human urine and cattle urine plus gypsum applied treatments (Table 4.13 and Fig. 5.6). Similar reasons can be quoted for increased Mg concentration in plant tissue i.e. presence of appreciable quantity of Mg in human urine and cattle urine (Thangavelu *et al.,* 2003). Sulphur content (Table 4.13 and Fig. 5.6) of crops increased with the application of human urine and cattle urine plus gypsum which may be attributed to more sulphur added to the soil. Maximum uptake was due to its higher content in the plant tissue and higher dry matter production.

5.4.5 Iron, manganese, zinc and copper

Iron concentration in fruits differed significantly due to application of human urine and cattle urine to ashgourd, french bean, pole bean and pumpkin crop (Table 4.14 and Fig. 5.7). Iron concentration was highest with recommended dose of N through human urine in three split doses plus gypsum followed by recommended dose of N through cattle urine in three split doses plus gypsum and the least content and uptake of iron was recorded with recommended dose of N through farmyard manure. This might be due to the presence of appreciable amount of iron in human urine and cattle urine, which enhanced the crop uptake and accumulation.

Similar trend was observed manganese in concentration recording highest Mn in human urine and cattle urine plus gypsum applied treatments (Table 4.14 and Fig. 5.7). Similar reasons can be quoted for increased Mn concentration in plant tissue i.e. presence of appreciable quantity of Mn in human urine and cattle urine.

Zinc content (Table 4.14 and Fig. 11) of crops increased with the application of human urine and cattle urine plus gypsum which may be attributed to more zinc added to the soil through urine. Maximum uptake was due to the presence of Zn in human urine and higher dry matter production. This could be attributed to the better nutrient availability and translocation which led to higher absorption of nutrients by the crops. Anthropogenic liquid waste is a factor of paramount importance for production of auxin a growth promoting substance which encourages better shoot growth. The increased content of zinc in the plant and the favourable rhizosphere environment created by the applied anthropogenic liquid waste would have resulted in better uptake of nutrients stimulating the biochemical reactions resulting in more zinc content. Copper content also



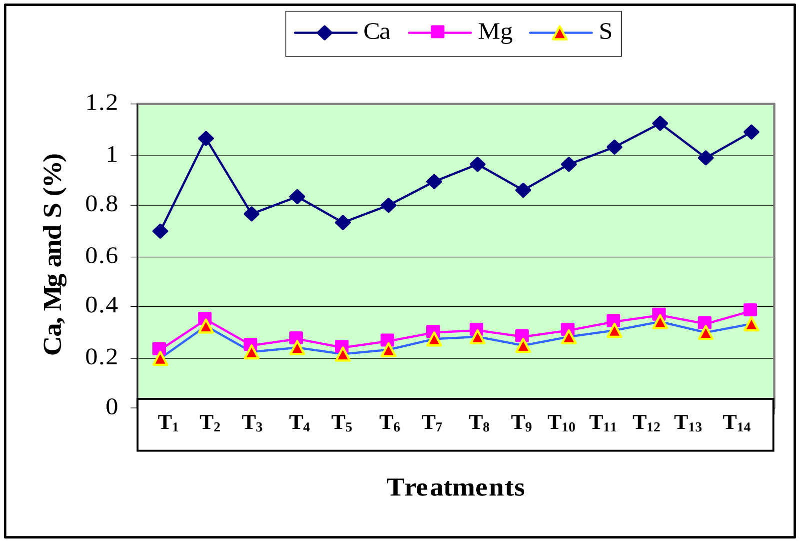


Fig. 5.5: Nitrogen, phosphorus and potassium content (%) of ashgourd fruits at harvest as influenced by split application of human urine and cattle urine with and without gypsum.

Fig. 5.6: Calcium, magnesium and sulfur content (%) of ashgourd fruits at harvest as influenced by split application of human urine and cattle urine with and without gypsum.

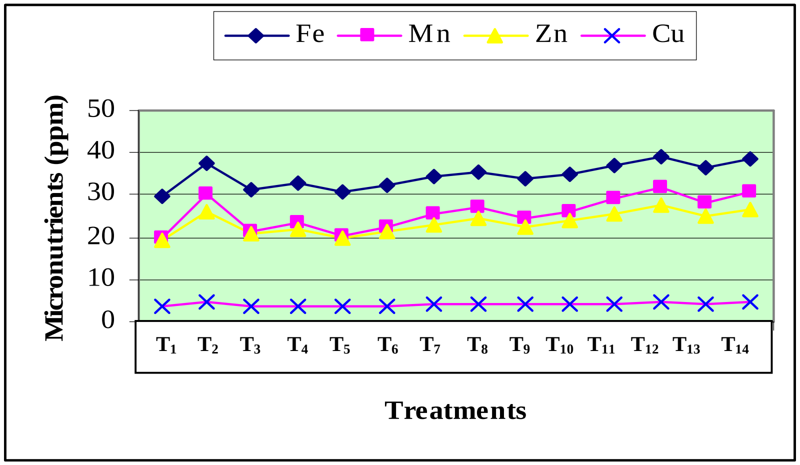
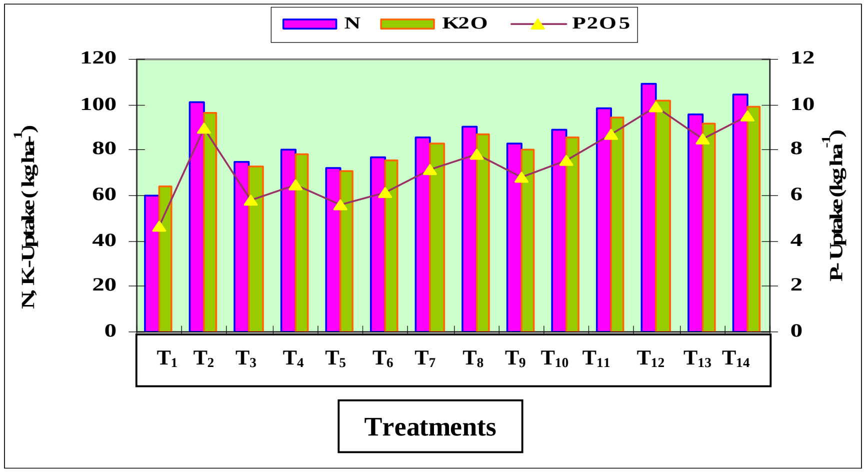


Fig. 5.7: Iron, manganese, zinc and copper content (ppm) of ashgourd fruits at harvest as influenced by split application of human urine and cattle urine with and without gypsum.

Legend	
T_1:	FYM (Farmyard Manure) alone
T_2:	Recommended dose of fertilizer + Farmyard manure
T_3:	RDN through human urine in single dose
T_4:	RDN through human urine in single dose + gypsum
T_5:	RDN through cattle urine in single dose
T_6:	RDN through cattle urine in single dose+ gypsum
T_7:	RDN through human urine in two split doses
T_8:	RDN through human urine in two split doses+ gypsum
T_9:	RDN through cattle urine in two split doses
T_{10}:	RDN through cattle urine in two split doses+ gypsum
T_{11}:	RDN through human urine in three split doses
T_{12}:	RDN through human urine in three split doses+ gypsum
T_{13}:	RDN through cattle urine in three split doses
T_{14}:	RDN through cattle urine in three split doses+ gypsum



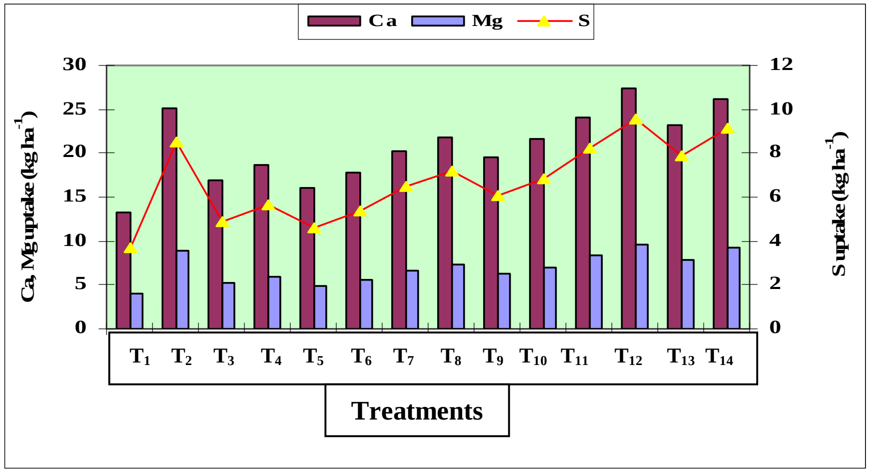


Fig. 5.8: Nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) uptake (kg ha^{-1}) by ashgourd crop at harvest as influenced by split application of human urine and cattle urine with and without gypsum.

Fig. 5.9: Calcium (Ca), magnesium (Mg) and sulphur (S) uptake (kg ha^{-1}) by ashgourd crop as influenced by split application of human urine and cattle urine with and without gypsum at harvest.

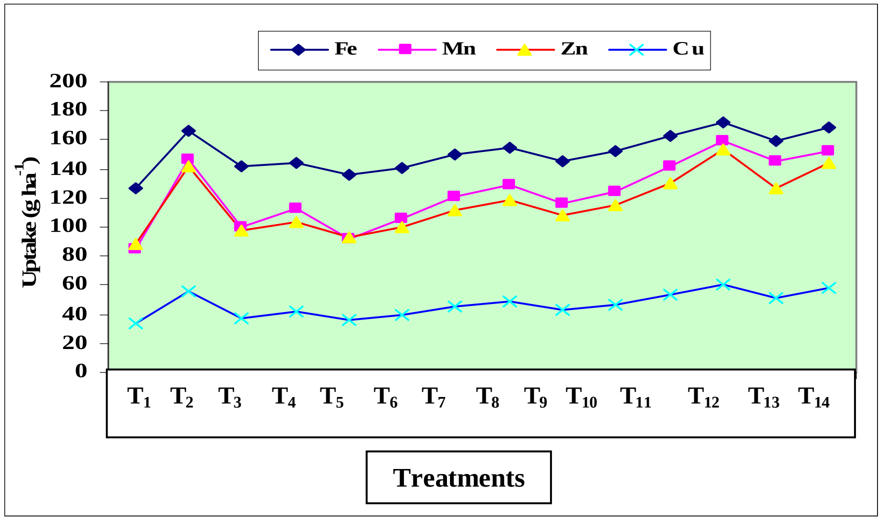


Fig. 5.10: Iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) uptake (g ha^{-1}) by different vegetable crops at harvest as influenced by split application of human urine and cattle urine with and without gypsum.

Legend	
T_1 :	FYM (Farmyard Manure) alone
T_2 :	Recommended dose of fertilizer + Farmyard manure
T_3 :	RDN through human urine in single dose
T_4 :	RDN through human urine in single dose + gypsum
T_5 :	RDN through cattle urine in single dose
T_6 :	RDN through cattle urine in single dose+ gypsum
T_7 :	RDN through human urine in two split doses
T_8 :	RDN through human urine in two split doses+ gypsum
T_9 :	RDN through cattle urine in two split doses
T_{10} :	RDN through cattle urine in two split doses+ gypsum
T_{11} :	RDN through human urine in three split doses
T_{12} :	RDN through human urine in three split doses+ gypsum
T_{13} :	RDN through cattle urine in three split doses
T_{14} :	RDN through cattle urine in three split doses+ gypsum

increased (Tables 4.13 and Fig. 5.7) with the application of human urine and cattle urine plus gypsum which may be attributed to more copper added to the soil. Maximum uptake was due to the presence of appreciable quantity of copper in human urine (Tables 4.17 and Fig. 5.10).

5.5 Effect of application of human urine and cattle urine on chemical properties of soil

The nutrient turn over in soil plant continuum concept is considerably high under intensive cropping, neither the chemical fertilizers nor the basic or biological sources alone can achieve production sustainability. Long term studies indicated that the balanced use of only NPK fertilizers could not maintain high yield levels because of emergence of secondary and micronutrient deficiencies and deterioration in soil physical eco-system. As a consequence of this and other constraints there seems to be no option but to fully exploit alternative source of plant nutrients. The judicious use of naturally available resources like human urine (anthropogenic liquid waste) and cattle urine help in maintaining yield stability on certain soils through correction of marginal deficiencies of macro and micro-nutrients, enhancing efficiency of applied nutrients and providing favourable soil chemical and physical conditions

5.5.1 Soil pH

Soil reaction differed significantly due to human urine and cattle urine application during crop growth period (Table 4.18 and Fig. 5.11). However, marginal increase in pH was observed in treatments, with human urine and cattle urine without gypsum application. The results are in accordance with Powell *et al*. (1998). The increase in pH may be due to addition of substantial amount of calcium, magnesium, bicarbonates and even sodium through human urine and cattle urine application. Similar increase in pH of soil with application of anthopogenic liquid waste were reported by Mnkeni *et al*. (2006) and Vinneras *et al*. (2006). The decomposition of urea will lead to an increase in the concentration of ammonium and an increase in pH in urine (Rodhe *et al.*, 2004).

