

**EFFECT OF FOLIAR APPLICATIONS OF ORGANIC
FORMULATIONS ON GROWTH AND YIELD OF ONION**

by

Barde Krunal Gajanan

(Reg. No. 018/13)



DEPARTMENT OF AGRONOMY

**POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI-413 722, DIST- AHMEDNAGAR
MAHARASHTRA STATE (INDIA)**

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In partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRONOMY



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MAHARASHTRA, INDIA**

2021

CANDIDATE'S DECLARATION

**I hereby declare that this thesis or part
there of has not been submitted
by me or any other person to any
other University or Institution
for a Degree or
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This is to certify that the thesis entitled, **“EFFECT OF FOLIAR APPLICATIONS OF ORGANIC FORMULATIONS ON GROWTH AND YIELD OF ONION”** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar in partial fulfilment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRONOMY**, embodies the result of a piece of bonafide research work carried out by **Mr. BARDE KRUNAL GAJANAN** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

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Place: M.P.K.V., Rahuri.

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Date: / /2021

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Date : / /2021

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LIST OF ABBREVIATIONS AND SYMBOLS

%	:	Per cent
/	:	Per
@	:	at the rate of
B:C	:	Benefit cost ratio
C.D.	:	Critical difference
CFU	:	Colony Forming Unit
cm	:	Centimeter
Cv	:	Cultivar
^o C	:	Degree Celsius
DAT	:	Days after transplanting
dSm ⁻¹	:	Deci siemen per meter
EC	:	Electrical conductivity
EM	:	Effective microorganisms
Even.	:	Evening
<i>et al.</i>	:	and others (etalli)
Fig.	:	Figure
FYM	:	Farmyard Manure
g	:	gram
GRDF	:	General Recommended Dose of Fertilizer
ha	:	hectare (s)
hr	:	hour (s)
i.e.	:	Id est (that is)
IW	:	Irrigation water
K	:	Potassium
kg	:	kilogram (s)
kg ha ⁻¹	:	kilogram per hectare
l ha ⁻¹	:	Litre per hectare
mm	:	Millimeter (s)
max.	:	Maximum
min.	:	Minimum
Morn.	:	Morning
MT	:	Metric tonne (s)
N	:	Nitrogen

N.S.	:	Non-significant
NSKE	:	Neem seed kernel extract
ppm	:	parts per million
PSB	:	Phosphate Solubilizing Bacteria
RDF	:	Recommended dose of fertilizer
₹	:	Rupees
S.Em	:	Standard error of mean
t	:	Tonne (s)
Var	:	variety
<i>viz.</i> ,	:	Videlicet (Namely)
VC	:	Vermicompost

ABSTRACT

EFFECT OF FOLIAR APPLICATIONS OF ORGANIC FORMULATIONS ON GROWTH AND YIELD OF ONION

by

Mr. BARDE KRUNAL GAJANAN

A candidate for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRONOMY

Mahatma Phule Krishi Vidyapeeth,

Rahuri – 413 722

2021

Research Guide : Dr. U. S. Surve

Department : Agronomy

The present investigation entitled, “Effect of foliar applications of organic formulations on growth and yield of onion” was conducted at All India Co-ordinated Research Project on Integrated Farming Systems, Mahatma Phule Krishi Vidyapeeth, Rahuri. Dist. Ahmednagar (MS) during *Rabi*, 2018-19.

The field experiment was laid out in randomized block design with eight treatments and three replications. The soil of experimental field was low in available nitrogen ($187.32 \text{ kg ha}^{-1}$), medium in phosphorus (14.12 kg ha^{-1}) and medium in potassium ($395.10 \text{ kg ha}^{-1}$). The treatments consisted of different organic formulation applications to onion, *viz.*, T₁- Control (no foliar spray), T₂- Water spray at 30 and 60 DAT, T₃- Foliar application of cow urine @ 6 % at 30 and 60 DAT, T₄- Foliar application of jeevamrut @ 5 % at 30 and 60 DAT, T₅- Foliar application of EM- solution @ 1 % at 30 and 60 DAT, T₆- Foliar application of humic acid @ 2 % at 30 and 60 DAT, T₇- Foliar application of vermiwash @ 5 % at 30 and 60 DAT, T₈- Foliar application of EM- solution @ 5 % at 30 and 60 DAT, The general recommended dose of fertilizer i.e. FYM 15 t ha^{-1} + $100:50:50 \text{ N:P}_2\text{O}_5:\text{K}_2\text{O} \text{ kg ha}^{-1}$ was applied to all treatment.