5.5.2 Electrical conductivity

Salt content in soil differed significantly due to application of human urine and cattle urine. Application of human urine and cattle urine marginally increased the EC after the harvest of vegetable crops when compared to recommended dose of fertilizers plus farmyard manure, application of farmyard manure alone and also initial EC value of soil (Table 4.18 and Fig. 5.11). This is attributed to the presence of high salt content in urine, which upon application to soil has enhanced the EC. However, the salt content after the harvest of the crop was below the threshold level (0.8 dS m^{-1}). The results are in accordance with Mnkeni and Austin (2009). Jonsson *et al.* (2004) opined that though the salt concentration is quite high in urine, the total quantity applied per year is not high when compared to that added through irrigation water.

5.5.3 Available nitrogen

Available N in soil differed significantly due to application of human urine and cattle urine. Application of recommended dose of N through human urine in three split doses plus gypsum (290.9, 291.3, 298.2 and 302.2 kg ha^{-1}, for ashgourd, french bean, pole bean and pumpkin, respectively), recommended dose of N through cattle urine in three split doses plus gypsum (287.0, 288.4, 294.0 and 295.6 kg ha^{-1}, respectively), recommended dose of fertilizer plus farmyard manure (288.0, 285.5, 289.9 and 292.5 2 kg ha^{-1}, respectively), recommended dose of N through human urine in three split doses plus without gypsum (283.6, 282.7, 281.1 and 289.0 kg ha^{-1}, respectively) and recommended dose of N through cattle urine in three split doses plus without gypsum (281.0, 281.0, 281.1 and 286.7 kg ha^{-1}, respectively) recorded maximum soil available nitrogen at harvest of ashgourd, french bean, pole bean and pumpkin crop. (Table 4.19 and Fig. 5.12). Vinneras *et al.* (2003) found that the plant nutrients in both anthropogenic liquid waste and faeces emanate from arable fields and thus should be recycled as fertilizers to support sustainability and to retain the fertility of the fields. Anthropogenic liquid waste becomes a quick acting fertilizer rich in nitrogen and with a composition of nutrients that well matches the needs of many crops. Marilene Aban (2005) made organic fertilizer formulation using ALW and studied the effect on soil properties. He observed that there was a decrease in phosphorus and potassium content in soil after harvest but nitrogen content increased. It is inferred that greater absorption of nitrogen was observed in ALW plus chicken manure, fish trash, rice hull ash and biosol. This could be due to the fibrous rooting system of the crops and the chicken manure might contain nitrogen that is in the readily available form. The urine is especially rich in nitrogen, and in the higher range of 3-7 g N/l given as indicative values by Jonsson *et al.* (2004). The split application of human urine and cattle during crop growth decreases the N loss from soil and maintains higher N potential throughout the plant growth period. And thus was found better in terms of N management and consequently better N uptake by crops.

5.5.4 Available phosphorus

Available P in soil varied significantly due to application of human urine and cattle urine after the harvest of vegetable crops (Table 4.19 and Fig. 5.12). The enhancement in phosphorus availability was due to the combined effect of released organic acids and organic anions on the decomposition of organic matter as a result of improving biological properties of soil and reduction in the activity of phosphorus complexing agent to make phosphorus available to the crop. Similar results were reported by Vinneras (2001). The highest phosphorus content registered under recommended dose of fertilizer may be ascribed to the release of phosphorus from the fixation sites by the decomposition products of organic manures and lack of antagonistic reaction due to treatment.

5.5.5 Available potassium

Available potassium content of soil differed significantly due to application of human urine and cattle urine after the harvest of vegetable crops. Maximum soil available K was recorded in treatments receiving human urine and cattle urine in three split doses plus gypsum (Table 4.19 and Fig. 5.12). Human urine and cattle urine application based on the N requirement of vegetable crops along with this also added K to soil. This is due to the fact that, urine had substantial amount of K and is mostly in ionic form and becomes immediately available to the plants. The results are in conformity with the findings of Carlander *et al*. (2001) and Hellstrom *et al*. (1999) and Vinneras *et al.* (2006). Jonsson *et al.* (2005) observed that the amount of plant nutrients excreted through

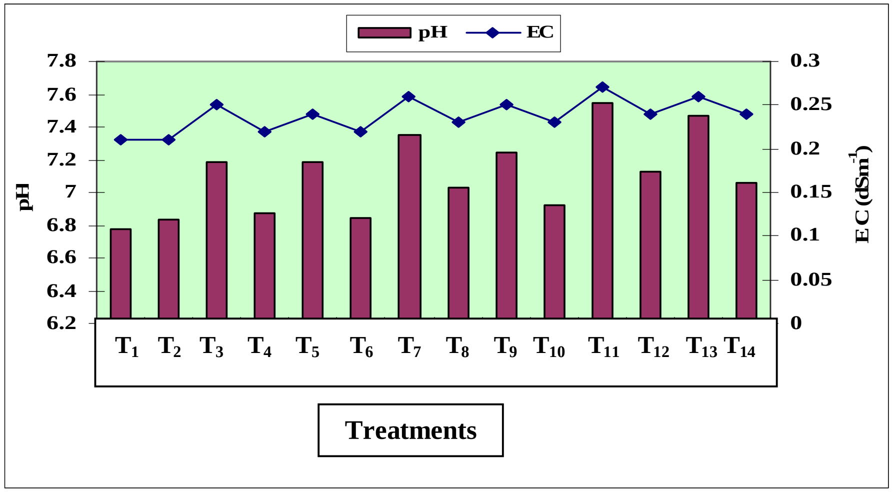


Fig. 5.11: Effect of split application human urine and cattle urine with and without gypsum on pH and electrical conductivity (dS m^{-1}) of soil at harvest of ashgourd crop.

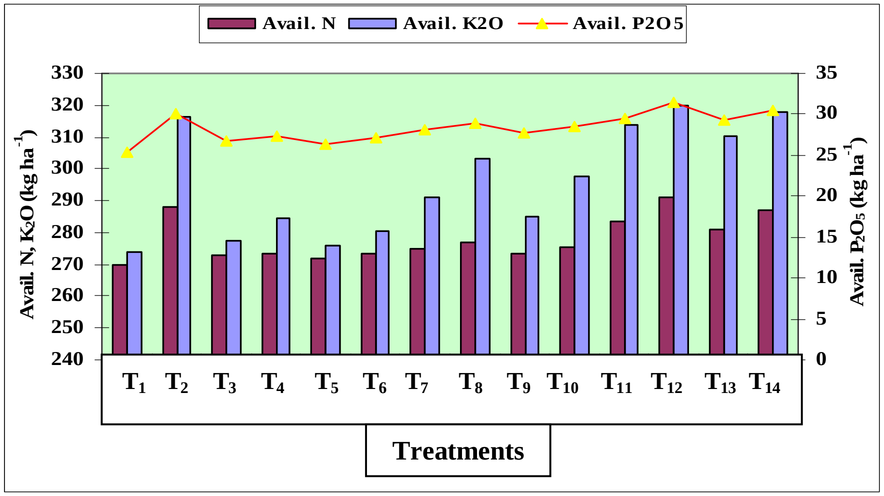


Fig. 5.12: Effect of split application of human urine and cattle urine with and without gypsum on available nitrogen, phosphorus and potassium (kg ha^{-1}) content of soil at harvest of ashgourd crop.

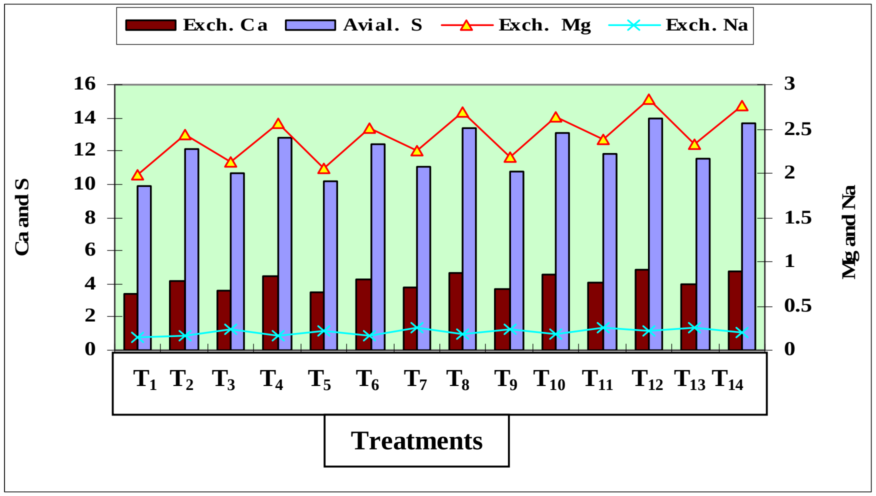


Fig. 5.13 Effect of split application of human urine and cattle urine with and without gypsum on exchangeable calcium, magnesium, sodium and available sulphur content of soil at harvest of ashgourd crop.

Legend	
T_1 :	FYM (Farmyard Manure) alone
T_2 :	Recommended dose of fertilizer + Farmyard manure
T_3 :	RDN through human urine in single dose
T_4 :	RDN through human urine in single dose + gypsum
T_5 :	RDN through cattle urine in single dose
T_6 :	RDN through cattle urine in single dose+ gypsum
T_7 :	RDN through human urine in two split doses
T_8 :	RDN through human urine in two split doses+ gypsum
T_9 :	RDN through cattle urine in two split doses
T_{10} :	RDN through cattle urine in two split doses+ gypsum
T_{11} :	RDN through human urine in three split doses
T_{12} :	RDN through human urine in three split doses+ gypsum
T_{13} :	RDN through cattle urine in three split doses
T_{14} :	RDN through cattle urine in three split doses+ gypsum

anthropogenic liquid waste per person per year was measured to be 4.5 to 4.6 kg nitrogen, 0.4 to 0.5 kg phosphorus and 1.3 to 1.4 kg potassium.

5.5.6 Exchangeable calcium, magnesium and available sulphur

Exchangeable Ca, Mg and available S content differed significantly due to human urine and cattle urine application (Table 4.20 and Fig. 5.13). Application of recommended dose of N through human and cattle urine in three split doses plus gypsum recorded higher Ca, Mg and S contents than treatment receiving recommended dose of N through farmyard manure alone. The presence of appreciable quantities of Ca, Mg and S in urine which upon application to soil increased the Ca, Mg and S content (Altman and Dittmer, 1994).

5.5.7 Exchangeable sodium

Exchangeable sodium content of soil differed significantly due to human urine and cattle urine application (Table 4.20 and Fig. 5.18). Exchangeable sodium content of soil was higher in the treatment receiving human and cattle urine without gypsum compared to treatments with recommended dose of N through fertilizers and farmyard manure alone. The presence of appreciable quantities of sodum in urine which upon application to soil increases the sodium content in soil (Kirchmann and Pettersson, 1995).

5.5.8 DTPA- Iron, manganese, zinc and copper

Significant accumulation of iron, manganese, zinc and copper in soil at harvest of crops was noticed with application of human urine and cattle urine in three split dose plus gypsum to grow different vegetable crops (Table 4.21 and Fig. 14). A note worthy impact was evident in the DTPA-micronutrients content of soil as influenced by anthropogenic liquid waste application. As could be expected, all the anthropogenic liquid waste recorded higher zinc values. This might be due to higher solubility, diffusion and mobility of the applied micronutrients through human and cattle urine. Similar findings were reported by Palmquist and Jonsson (2003).

5.6 Effect of human urine and cattle urine on soil beneficial microorganisms

The soil beneficial microorganisms such as soil fungi, bacteria, actinomycetes, N-fixers and P-solublizer populations differed significantly due to application of human urine and cattle urine (Table 4.22a, 4.22b and Fig. 5.15). Application of recommended dose of N through human urine in three split doses plus gypsum, recommended dose of N through cattle urine in three split doses plus gypsum, recommended dose of fertilizer plus farmyard manure, recommended dose of N through human urine in three split doses plus without gypsum and recommended dose of N through cattle urine in three split doses without gypsum, recorded higher soil microorganisms at harvest of ashgourd, french bean, pole bean and pumpkin crops.

The enhancement in soil microbial populations could be attributed to addition of higher quantities of organic matter present in soil at harvest of the crops. Soil pH above neutral range favours the growth and multiplication of bacteria. Similar results have been observed by Sekar and Bhattacharya (1982) and they found that addition of sewage increased the bacterial and fungal population. Srinivasamurthy *et al.* (2008) indicated that there was no adverse effect of distillery spentwash applied as ferti-irrigation to maize crop on the soil microbial population. Lovell and Jarvis (1996) reported that CO_2 production increased within one day of urine application indicating significant increase in metabolic activity of microorganisms. Majumdar *et al*. (2006) stated that urine supplied essential nutrients to help an increasing microbial population making them respire more. Sadaf Javaria and Qasim Khana (2010) studied that the use of organic fertilizer together with chemical fertilizers, compared to the addition of organic fertilizers alone, has a higher positive effect on microbial biomass.

5.7 Nitrogen, phosphorus and potassium balance in soil

5.7.1 Nitrogen

Balance of nitrogen revealed that recovery of nitrogen ranged from 285.5 to 302.2 kg ha^{-1} from initial to that at harvest of pumpkin crop with the treatment receiving recommended dose of N through human urine in three split doses plus gypsum which was derived from soil pool and added sources and also from incorporation of biomass during

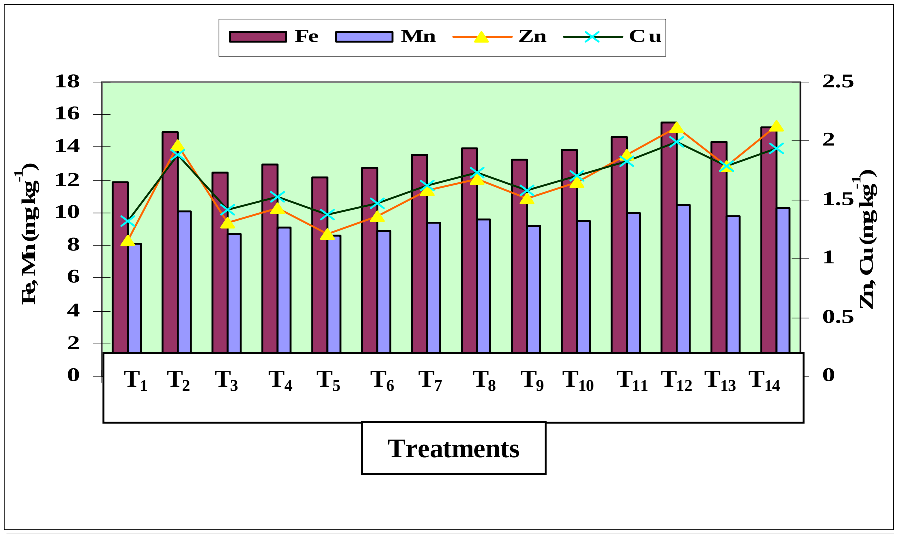


Fig. 5.14: Effect of split application of human urine and cattle urine with and without gypsum on DTPA extractable micronutrients (mg kg^{-1}) content of soil at harvest of ashgourd crop.

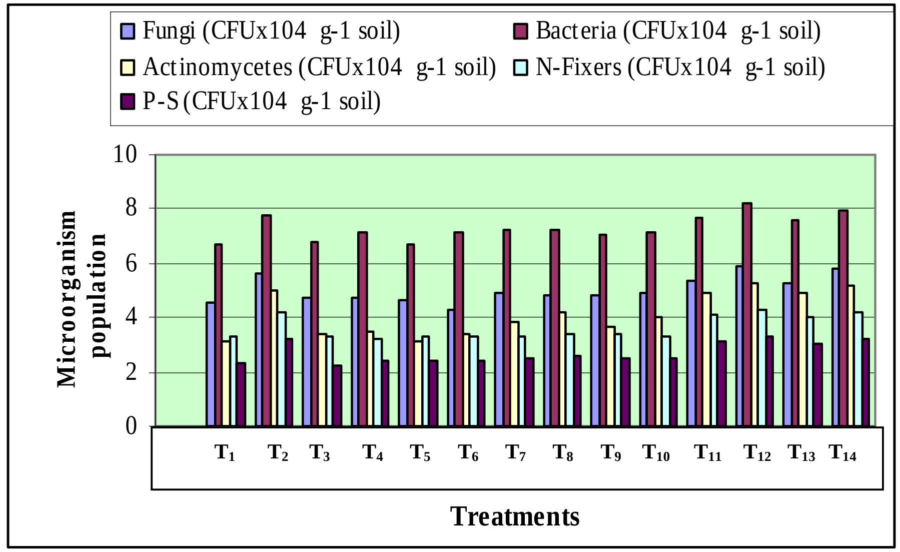


Fig. 5.15: The population of different groups of microorganisms in soil at harvest of ashgourd crop as influenced by split application of human urine and cattle urine with and without gypsum.

Legend	
T_1 :	FYM (Farmyard Manure) alone
T_2 :	Recommended dose of fertilizer + Farmyard manure
T_3 :	RDN through human urine in single dose
T_4 :	RDN through human urine in single dose + gypsum
T_5 :	RDN through cattle urine in single dose
T_6 :	RDN through cattle urine in single dose+ gypsum
T_7 :	RDN through human urine in two split doses
T_8 :	RDN through human urine in two split doses+ gypsum
T_9 :	RDN through cattle urine in two split doses
T_{10} :	RDN through cattle urine in two split doses+ gypsum
T_{11} :	RDN through human urine in three split doses
T_{12} :	RDN through human urine in three split doses+ gypsum
T_{13} :	RDN through cattle urine in three split doses
T_{14} :	RDN through cattle urine in three split doses+ gypsum

crop growth. The actual balance of nitrogen was least in treatment receiving farmyard manure alone (T_1) as compared to rest of the treatments (Table 4.23a and 4.23b). The higher actual balance was noticed due to application of recommended dose of N through human urine in three split doses plus gypsum (T_{12}) which was due to efficient use of applied nitrogen as it was subjected to least losses through leaching, volatilization. Andr Bationo (1997) observed reported that the concentrations of ammonium (NH_4) + nitrate (NO_3) also increased markedly in the immediate soil layers of the urine and urea placement zones, and then decreased over time probably due to N losses by volatilization and leaching. Concentration of mineral N at the periphery of the placement site were similar for all the treatments throughout the study period, indicating very little lateral N diffusion. These results provided evidence that animal urine causes significant variations in soil chemical composition, even in short distance from the deposition zones. Marilene Aban (2005) made organic fertilizer formulation using ALW and studied the effect on soil properties. He observed that there was an increased nitrogen content in soil after harvest of crop.

5.7.2 Phosphorus

Available P_2O_5 balance was negative in all the treatments (Table 4.24a and 4.24b). The lower P_2O_5 uptake during the crop growth (4.7 to 9.9, 4.8 to10.7, 5.3 to 11.1 and 5.7 to 16.5 kg ha^{-1}, by ashgourd, french bean, pole bean and pumpkin crop, respectively) was noticed as against the application rate of 75, 150, 150 and 150 kg ha^{-1}, respectively for ashgourd, french bean, pole bean and pumpkin crops. Even with the same quantity of P application and high level of native P, the available P_2O_5 content after harvest of crops did not show positive balance due to the high P fixation capacity on the clay complexes. (Kirchmann, 1998, Parkinson *et al.*, 2004). Jonsson *et al*. (2004) stated that phosphorus in urine is directly available to plants , and phosphorus loss during urine management is not so high.

5.7.3 Potassium

The uptake of potassium by ashgourd, french bean, pole bean and pumpkin crops ranged from 64.2 to 102.0, 59.1 to 117.4, 54.2 to 109.1 and 62.0 to 150.8 kg ha^{-1} in different treatments, respectively (Table 4.24a and 4.24b). In urine applied treatments higher actual balance of potassium was recorded with application of recommended dose of human urine in three split doses plus gypsum treatment (T_{12}) and lower balance was noticed with application of farmyard manure alone (T_1). This may be due to the fact that, anthropogenic liquid waste contains substantial amount of potassium which is mostly in ionic form and becomes immediately available to plants and thus the excess K might have accumulated in soil. Guyton (1986) confirmed that the physiological measurements indicated that the amount of plant nutrients excreted via urine per person per year would be 2.5-4.3 kg nitrogen, 0.7-1.0 kg phosphorus and 0.9-1.0 kg potassium and are larger than the amounts excreted via faeces (0.5-0.7 kg nitrogen, 0.3-0.5 kg phosphorus and 0.1-0.2 kg potassium). Thus, separation of urine means that 60-90% of the plant nutrients N, P and K ingested can be retrieved in solution. This is in conformity with the findings of Stinzing *et al*. (2007).

The results obtained from the present study are in conformity with the findings of Mitra and Gupta (1999) who also found that potassium concentration was at moderate to high level when soil was irrigated with sewage effluent. Patak *et al*. (1999) obtained appreciable increase in available potassium status in soil irrigated with distillery effluent (Joshi *et al*., 1996).

5.8 Economics of human urine and cattle urine application

Application of recommended dose of N through human urine in three split doses plus gypsum recorded maximum gross returns (Rs. 1,22,760, 1,24,000, 1,49,400 and 1,35,450 ha^{-1}, for ashgourd, french bean, ploe bean and pumpkin crops, respectively), net returns (Rs. 97,799, 85,481, 1,13,311 and 98,829 ha^{-1}, for ashgourd, french bean, pole bean and pumpkin crop, respectively) as compared to other treatments. The benefit: cost ratio recorded was maximum with application of recommended dose of N through human urine in three split doses plus gypsum and recommended dose of fertilizer plus farmyard manure treatments. This was due to higher crop yield indicating favourable nutrient supply to crops in addition to reduced cost on fertilizers as compared to recommended dose of fertilizers and farmyard manure. The lowest net returns and benefit: cost ratio was recorded with the application of recommended dose of N through farmyard manure alone and this was due to lower crop yield in addition to highest cost of cultivation (Table 4.26a and 4.26b). This is in conformity with the findings of Ek *et al*. (2006) and Sridevi *et al*. (2009).

Experiment-III : Effect of graded levels of human and cattle urine on soil properties, crop growth and yield of tomato crop grown in three different soils under green house conditions

5.9 Effect of graded levels of human urine and cattle urine on yield components and yield of tomato

Fruit weight was significantly influenced by application of graded levels of human urine and cattle urine under three different soils. The fruit weight was significantly higher in 2 times the recommended dose of nitrogen through human urine (T_6: 68.8 g) and it was on par with T_9, T_3, $T_{5,}$ T_8 and T_2. Significantly lower fruit weight was recorded with recommended dose of nitrogen through chemical fertilizers (T_1: 50.8. g) which was at par with T_4 and T_7. Whereas in case of black soil, application of 2 times the recommended dose of nitrogen through chemical fertilizers showed significantly higher fruit weight (T_3: 72.2 g) followed by application of 2 times the recommended dose of nitrogen through human urine and application of 2 times the recommended dose of nitrogen through cattle urine. Application of 2 times recommended dose of nitrogen through human urine (T_6) recorded significantly higher fruit weight (3.6 and 3.4 kg plant^{-1}) in red and laterite soils and it was significantly superior over treatments receiving recommended dose of nitrogen through chemical fertilizers (T_1) and cattle urine (T_7: 2.2 and 2.0 kg plant^{-1}) but in black soil fruit weight varied significantly due to varied rate of application of human, cattle urine and fertilizer. Significantly higher fruit weight was recorded in treatment receiving 2 times recommended dose of nitrogen through chemical fertilizers (T_3: 3.67 kg plant^{-1})

Higher yield was recorded with application of 2 times the recommended dose of N through human urine but it was on par with 1.5 times the recommended dose of N application. It was attributed to better availability of nutrients and root development with the timely availability of nutrients to the crops. These results are in agreement with the findings of Peter Morgan (2004) and Kedar and Deepak (2003) used the source-separated human urine for the vegetable plants particularly broad bean, black gram and green pea and studied actual nutrient uptake by vegetable plants from source separated human urine and chemical fertilizers in soil media with different dilution or loading rate in the same condition can be investigated in terms of bio-mass growth (Table 4.29 and Fig. 5.18).

In black soil, higher yield was recorded with application of 2 times the recommended dose of N through chemical fertilizer but was on par with application of human urine and cattle urine which might be due to higher pH of soil leading to loss of applied nitrogen through volatilization. Olga Singurindy *et al*. (2006) observed ammonia volatilization during the first day of the treatments, with volatilization rate closely related to evaporation rates in both sand textures (fine and coarse). Sand texture caused reductions in the urine evaporation rate and therefore in NH_3 volatilization rates. Urine evaporation increased air-filled pore space, thereby improving aeration conditions in the sand that contribute to nitrification and dominance of N_2O production. Moreover, evaporation of urine, enriched with dissolved N_2O, increased total N_2O emission.

Application of 2 time the recommended dose of N through human urine and cattle urine contributed to the significant improvement in yield parameters like number of flower cluster plant^{-1}, number of fruits plant^{-1}, fresh weight fruit^{-1} and fruit yield plant^{-1} red and laterite soils. In black soil, the increased yield was observed intreatment receiving 2 times the recommended dose of N through chemical fertilizer (Table 4.28 to 4.30).