The growth parameters of onion *viz.*, plant height, number of leaves plant⁻¹ and neck thickness were significantly higher due to treatment GRDF with foliar applications of humic acid @ 2 % at 30 and 60 DAT (T₆).

Abstract contd.....**K. G. BARDE**

The yield contributing characters *viz.*, average bulb weight (g), dry matter bulb⁻¹ (g), polar diameter (cm), equatorial diameter (cm), total bulb yield (t ha⁻¹), marketable bulb yield (t ha⁻¹), yield of green leaves (t ha⁻¹) and yield of dry leaves (t ha⁻¹) were significantly higher under treatment GRDF with foliar applications of humic acid @ 2 % at 30 and 60 DAT (T₆). The yield contributing characters *viz.*, total bulb yield (t ha⁻¹) and marketable bulb yield (t ha⁻¹) was significantly highest where GRDF with foliar applications of humic acid @ 2 % at 30 and 60 DAT (T₆) given was 35.13 t ha⁻¹ and 33.91 t ha⁻¹ respectively followed by treatment GRDF with foliar applications of EM solution @ 5 % at 30 and 60 DAT (T₈).

The highest amount of available N (188.55 kg ha⁻¹) and available K (380.80 kg ha⁻¹) was recorded under treatment GRDF with T₇ -Foliar applications of vermiwash @ 5% at 30 and 60 DAT however, The highest total nitrogen uptake (35.50 kg ha⁻¹), total phosphorus uptake (10.81 kg ha⁻¹) and total potassium uptake (24.81 kg ha⁻¹) was recorded in treatment GRDF with foliar applications of humic acid @ 2 % at 30 and 60 DAT (T₆). The microbial count i.e. bacteria (40 CFU x 10⁻⁶ g⁻¹ soil), fungi (27.67 CFU x 10⁻⁵ g⁻¹ soil) and actinomycetes (43.33 CFU x 10⁻³ g⁻¹ soil) was found maximum at 60 DAT in treatment GRDF with foliar applications of EM- solution @ 5 % at 30 and 60 DAT (T₈).

The net returns (₹ 233269 ha⁻¹) was recorded higher in treatment GRDF with foliar application of humic acid @ 2 % (T₆) followed by GRDF with foliar application of EM-solution @ 5 % (T₈) (₹ 229825 ha⁻¹) and minimum net returns (₹ 175423 ha⁻¹) was recorded in treatment GRDF with T₁- Control (no foliar spray).

It was concluded that GRDF (FYM 15 t ha⁻¹ + 100:50:50 N:P₂O₅:K₂O kg ha⁻¹) with foliar application of humic acid @ 2 % at 30 and 60 DAT was found best option for the productivity and profitability of *rabi* onion.

1. INTRODUCTION

Onion (*Allium cepa* L.) known as “Queen of kitchen” is one of the most important vegetable grown in India. It belongs to the family Alliaceae and genus *Allium* is very large comprising of more than 500 species usually perennial bulbous plants. It is consumed as a vegetable and condiment. Green leaves and immature or mature bulbs of onion are eaten as green vegetable. It is an indispensable item in every kitchen and used to enhance flavour of different recipes. Nutritive value of onion varies variety to variety, small size onion is more nutritive than big size onion. Onion ranks medium in caloric low in protein and very low in vitamins. It has recently received considerable attention for its high medicinal value. Onion affords an excellent form of food iron and on this account many often be eaten freely with advantage by persons suffering from anaemia. It also used for preparation of various homeopathic, unani and ayurvedic medicines. Consumption of onions may prevent gastric ulcers by scavenging free radicals and by preventing growth of the ulcer-forming microorganism, *Helicobacter pylori*, confirm the potency of the onion as a blood thinner and platelet inhibitor. Researchers found that the more pungent onions exhibit strong anti-platelet activity. Platelet aggregation is associated with diseases like atherosclerosis, cardiovascular disease, heart attack and stroke.