Increase in dry matter production per unit area is a first step in achieving higher yield. Dry matter production and its accumulation in different parts of plants during various growth phases of life cycle of any crop is an important pre-requisite for higher yields as it signifies photosynthetic ability of the crop and also indicates other synthetic processes during developmental sequences. Maintenance of higher total dry matter at harvest was recorded with application of 2 times the recommended dose of N through human urine (236.7 and 218.6 g plant^{-1}, respectively for red and laterite soil) followed by application of 2 times the recommended dose of N through cattle urine (234.6 and 216.4

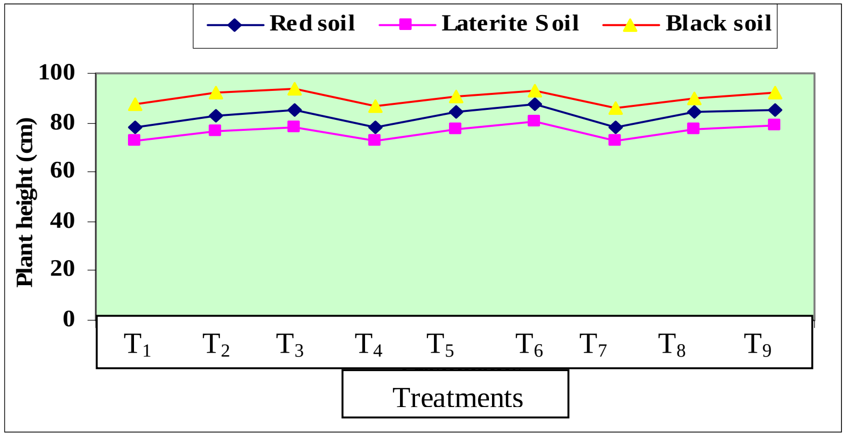


Fig 5.16: Plant height of tomato as influenced by graded levels of human urine, cattle urine and fertilizer in three different soils at harvest.

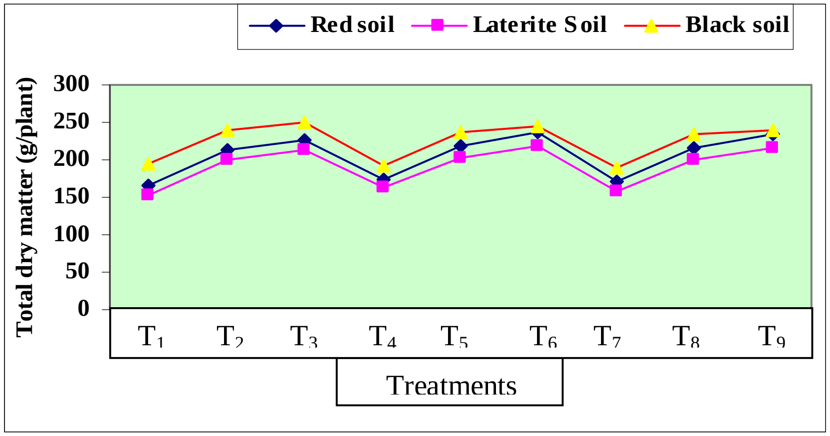


Fig. 5.17: Total dry matter of tomato as influenced by graded levels of human urine, cattle urine and fertilizer in three different soils at harvest.

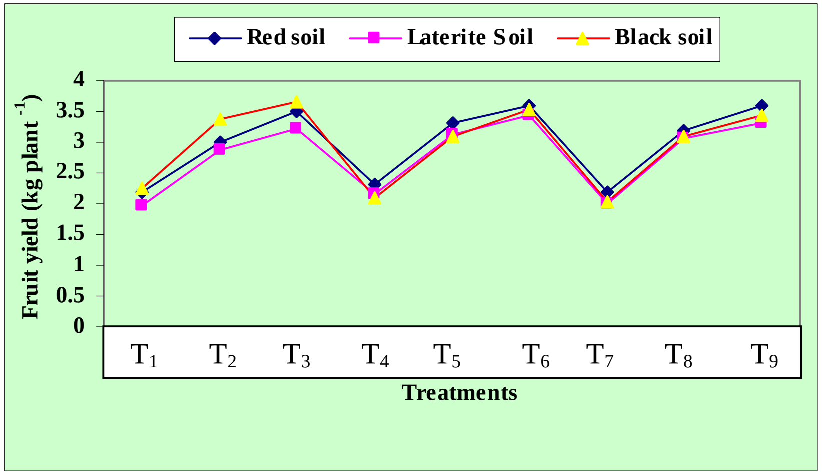


Fig. 5.18 Yield of tomato (kg $plant^{-1}$) as influenced by graded levels of human urine, cattle urine and fertilizer in three different soils.

Legend	
T_1 :	Control-Recommended dose of NPK
T_2 :	1.5 times Recommended dose of N through fertilizer + Recom. Dose of P & K
T_3 :	2 times Recommended dose of N through fertilizer + Recom. Dose of P & K
T_4 :	Recommended dose of N through Human urine + Balance P & K
T_5 :	1.5 times Recommended dose of N through Human urine + Balance P & K
T_6 :	2 times Recommended dose of N through Human urine + Balance P & K
T_7 :	Recommended dose of N through Cattle urine + Balance P & K
T_8 :	1.5 times Recommended dose of N through Cattle urine + Balance P & K
T_9 :	2 times Recommended dose of N through Cattle urine + Balance P & K

g plant^{-1}, respectively for red and laterite soil). The increased dry matter yield was recorded in black soil with 2 times the recommended dose of N through chemical fertilizer, over application of recommended dose of N through human urine, cattle urine and chemical fertilizer (Table 4.27 and Fig 5.16).

The higher yield of vegetable crops with application of 2 times the recommended dose of N through human urine is favourably influenced by taller plants at harvest (87.2 and 80.2 cm, respectively in red and laterite soil), more number of branches (5.90 and 5.80, respectively, in red and laterite soil) at harvest, more number of leaves (40.8 and 36.2, respectively in red and laterite soil) at harvest. Whereas in black soil higher values in respectively these parameter were observed with application of 2 times the recommended dose of N through chemical fertilizer (Tables 4.27 and Fig. 5.17).

This has been the consequence of slow and steady release and better availability of nutrients and higher nutrient uptake observed due to application of human urine in three split doses during the crop growth period in addition to the presence of all essential nutrients in human urine and cattle urine which might have stimulated the growth of vegetable crops. Hoglund (2001) and Simons and Clemens (2004) recorded similar observations on improved yield and yield attributing characters due to human urine application in rice, barley and vegetable crops like chard, turnip, carrot and fruit crops like banana, orange.

5.10 Effect of graded levels of human urine and cattle urine on quality parameters of tomato

Maximum per cent juice, acidity and ascorbic acid contents were recorded with application of 2 times the recommended dose of N through human urine (T_6: 79.5, 0.57 and 16.60 %, respectively in red soil and 75.5, 0.46 and 15.02 %, respectively in laterite soil) followed by application of 2 times the recommended dose of N through cattle urine and application of 2 times the recommended dose of N through chemical fertilizer. While it was T_3 followed by T_6 and T_9 in tomato grown in black soil. Lowest per cent juice, acidity and ascorbic acid content was recorded with application of recommended dose of N through human urine, cattle urine and fertilizers treatments (Table 4.31).

The total soluble solids content of fruits was found to be highest (Table 4.31) in treatment receiving 2 times the recommended dose of N through human urine (4.90 and 4.44 ^{0}Brix, respectively in red and laterite soil) followed by application of 2 time the recommended dose of N through cattle urine and application of 2 times the recommended dose of N through chemical fertilizer while in black soil it was maximum with application of 2 times the recommended dose of N through chemical fertilizer (5.02 ^{0}Brix) followed by application of 2 times the recommended dose of N through human urine and cattle urine treatments.

Increased TSS and total sugars and lower acidity with increased level of fertilizers might be due to the effect of potassium (Hasan *et al.*, 1999). Similar results were reported by Narayan *et al*. (2008) and Ayeni *et al*. (2010) found that application of organic manure, inorganic fertilizes and their combinations showed significant differences in fruit yield and yield attributing traits.

5.11 Effect of graded levels of human urine and cattle urine on concentration and uptake of nutrients by tomato

Nutrient content and uptake higher were with application of graded levels of human urine and cattle urine (Table 4.32 to 4.37 and Fig.5.19 and 5.24).

5.11.1 Content and uptake of nitrogen, phosphorus and potassium

The nitrogen content was significantly higher (3,67 and 3.41 %) in red and laterite soil) (Table 4.32) and significantly higher nitrogen uptake by tomato (186.3 and 153.8 kg ha^{-1}, respectively in red and laterite soil) was due to application of 2 times the recommended dose of N through human urine (Table 4.35 and Fig. 5.22) followed by application of 2 times the recommended dose of N through cattle urine and application of 2 times the recommended dose of N through fertilizer. In black soil significantly higher nitrogen content and uptake was recorded with application of 2 times the recommended dose of N through fertilizer. The least concentration of nitrogen in fruit and total uptake by tomato was recorded due to application of recommended dose of N through human urine, application of recommended dose of N through cattle urine and recommended dose of N through fertilizer. The increase in uptake was due to higher availability of nutrients at the root zone as a result of application of different rates of nutrients through organic sources like human urine and cattle urine coupled with the better root activity. Similar observations of increased uptake was reported by Kadam *et al*. (2005).

Increased phosphorus content in fruit (Table 4.32 and Fig. 20) and uptake by tomato crop grown in red and laterite soil (Table 4.35 and Fig. 5.23) was due to application of 2 times the recommended dose of N through human urine, 2 times the recommended dose of N through cattle urine and 2 times the recommended dose of fertilizer could be attributed to conversion of fixed phosphorus into readily available form by organic acids released during decomposition of organic manure and consequent improvement in the available P in soil and also due to continuous release of nutrients through the application of human urine and cattle urine to soil during crop growth period. But in black soil higher phosphorus content and uptake by tomato cop was observed with application of 2 times the recommended dose of fertilizer These results corroborate with the findings of Mussie *et al*. (2006) who found higher organic carbon, available N, P and K with the usage of dairy waste for five years. Apart, from higher availability improved nitrogen management and higher nitrogen accumulation in plant might have enhanced the phosphorus concentration. Similar findings were reported by Mnkeni *et al*. (2006). Singh Andhupe *et al*. (2003) opined that the application of more quantity of N during reproductive stage enhanced the vegetative growth and produced less fruit yield.

The K concentration in fruit significantly increased with application of human urine and cattle urine (Table 4.32 and Fig. 5.21). Highest potassium content and uptake (Fig. 5.24) by tomato crop grown in red and laterite soil was noticed with 2 times the recommended dose of N through human urine along with balanced potassium supplied through chemical fertilizer. Higher K content and uptake by tomato was observed in black soil in treatment with 2 times the recommended dose of N through fertilizer. This might be due to better root growth and higher absorption capacity resulting in increased assimilation of potassium in plant tissue which in turn improved the absorption and translocation of elements in plant system. Hellstrom (1999) observed that nutrients in

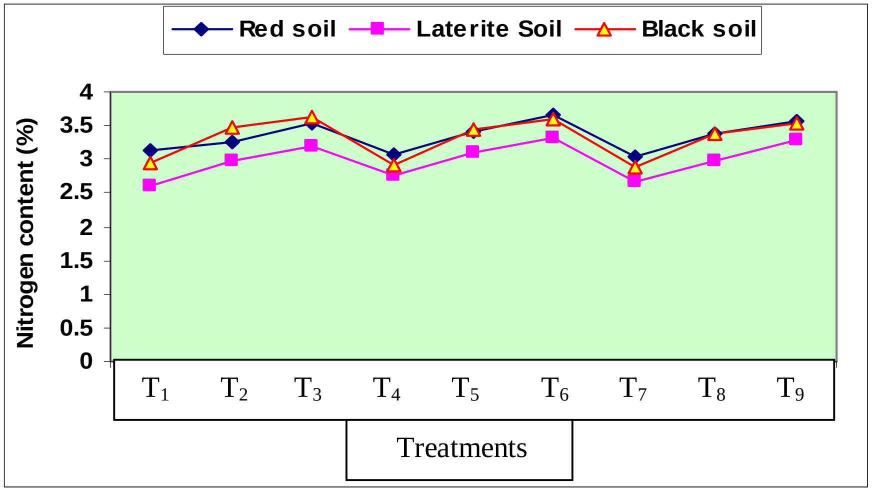


Fig. 5.19: Nitrogen content (%) in tomato fruits as influenced by graded levels of human urine, cattle urine and fertilizer in three different soils at harvest.

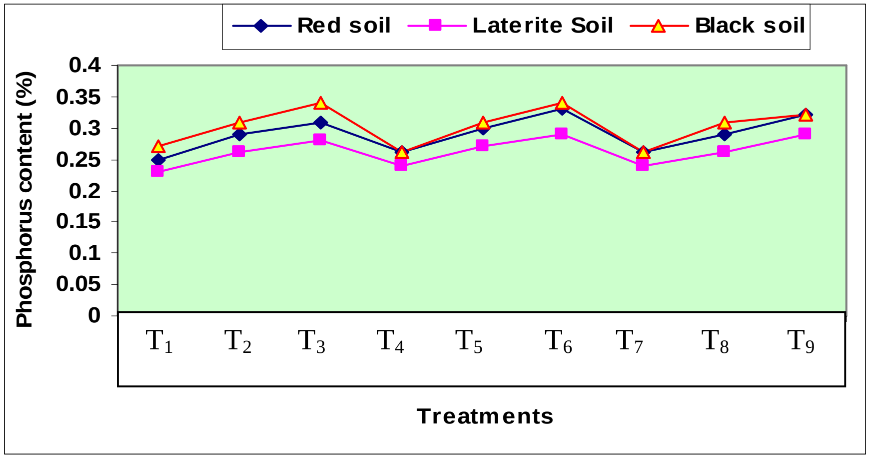


Fig. 5.20: Phosphorus content (%) in tomato fruits as influenced by graded levels of human urine, cattle urine and fertilizer in three different soils at harvest.

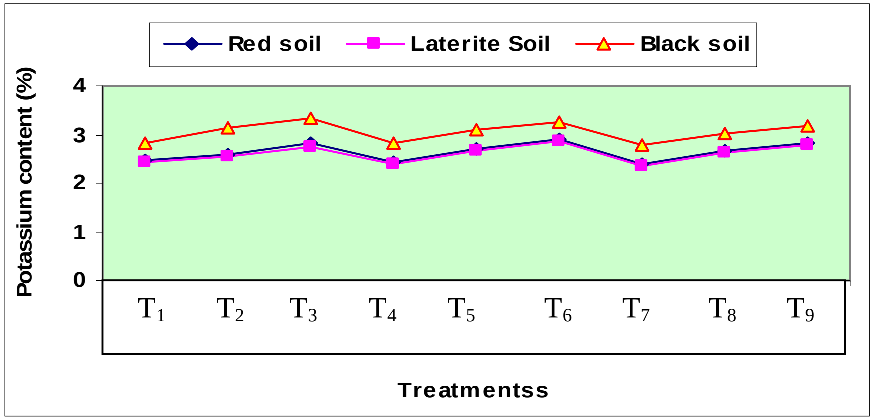


Fig. 5.21: Potassium content (%) in tomato fruits as influenced by graded levels of human urine, cattle urine and fertilizer in three different soils at harvest.

Legend	
T_1 :	Control-Recommended dose of NPK
T_2 :	1.5 times Recommended dose of N through fertilizer + Recom. Dose of P & K
T_3 :	2 times Recommended dose of N through fertilizer + Recom. Dose of P & K
T_4 :	Recommended dose of N through Human urine + Balance P & K
T_5 :	1.5 times Recommended dose of N through Human urine + Balance P & K
T_6 :	2 times Recommended dose of N through Human urine + Balance P & K
T_7 :	Recommended dose of N through Cattle urine + Balance P & K
T_8 :	1.5 times Recommended dose of N through Cattle urine + Balance P & K
T_9 :	2 times Recommended dose of N through Cattle urine + Balance P & K

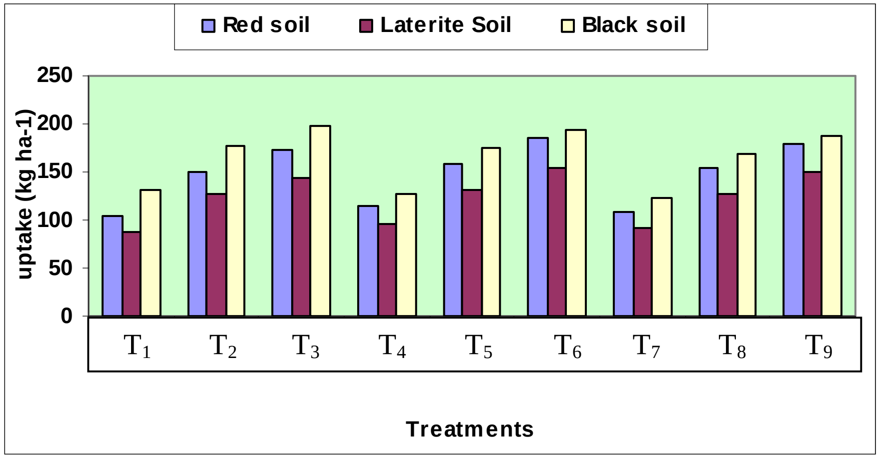


Fig. 5.22: Nitrogen uptake (kg ha^{-1}) by tomato as influenced by graded levels of human urine, cattle urine and fertilizer at harvest in three different soils.

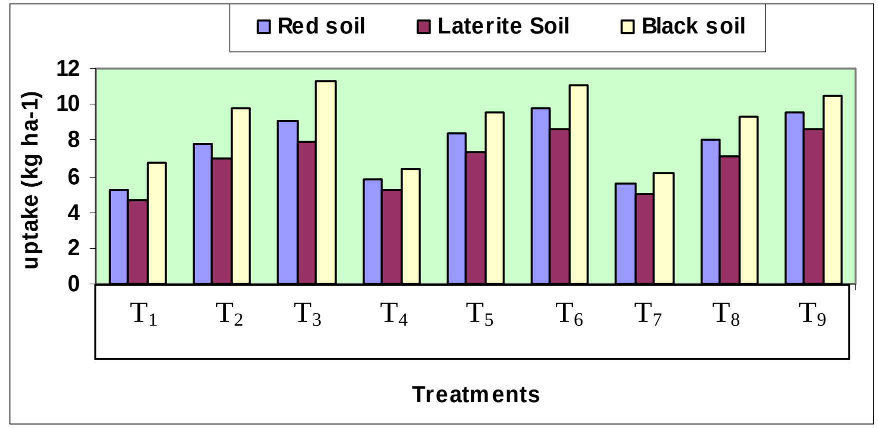


Fig. 5.23: Phosphorus uptake (kg ha^{-1}) by tomato as influenced by graded levels of human urine, cattle urine and fertilizer at harvest in three different soils.

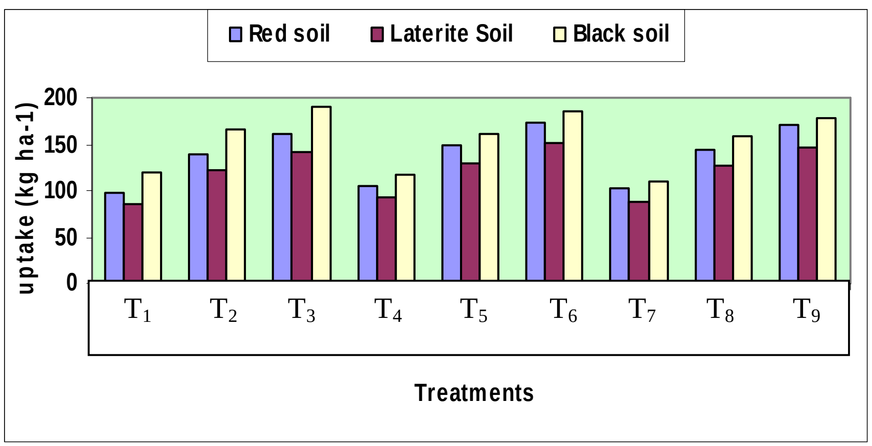


Fig. 5.24: Potassium uptake (kg ha^{-1}) by tomato as influenced by graded levels of human urine, cattle urine and fertilizer at harvest in three different soils.

Legend	
T_1 :	Control-Recommended dose of NPK
T_2 :	1.5 times Recommended dose of N through fertilizer Recom. Dose of P & K
T_3 :	2 times Recommended dose of N through fertilizer + Recom. Dose of P & K
T_4 :	Recommended dose of N through Human urine + Balance P & K
T_5 :	1.5 times Recommended dose of N through Human urine + Balance P & K
T_6 :	2 times Recommended dose of N through Human urine + Balance P & K
T_7 :	Recommended dose of N through Cattle urine + Balance P & K
T_8 :	1.5 times Recommended dose of N through Cattle urine + Balance P & K
T_9 :	2 times Recommended dose of N through Cattle urine + Balance P & K

anthropogenic liquid waste are water soluble and are easily available to the plants for uptake and are easily transported into plant parts.

5.11.2 Content and uptake of Calcium, magnesium and sulphur

Calcium concentration in tomato fruit varied significantly due to application of graded levels of human urine and cattle urine to tomato crop grown in red, laterite and black soil (Table 4.33). Calcium concentration was highest with 2 times the recommended dose of N through human urine followed by 2 times the recommended dose of N through cattle urine and 2 times the recommended dose of N through fertilizer under red and laterite soil, while in black soil highest calcium content and uptake was recorded with treatment receiving 2 times the recommended dose of N through fertilizer. Higher calcium content and uptake of tomato was recorded due to application of recommended dose of N through human urine, cattle urine and fertlizer to soil during tomato crop. This might be due to the presence of appreciable amount of Ca in human urine and cattle urine, which enhanced the crop uptake and accumulation. Accumulation of higher N and K in treatments with human and cattle urine might have enhanced the Ca accumulation. Similar findings were observed by Christou *et al*. (1992).

Similar trend highest in magnesium concentration and uptake by tomato was recorded in treatment with higher dose of urine applied to red and laterite soil (Table 4.32). Similar reasons can be quoted for increased Mg concentration in leaf sheath i.e. presence of appreciable quantity of Mg in urine and greater accumulation of Mg with increased N in leaf (Thangaselvabai *et al.*, 2009). Potassium was found to regulate the transfer of nutrients to the xylem. Where potassium supply was low, the transfer of nitrogen, phosphorus, calcium, magnesium, sodium, manganese, copper and zinc across the xylem is restricted (Turner, 1985). Sulphur content of fruit (Table 4.32) increased with the application of human urine and cattle urine which may be attributed to addition of sulphur through these sources. Maximum uptake of sulfur by tomato crop may be account of its higher content and higher dry matter production. Similar results have been reported by Raghupathi *et al.* (2002). Whereas in black soil content and uptake of calcium, magnesium and sulphur by tomato crop was recorded by treatment receiving 2 times the recommended dose of N through fertilizer. The lower concentration of calcium, magnesium and sulfur in tomato fruit in treatment receiving human/ cattle urine to black soil may be because of volatilization loss of nitrogen due to high pH in turn may result in lower uptake of other nutrients by crops.

5.11.3 Content and uptake of iron, manganese, zinc and copper

Iron concentration in fruit of tomato crop grown in red and laterite soil differed significantly due to application of human urine and cattle urine (Table 4.34). Iron concentration was highest with 2 times the recommended dose of N through human urine followed by 2 times the recommended dose of N through cattle urine and the least content and uptake of iron was recorded with recommended dose of N through chemical fertilizer. This might be due to the presence of appreciable amount of iron in human urine and cattle urine, which enhanced the crop uptake and accumulation.

Similar trend was observed in manganese concentration of tomato fruits. Highest manganese concentration in tomato fruit was recorded in treatment receiving human urine and cattle urine applied treatments (Table 4.34). Similar reasons can be quoted for increased Mn concentration in plant tissue i.e. presence of appreciable quantity of Mn in human urine and cattle urine.

Zinc content (Table 4.33) of tomato crop increased with application of graded levels of human urine and cattle urine which may be attributed to more quantity of zinc added to the soil through urine. Higher uptake of zinc was due to its higher content and higher dry matter production. (Table 4.37). Whereas in black soil the content and uptake of micronutrients by tomato crop was higher in treatment receiving 2 times the recommended dose of N through fertilizer which might be due to application of urine to black soil leads to increase in pH of soil which might leads to decrease the solubility of micronutrients and there by lesser the availability and also uptake and content of plant less. The reasons are quoted in section 5.4.5.

5.12 Effect of application of graded levels of human urine and cattle urine on chemical properties of soil

5.12.1 Soil pH

Soil reaction differed significantly due to application of graded levels of human urine and cattle urine to tomato crop grown in different soils (Table 4.38 and Fig. 5.25). However, marginal increase in pH was observed in treatments, which received human urine and cattle urine. The results are in accordance with Powell *et al*. (1998). The increase in pH might be due to addition of substantial amount of bicarbonates and even sodium following human urine application. Similar findings of increase in pH of soil with application of ALW were reported by Mnkeni *et al*. (2006) and Vinneras *et al*. (2006).

5.12.2 Electrical conductivity

Salt content of soil differed significantly due to application of graded levels of human urine and cattle urine (Table 4.38 and Fig. 5.26). Application of human urine and cattle urine increased the EC of soil after the harvest of crop when compared to RDF treatments and also initial EC value of soil. This is attributed to the presence of higher amount of salts in human urine and cattle urine, which upon application to soil might enhance the EC. Salt content at harvest were below the thresh hold level (1.0 dS m^{-1}) due to removal by crops. The results are in accordance with Mnkeni Pearson (2008). Jonsson *et al*. (2004) opined that the salt concentration is quite high in urine, but the total quantity applied per year is not high when compared to irrigation water.

5.12.3 Available nitrogen

Available N in soil differed significantly due to application of graded levels of human urine and cattle urine. In red and laterite soils, application of 2 times the recommended dose of N through human urine recorded highest available N content (262.1 and 228.6 kg ha^{-1}, respectively), followed by 2 times the recommended dose of N through cattle urine (262.0 and 226.3 kg ha^{-1}, respectively), 2 times the recommended dose of fertilizer (261.5 and 225.6 kg ha^{-1}, respectively) (Table 4.39 and Fig. 5.27). Whereas in black soil higher available N at harvest was recorded with 2 times the

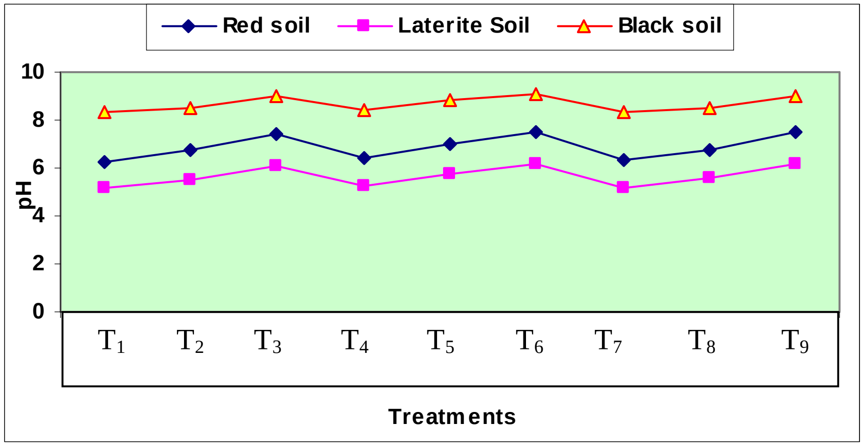


Fig. 5.25: Effect of graded levels of human urine, cattle urine and fertilizer application on pH at harvest of the tomato in three different soils.

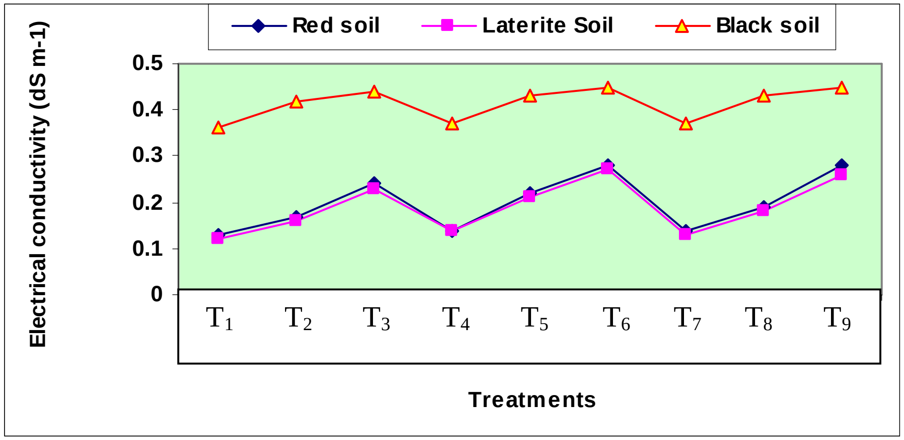


Fig. 5.26: Effect of graded levels human urine, cattle urine and fertilizer application on electrical conductivity (dS m^{-1}) at harvest of the tomato in three different soils.

Legend	
T_1 :	Control-Recommended dose of NPK
T_2 :	1.5 times Recommended dose of N through fertilizer + Recom. Dose of P & K
T_3 :	2 times Recommended dose of N through fertilizer + Recom. Dose of P & K
T_4 :	Recommended dose of N through Human urine + Balance P & K
T_5 :	1.5 times Recommended dose of N through Human urine + Balance P & K
T_6 :	2 times Recommended dose of N through Human urine + Balance P & K
T_7 :	Recommended dose of N through Cattle urine + Balance P & K
T_8 :	1.5 times Recommended dose of N through Cattle urine + Balance P & K
T_9 :	2 times Recommended dose of N through Cattle urine + Balance P & K

recommended dose of N through fertilizer. The reasons for this trend of results has been elaborated in 5.5.4

5.12.4 Available phosphorus

Available P content of soil varied significantly due to application of human urine and cattle urine to tomato crop in different soils (Table 4.39 and Fig. 5.28). The enhancement in phosphorus availability may be due to the combined effect of released organic acids and organic anions upon decomposition of organic matter as a result of improvement in biological properties of soil and reduction in the activity of phosphorus complexing agent. In black soil, the higher phophorus content was recorded in treatment receiving 2 times the recommended dose of N through fertilizer which might be due to alkaline pH of the soil. And due to the release of phosphorus from the fixation sites by the decomposition products of organic manures and lack of antagonistic reaction due to treatment. Similar results were reported by Vinneras (2001).

5.12.5 Available potassium

Available potassium content of soil differed significantly due to application of graded levels of human urine and cattle urine after the harvest of tomato crop. Maximum soil available K was recorded in treatment receiving human urine and cattle urine (Table 4.39 and Fig. 5.29). This is due to the fact that, urine contains substantial amount of K mostly in ionic form and becomes immediately available to plants. In black soil, higher available K content was recorded in treatment receiving 2 times the recommended dose of N through fertilizer which might be due to high pH soil reduced by availability of other nutrients by formation of insoluble salts. The results are conformity with the findings of Carlander *et al*. (2001) and Hellstrom and Johansson (1999) and Vinneras *et al.* (2006).

5.12.6 Exchangeable calcium, magnesium and available sulphur

Exchangeable calcium and magnesium and available sulfur content of soil differed significantly due to application of graded levels of human urine and cattle urine (Table 4.40). Application of 2 times the recommended dose of N through human and

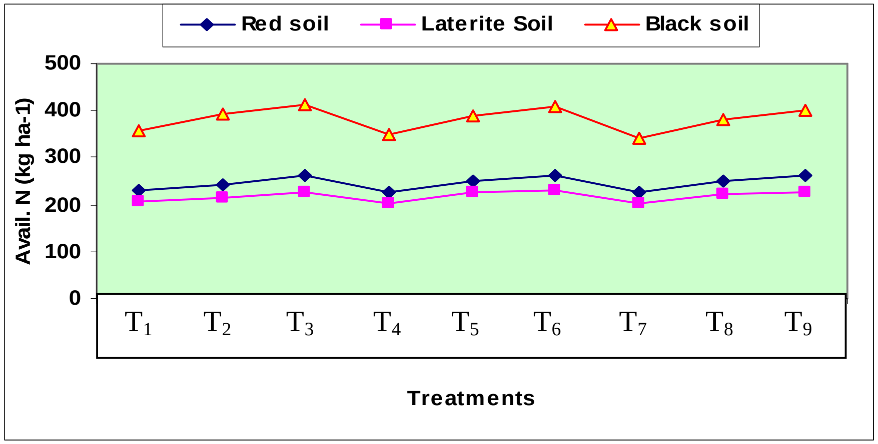


Fig. 5.27: Effect of human urine, cattle urine and fertilizer application on available nitrogen, (kg ha^{-1}) content at harvest of the tomato in three different soils.

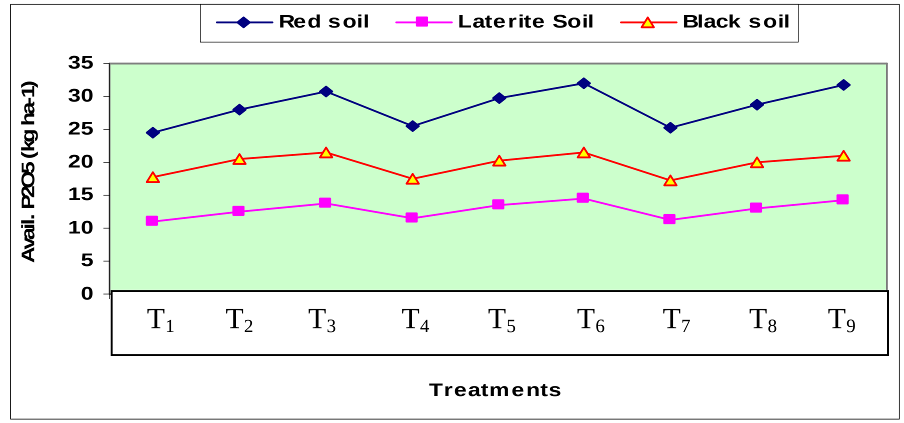


Fig. 5.28: Effect of human urine, cattle urine and fertilizer application on available phosphorus (kg ha^{-1}) content at harvest of the tomato in three different soils.

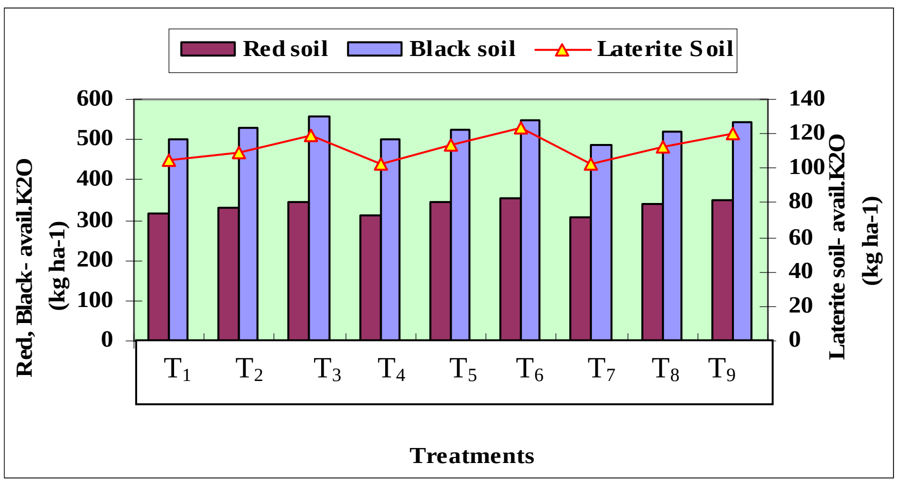


Fig. 5.29: Effect of human urine, cattle urine and fertilizer application on available potassium (kg ha^{-1}) content at harvest of the tomato in three different soils.

Legend	
T_1 :	Control-Recommended dose of NPK
T_2 :	1.5 times Recommended dose of N through fertilizer + Recom. Dose of P & K
T_3 :	2 times Recommended dose of N through fertilizer + Recom. Dose of P & K
T_4 :	Recommended dose of N through Human urine + Balance P & K
T_5 :	1.5 times Recommended dose of N through Human urine + Balance P & K
T_6 :	2 times Recommended dose of N through Human urine + Balance P & K
T_7 :	Recommended dose of N through Cattle urine + Balance P & K
T_8 :	1.5 times Recommended dose of N through Cattle urine + Balance P & K
T_9 :	2 times Recommended dose of N through Cattle urine + Balance P & K

cattle urine recorded higher Ca, Mg and S contents in soil than treatment receiving recommended dose of fertilizer. This may be due to addition of appreciable quantities of Ca, Mg and S in urine which upon application to soil increased the Ca, Mg and S content. Similar results were reported by Altman and Dittmer (1994)

5.12.8 Exchangeable sodium

Exchangeable sodium content of soil differed significantly due to application of graded levels of human urine and cattle urine (Table 4.40). Application of 2 times the recommended dose of N through human urine and cattle urine recorded higher sodium content of soil than the treatment recommended dose of N through fertilizer. This may be due to the presence of appreciable quantities of sodium in urine. Kirchmann and Pettersson (1995) observed that stored human urine had pH value of 8.9 and composed of the cations like Na^+, K^+, NH_4^+ and Ca^{2+}.

5.12.9 DTPA- iron, manganese, zinc and copper

Significant accumulation of iron, manganese, zinc and copper content in soil at harvest of crops was noticed with treatment receiving 2 times the recommended nitrogen through human urine and cattle urine to tomato crop under different soils (Table 4.41). A note worthy impact was evident in the DTPA-micronutrients content of soil as influenced by application of graded levels of human and cattle urine to soil. As could be expected, the anthropogenic liquid waste recorded higher micronutrients. This may be due to higher solubility, diffusion and mobility of the applied micronutrients through human and cattle urine. Similar findings were found by Palmquist and Jonsson (2003). Laanbroek and Gerards (1991) observed enhanced microbial activity in soil surface after application of organic waste there by enhanced in the availability of micronutrients in soil.

5.13 Effect of application of graded levels of human urine and cattle urine on soil beneficial microorganisms

The soil beneficial microorganisms such as fungi, bacteria, actinomycetes, N-fixers and P-solublizer populations differed significantly due to application of human urine and cattle urine (Table 4.42a, 4.42b and Fig. 5.30 and 5.31). Treatment receiving 2

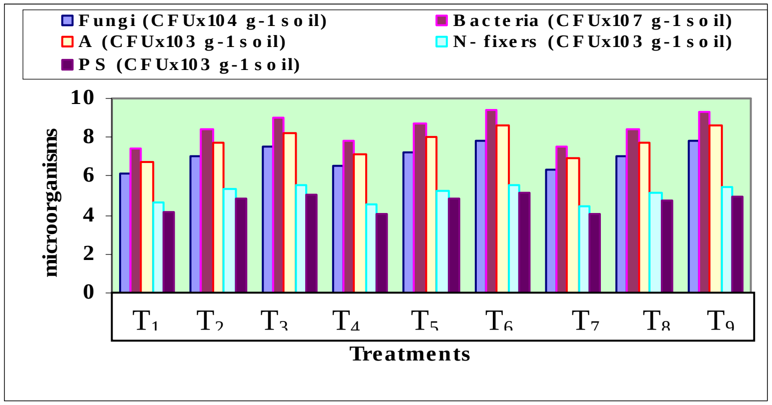


Fig. 5.30: Effect of graded levels of human urine, cattle urine and fertilizer application on available potassium (kg ha^{-1}) content at harvest of the tomato in red soil.

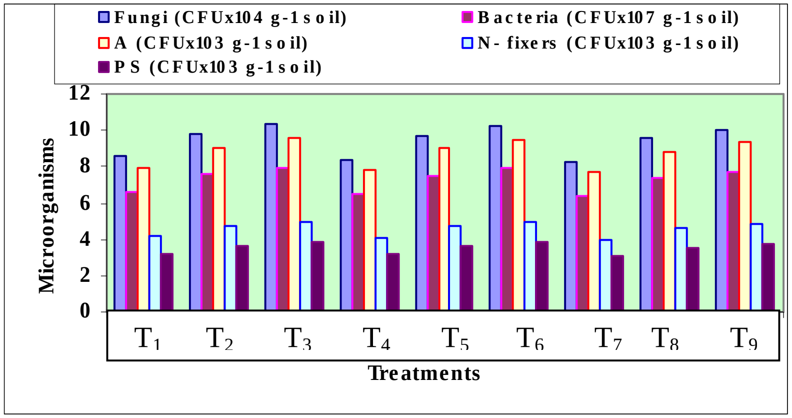


Fig. 5.31: Effect of graded levels of human urine, cattle urine and fertilizer application on available potassium (kg ha^{-1}) content at harvest of the tomato in black soil.

Legend	
T_1 :	Control-Recommended dose of NPK
T_2 :	1.5 times Recommended dose of N through fertilizer + Recom. Dose of P & K
T_3 :	2 times Recommended dose of N through fertilizer + Recom. Dose of P & K
T_4 :	Recommended dose of N through Human urine + Balance P & K
T_5 :	1.5 times Recommended dose of N through Human urine + Balance P & K
T_6 :	2 times Recommended dose of N through Human urine + Balance P & K
T_7 :	Recommended dose of N through Cattle urine + Balance P & K
T_8 :	1.5 times Recommended dose of N through Cattle urine + Balance P & K
T_9 :	2 times Recommended dose of N through Cattle urine + Balance P & K

times the recommended dose of N through human urine, 2 times the recommended dose of N through cattle urine, 2 times the recommended dose of N through fertilizer recorded maximum soil microorganism at harvest of tomato crop. For the reasons refer section 5.6

5.14 Results of practical significance

Based on the results of the research work carried out, the following conclusion can be drawn:

- Human urine has appreciable amount of major, secondary and micronutrients. Hence, it can be considered as a wholesome liquid fertilizer.
- Human urine was found to have slightly higher quantities of plant nutrient elements compared to cattle urine.
- Human urine was found to be on par or slightly better than cattle urine and fertilizers in terms of increasing the yield of all the four vegetable crops. Application of recommended dose of nitrogen through human urine in three split doses plus gypsum applied to soil was found to be the best treatment.

5.15 Future line of work

- Detailed study on the presence of growth promoting substances if any in human urine
- Long term impact of repeated application of human urine and cattle urine on physical, chemical and biological properties of soil and growth and yield of crops and ground water pollution
- Impact of urine discharged by persons with varied ailment and who consume medicines on soil and crops

SUMMARY

VI SUMMARY

In order to assess the nutritive value of human urine and its use as a supplement to fertilizers in crop production, characterisation of human urine samples collected from persons of vegetarian and non-vegetarian food habit representing three different age groups (<20, 20-40 and >40 years) was done. Urine collected from Holstein Friesian, local cow, ox and buffalo also was characterised for composition. An incubation experiment was conducted to study the changes in composition of human and cattle urine incubated under open and closed conditions.

Field experiment was conducted in a farmer's field, at Nagasandra village Doddaballapur, Bangalore rural District, during 2009-11 to study the effect of repeated application of human urine and cattle urine on soil properties, growth and yield of ashgourd, french bean, pole bean and pumpkin crops grown in succession in the same plot. Also a pot experiment was conducted under green house condition at GKVK to study the effect of different quantities of human urine and cattle urine on properties of red, black and laterite soils and growth, yield and quality of tomato. The results of these experiments are summarised below.

(A) Characterisation of human and Cattle urine

- The fresh human urine from persons of vegetarian diet and of different age group was acidic in reaction and the pH ranged from 4.97 to 6.51, 4.79 to 6.65 and 4.26 to 6.23. It has appreciable amount of salts and the electrical conductivity ranged from 5.64 to 6.97, 6.85 to 8.17 and 6.81 to 7.89 dS m^{-1} for <20, 20 to 40 and >40 years age group, respectively.

- The concentration of nitrogen varied from 0.21 to 0.41, 0.25 to 0.43 and 0.26 to 0.43 per cent, phosphorus concentration varied from 0.17 to 0.22, 0.11 to 0.26 and 0.13 to 0.24 per cent and the potassium content varied from 0.12 to 0.23, 0.14 to 0.20 and 0.17 to 0.22 per cent, for <20, 20 to 40 and >40 years age group, respectively.

- It also had appreciable quantity of secondary and micronutrients. The sodium concentration varied from 0.22 to 0.31, 0.13 to 0.23 and 0.14 to 0.22 per cent for samples of < 20, 20 to 40 and >40 years age group, respectively.
- The chemical composition of human urine collected from persons of non-vegetarian and of different age group was slightly higher compared to urine from persons of vegetarian diet.
- The urine samples from different categories of cattle viz., HF, cow, ox buffalo showed the pH ranging from 6.69 to 8.10, 5.23 to 6.35, 5.37 to 6.65 and 6.69 to 8.16. The electrical conductivity ranged from 7.52 to 9.10, 6.75 to 8.19, 6.69 to 8.38 and 7.52 to 9.17 dS m^{-1} for HF, cow, ox and buffalo's urine samples, respectively.
- The concentration of nitrogen varied from 0.20 to 0.34, 0.21 to 0.35, 0.22 to 0.35 and 0.21 to 0.37 per cent, phosphorus concentration varied from 0.13 to 0.21, 0.15 to 0.23, 0.15-0.23 and 0.12-0.21 per cent and the potassium content varied from 0.194 to 0.248, 0.19 to 0.23, 0.18 to 0.26 and 0.02 to 0.22 per cent in urine samples of HF, cow, ox and buffalo's respectively.
- The cattle urine samples also had appreciable amount of sodium and the concentration varied from 0.09 to 0.30, 0.09 to 0.39, 0.09 to 0.30 and 0.09-0.19 per cent with mean value of 00.19, 0.20, 0.19 and 0.13 per cent for HF, cow, ox and buffalo's urine.
- Cattle urine also contained good amount of micronutrients like zinc, manganese, iron and copper.

(B) Monitoring changes in the quality of human urine, incubated under open and closed conditions

- In open condition, changes in chemical composition of human urine samples collected from persons of <20 years age group of vegetarian and non-vegetarian diet was more compared to samples incubated under closed condition
- A gradual increase in pH of urine was observed with time. The pH ranged from 7.93 to 8.93 and 8.09 to 9.11 with an average value of 8.66 and 8.84 for samples of <20

years age group at 30 and 60 days after incubation, respectively. Under closed condition there was slight increase in pH the valves ranged from 7.85 to 8.84 and 7.85 to 8.84 for samples of <20 years age group at 30 and 60 days after incubation, respectively.

- There was an appreciable reduction in the nitrogen concentration of urine kept under open condition compared to closed condition. The nitrogen content varied from 0.16 to 0.32 and 0.16 to 0.31 per cent with mean value of 0.24 per cent at both 30 and 60 days after incubation. The phosphorus content varied from 0.16 to 0.28 and 0.16 to 0.27 per cent with mean value of 0.20 and 0.19 per cent on 30 and 60th day, respectively. The potassium content varied from 0.14 to 0.26 and 0.13 to 0.25 per cent with an average value of 0.18 per cent at 30 and 60 days after incubation. In closed condition the concentration of nitrogen varied from 0.19 to 0.38 and 0.19 to 0.37 per cent with an average value of 0.28 and 0.27 per cent. There was no change in the P and K content of urine samples with incubation.
- The fresh urine samples from vegetarian and non-vegetarian diet persons were having only bicarbonate not any carbonates. But appreciable amount of carbonate also was found at 30 days after incubation and it increased further at 60 days after incubation under open condition.
- There was slight reduction in the concentration of micronutrients.

(C) Experiment to study the changes in quality of cattle urine incubated under open and closed condition

- In open condition, the pH ranged from 8.57 to 9.21, 8.49 to 9.23, 8.52 to 9.19 and 8.64 to 9.24 with a mean value of 8.93, 8.89, 8.85 and 8.92 in samples from HF, cow, ox and buffalo, respectively. In closed condition, the pH ranged from 8.48 to 9.12, 8.40 to 9.14, 8.43 to 9.10 and 8.55 to 9.15 with mean value of 8.84, 8.80, 8.76 and 8.83 for urine samples of HF, local cow, ox and buffalo respectively.
- The concentration of nitrogen varied from 0.16 to 0.27, 0.17 to 0.27, 0.16 to 0.28, and 0.17 to 0.29 per cent with an average value of 0.22, 0.22, 0.21 and 0.22 per cent. The phosphorus concentration varied from 0.14 to 0.19, 0.15 to 0.21, 0.15 to 0.21 and

0.14 to 0.19 per cent with mean value of 0.16, 0.18, 0.18 and 0.16 per cent respectively for samples from HF, cow, ox and buffalo, respectively. The potassium content varied from 0.17 to 0.19, 0.17 to 0.20, 0.17 to 0.20 and 0.17 to 0.19 per cent with an average value of 0.18 per cent in urine samples of all the four categories of cattle. The concentration of nitrogen varied from 0.19 to 0.31, 0.20 to 0.32, 0.19 to 0.32, and 0.19 to 0.34 per cent with an average value of 0.25, 0.25, 0.24 and 0.26 per cent, phosphorus concentration varied from 0.15 to 0.20, 0.16 to 0.19, 0.15 to 0.22 and 0.15 to 0.20 per cent with mean value of 0.16, 0.17, 0.19 and 0.17 per cent and the potassium content varied from 0.17 to 0.22, 0.19 to 0.22, 0.18 to 0.22 and 0.18 to 0.22 per cent with an average value of 0.20, 0.20, 0.20and 0.21 per cent for urine samples of HF, local cow, ox and buffalo respectively.

- The concentration of anions viz., carbonate and bicarbonate was found to increase slightly when incubated under open condition with time. In closed condition, the carbonate concentration ranged from 9.00 to 21.60, 9.00 to 21.60, 9.00 to 19.80 and 10.80 to 21.60 meqL^{-1} with mean value of 14.94, 14.76, 13.68 and 15.48 meql^{-1}, the bicarbonate concentration ranged from 34.70 to 52.47, 44.01 to 55.01, 44.01 to 54.16 and 41.47 to 51.62 meql^{-1} with an average value of 47.65, 49.76, 48.92 and 47.48 meq$l^{-1}$for urine samples of HF, local cow, ox and buffalo respectively.

- The zinc concentration under open condition varied from 13.28 to 15.55, 2.80 to 16.04, 13.28 to 16.04 and 13.28 to 16.04 mgL^{-1} with mean value of 14.69, 14.84, 14.30 and 14.74 mgl^{-1}. The iron content varied from 95.74 to 103.03, 95.42 to 100.93, 96.23 to 101.90 and 95.42 to 101.90 mgl^{-1} with mean value of 98.56, 98.32, 98.50 and 98.46 mgL^{-1}. In closed condition, the zinc concentration varied from 13.28 to 15.55, 12.80 to 16.04, 13.28 to 16.04 and 13.28 to 16.04 mgL^{-1} with mean value of 14.69, 14.84, 14.30 and 14.74 mgl^{-1}, the iron content varied from 97.40 to 104.81, 97.07 to 102.67, 97.89 to 103.66 and 97.07 to 103.66 mgL^{-1} with mean value of 100.26, 100.02, 100.20 and 100.17 mgL^{-1},

- Under open condition, the manganese concentration varied from 14.09 to 20.57, 14.42 to 20.57, 14.09 to 21.55 and 14.09 to 20.57 mgL^{-1} average value of 17.64, 18.21, 17.59 and 18.52 mgL^{-1}. The copper content ranged from 23.67 to 32.27, 25.29

to 30.75, 23.67 to 32.27 and 23.667 to 32.27 mgL^{-1} with the mean of 35.49, 35.85, 34.21 and 35.39 mgL^{-1} in urine samples of HF, local cow, ox and buffalo, respectively. In closed condition the manganese concentration varied from 14.110 to 20.60, 14.43 to 20.60, 14.110 to 21.57and 14.110 to 20.60 mgl^{-1} average value of 17.66, 18.23, 17.61 and 18.54 mgL^{-1}. The copper content ranged from 23.71 to 32.33, 25.33 to 30.80, 23.71 to 32.33 and 23.71 to 32.33 mgL^{-1} with the mean of 28.80, 27.76, 29.09 and 28.74 mgL^{-1} for urine samples of HF, local cow, ox and buffalo respectively.

(D) Field Experiment to study the effect of application of graded levels of human urine and cattle urine on soil properties, growth and yield of vegetable crops

- All the growth parameters and yield parameters at harvest of ashgourd, french bean, pole bean and pumpkin crops were significantly influenced by the application of human urine and cattle urine.
- Total dry matter accumulation was significantly higher due to recommended dose of N through human urine in three split doses plus gypsum (T_{12}: 701.7 g $plant^{-1}$) followed by recommended dose of N through cattle urine in three split doses plus gypsum (T_{14}) at all the growth stages. Similar trend was observed at harvest of french bean, pole bean and pumpkin crops. The trend of variation in total dry matter accumulation at harvest observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving the same treatments.
- Yield of ashgourd, french bean, pole bean and pumpkin crops recorded was significantly higher with application of recommended dose of N through human urine in three split doses plus gypsum (T_{12}: 39.2, 14.2, 17.4 and 38.7 t ha^{-1}) followed by recommended dose of N through cattle urine in three split doses plus gypsum (T_{14}) and application of recommended dose of fertilizer plus farmyard manure (T_2).
- The converted yields of french bean, pole bean and pumpkin crops interms of ashgourd yield also followed the similar trend as that of growing ashgourd. The maximum converted yield of french bean, pole bean and pumpkin was observed in T_{12} treatment receiving recommended dose of N through human urine in three split

doses plus gypsum as found in case of ashgourd. Similarly application of human urine/ cattle urine with or without gypsum was superior to two split application and one time application. However, the treatments involving addition of urine along with gypsum noticeably increased the ashgourd yield as well as the converted yields of french bean, pole bean and pumpkin crops.

- In all the crops application of human/ cattle urine in three split doses was statistically equivalent to the yield recorded by application of recommended dose of fertilizers plus farmyard manure.
- Significantly higher nitrogen content in ashgourd fruit (4.09 %) was observed in treatment receiving recommended dose of N through human urine in three split doses plus gypsum (T_{12}) and it was at par with T_{14}, T_2, T_{11} and T_{13} but was found significantly superior over rest of the treatments in ashgourd crop. The trend of variation in nitrogen content observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.
- Phosphorus and potassium content in ashgourd fruit was significantly higher in treatment receiving recommended dose of N through human urine in three split doses plus gypsum (T_{12}) followed by recommended dose of N through cattle urine in three split doses plus gypsum (T_{14}). The trend of changes in phosphorus and potassium content observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.
- Higher calcium, magnesium and sulphur content was recorded with recommended dose of N through human urine in three split doses plus gypsum (T_{12}) and it was at par with T_{14}, T_2, T_{11} and $T_{13.}$ The trend of changes in calcium, magnesium and sulphur content observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.
- Significantly higher micronutrients content in ashgourd fruit was observed in treatment receiving recommended dose of N through human urine in three split doses

plus gypsum (T_{12}) and it was on par with T_{14}, T_2, T_{11} and T_{13} but was found significantly superior over rest of the treatments in ashgourd crop and The trend of changes in micronutrients content observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

- Uptake of nutrients by ashgourd, french bean, pole bean and pumpkin crops recorded was significantly higher with application of recommended dose of N through human urine in three split doses plus gypsum (T_{12}) followed by recommended dose of N through cattle urine in three split doses plus gypsum (T_{14}) and application of recommended dose of fertilizer plus farmyard manure (T_2). but significantly lower nutrient uptake was observed in farmyard manure alone treatment (T_1) and it was on par with T_3, T_4, T_5 and T_6. The trend of variation in nutrient uptake observed in ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plot receiving same treatments.

- Higher pH and EC of soil after harvest of ashgourd crop was recorded with recommended dose of N through human urine in three split doses (T_{11}) which was on par with cattle urine in three split doses without gypsum (T_{13}), recommended dose of nitrogen through application of human urine in two split doses without gypsum (T_7) and application of cattle urine in two split doses without gypsum (T_9). The slight increase in soil pH and EC by application of human/ cattle urine was restricted to treatment without gypsum application, whereas, the original soil pH was not much affected in treatments with gypsum. A slight increase in pH was observed at harvest of french bean, pole bean and pumpkin crops with treatment involving application of human urine in three split doses without gypsum (T_{11}) compared to other treatments.

- Higher nitrogen, phosphorus and potassium content in soil were recorded with recommended dose of N through human urine in three split doses plus gypsum (T_{12}) at harvest of ashgourd crop. The trend of variation in available nitrogen, phosphorus and potassium content of soil recorded at harvest of ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

- Exchangeable calcium, magnesium and micronutrients content of soil also varied significantly due to application of human urine and cattle urine. Highest content of all these nutrients in soil was recorded in treatment with recommended dose of N through human urine in three split doses plus gypsum (T_{12}) followed by recommended dose of N through cattle urine in three split doses plus gypsum (T_{14}) at harvest of ashourd crop. The trend of variation in exchangeable calcium, magnesium and DTPA extractable micronutrients content of soil recorded at harvest of ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

- Application of recommended dose of N through human urine in three split doses plus gypsum (T_{12}) recorded significantly higher soil fungi, bacteria, actinomycetes, N-fixers and P-solublizer population (5.92 CFUx10^4 g^{-1} soil, 8.24 CFUx10^7 g^{-1} soil, 5.26 CFUx10^3 g^{-1} soil, 4.32 CFUx10^3 g^{-1} soil and 3.30 CFUx10^3 g^{-1} soil, respectively) during ashgourd crop followed by recommended dose of N through cattle urine in three split doses plus gypsum (T_{14}). The trend of variation in population of soil fungi recorded at harvest of ashgourd was retained in subsequent seasons when french bean, pole bean and pumpkin crops were grown in sequence after ashgourd crop in the same plots receiving same treatments.

- A slight increase in population of soil fungi was recorded after the harvest of french bean, pole bean and pumpkin crops (6.45, 7.04 and 7.26 CFUx10^4 g^{-1}, respectively) due to continuous application of human urine in three split doses plus gypsum (T_{12}) followed by T_{14}, T_2, T_{11} and T_{13}. Lowest soil fungi population was recorded in treatment receiving farmyard manure alone (T_1) followed by T_3, T_4, T_5 and T_6 treatments.

- Application of recommended dose of N through human urine in three split dose plus gypsum (T_{12}) recorded maximum gross returns (Rs. 1,17635.7 ha^{-1}), net returns (Rs. 92675.0 ha^{-1}) and benefit: cost ratio (4.71) in ashgourd crop. Similar trend was noticed in french bean, pole bean, pumpkin crops and the benefit: cost ratio values being 3.22, 4.14 and 3.70, respectively.

(E) Effect of graded levels of human and cattle urine on soil properties, growth and yield of tomato in red, laterite and black soils under green house conditions.

- Significantly higher plant height (87.2 and 80.2 cm, respectively), number of branches (5.90 and 5.80, respectively), and number of leaves (40.8 and 36.2) at harvest were recorded in treatment receiving 2 times the recommended dose of N through human urine to tomato crop in red and laterite soil, respectively. Whereas, in black soil, higher plant height and number of leaves was recorded with treatment receiving 2 times the recommended dose of N through fertilizer.
- Highest total dry matter accumulation was recorded in treatment receiving 2 times the recommended dose of N through human urine in red and laterite soil. In black soil, higher total dry matter accumulation in plant was recorded with treatment receiving 2 times the recommended dose of N through fertilizer.
- Application of 2 times the recommended dose of N through human urine in red and laterite soil recorded the higher yield components such as number of flower plant^{-1} (15.2 and 14.0) at 90 DAT, number of fruits plant^{-1} (52.7 and 49.1), fresh fruit weight (68.8 and 68.3 g friut^{-1}), fruit yield (3.6 and 3.4 kg plant^{-1}) at harvest of tomato, respectively. In black soil, it was found significant in treatment receiving 2 times the recommended dose of N through chemical fertilizers (T_3).
- The highest total soluble solids (4.90 %) were recorded in treatment receiving 2 times the recommended dose of N through human urine (T_6) in red and laterite soil. In black soil, it was found significant in treatment receiving 2 times the recommended dose of N through chemical fertilizers (T_3).
- The nitrogen content in tomato fruit was significantly higher (3.67 and 3.41 %) in tomato crop grown in red and laterite soil receiving 2 times the recommended dose of N through human urine (T_6). In black soil it was observed with application of 2 times the recommended dose of N through fertilizer (T_3).

- The nutrients uptake by tomato was significantly higher in red and laterite in treatment receiving 2 times the recommended dose of N through human urine (T_6). In black soil it was observed with application of 2 times the recommended dose of N through fertilizer (T_3).
- The soil reaction and electrical conductivity was significantly higher with treatment receiving 2 times the recommended dose of N through human urine (T_6) in red and laterite soils. In black soil, it was found significant in treatment receiving 2 times the recommended dose of N through chemical fertilizers (T_3).
- Available nitrogen, phosphorus and potassium content of soil varied significantly due to application of graded levels of human and cattle urine to soil. The treatment receiving 2 times the recommended dose of N through human urine (T_6) recorded significantly higher available nitrogen, phosphorus and potassium in soil at harvest of tomato in red and laterite soils. In black soil, it was found significant by higher treatment receiving 2 times the recommended dose of N through chemical fertilizers (T_3).
- Exchangeable Ca, Mg, S, sodium and also micronutrients after harvest of the crop differed significantly due to application of graded levels of human and cattle urine to soil. The treatment receiving 2 times the recommended dose of N through human urine (T_6) recorded significantly higher available nitrogen, phosphorus and potassium in soil at harvest of tomato in red and laterite soils. In black soil, it was found significant in treatment receiving 2 times the recommended dose of N through chemical fertilizers (T_3).
- Graded levels of human urine and cattle urine application to grow tomato crop recorded significantly higher soil fungi, bacteria, actinomycetes, N-fixers and P-solubalizers population in soil after harvest. The treatment receiving 2 times the recommended dose of N through human urine (T_6) recorded significantly higher available nitrogen, phosphorus and potassium in soil at harvest of tomato in red and laterite soils. In black soil, it was found significant in treatment receiving 2 times the recommended dose of N through chemical fertilizers (T_3).

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* Original not seen

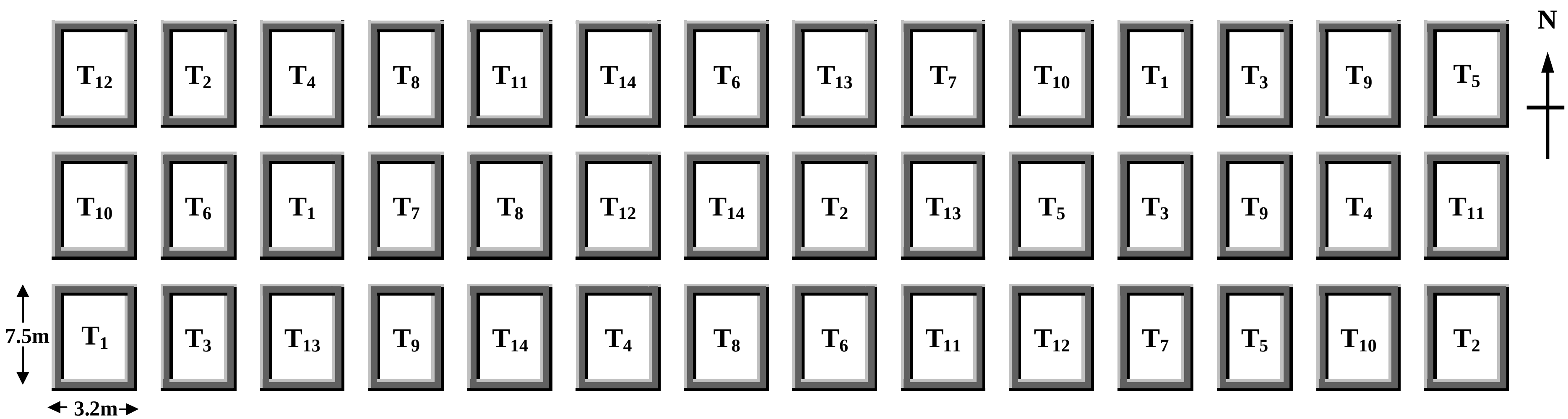

Fig. 3.1: Plan of layout of experiment II

Legend:

T_1	:	FYM (Farmyard Manure) alone
T_2	:	Recommended dose of fertilizer + Farmyard manure
T_3	:	RDN through human urine in single dose
T_4	:	RDN through human urine in single dose + gypsum
T_5	:	RDN through cattle urine in single dose
T_6	:	RDN through cattle urine in single dose+ gypsum
T_7	:	RDN through human urine in two split doses
T_8	:	RDN through human urine in two split doses+ gypsum
T_9	:	RDN through cattle urine in two split doses
T_{10}	:	RDN through cattle urine in two split doses+ gypsum
T_{11}	:	RDN through human urine in three split doses
T_{12}	:	RDN through human urine in three split doses+ gypsum
T_{13}	:	RDN through cattle urine in three split doses
T_{14}	:	RDN through cattle urine in three split doses+ gypsum

Note: Balance P_2O_5 and K_2O supply through SSP and MOP respectively; **Gypsum application:** applied gypsum @ 6.45kg m^{-3} urine;
RDN: Recommended Dose of Nitrogen