Onion (*Allium cepa* L.) is one of the most important vegetable cum condiment crop grown throughout the world including India. It is native of the Central Asia and Mediterranean region and commercially grown in China, India, U.S.A., erstwhile U.S.S.R., Japan, Spain, Turkey, Brazil, Egypt etc. (Anon, 2004). India is the second largest producer of onion in the world, next to China, with 70% of the total production comes as *rabi* crop and remaining 30% as *kharif* onion. As a off season crop, accounting for 11.40 percent of the area and 10.40 percent of the world production and 16 percent of productivity. In India, the area under onion is of 12.70 lakh hectares with production of 220.71 lakh MT and the average productivity of 18.82 tonnes per hectare (Gurjar *et al.* 2018). The major onion producing states are Maharashtra, Madhya Pradesh, Karnataka, Rajasthan, Gujarat, Bihar, Andhra Pradesh, Haryana, West Bengal, Uttar Pradesh and Chhattisgarh in the country. These states account for almost 90 percent of the total onion production of the country.

Onion is the major cash (vegetable) crop of Maharashtra state next to sugarcane and cotton. It is the crop where socio-economic status of small and marginal farmers is dependent. More importantly it is a cash crop where seasonal and limited irrigation facilities are available. However, particularly during drought situations, the crop acreage of sugarcane in Maharashtra rapidly comes under onion and thus these two cash crops are inversely correlated with each other. At present, Maharashtra is leading state in onion production having an area of 3.82 lakh hectares with

production of 65.22 lakh MT with average productivity of 14.76 tonnes per hectare. Maharashtra state alone accounting for 29.55 per cent of India's onion production (Anon, 2018). In Maharashtra the major onion growing districts are Nasik, Ahmednagar, Pune, Satara, Dhule, Jalgaon and Solapur. About 70 per cent of total onion exported from India is from Maharashtra state.

The pungency in onion is due to sulphur bearing compound allyl propyl disulphide ($C_6H_{12}O_2$) in very small quantity (about 0.005%) in the volatile oil. The colour of the outer skin of onion bulbs is due to quercetin. The quality of onion depends on shape, size, colour and pungency of bulbs. Highly pungent red colour onions are preferred in India while less pungent, yellow or white skinned ones are demanded in European and Japanese market. As regard with the productivity the combined application of organic manures and inorganic fertilizers to increase yield but has paramount importance in ameliorating the yield. The use of inorganic fertilizers now a day is costly affair and increases cost of cultivation. Secondly the sole application of inorganic fertilizers deteriorates soil fertility level day by day, that affect the production, economics of production and human health, where organic manure and bio-fertilizers are cheap, easily available and eco-friendly, giving quality produce, improving keeping quality, T.S.S. and pungency. It improves the physiochemical properties of the soil which is very useful for the sustainable crop production as well as soil fertility and productivity.

The continuous use of high analysis fertilizers increased the crop yield in initial years and adversely affected the yield stability at a later stage. In India the demographic projections indicated that the per capita land availability from 0.14 ha in the year 2000 will be reduced to 0.10 ha in the year 2025. Moreover, besides the shrinking land area, the quality of land likely to remain available for agriculture which will be poor due to severe competition from urbanization, industrialization and civic needs. Also the decline in soil fertility and resultant productivity are the matter of nutrient imbalance which has been recognized as one of the recycling of organic inputs to improve physical, chemical, biological characteristics and thereby productivity of soil to get sustainable crop yield. The additions of organic formulations not only supply the nutrients for crop growth but also improve structural status and physical properties of soil. This necessitates the knowledge of application of different organic inputs *viz.*, EM solution, vermiwash, cow urine, humic acid and jeevamrut to be used in crop cultivation most important factor that limits crop yield. The high cost fertilizers and very poor purchasing capacity of marginal farmers restrict the use of costly fertilizer inputs under the condition of escalating energy crisis. Total nutrient (N, P_2O_5 and K_2O) consumption is estimated as 30-35 million tonnes in 2025 A.D. The gap between nutrient's removal by crops and addition through fertilizers would be about 10 million tonnes per annum. The fertilizer production in the country lags behind actual consumption and the import bill for

augmenting the deficit is staggering high. Hence, sustainable agriculture is a need to mitigate the gap of nutrients in agriculture.

Foliar feeding has proved to be the fastest way of curing nutrient deficiencies and boosting plant performances at specific physiological stages. Use of liquid organic formulations as foliar spray is gaining importance in crop production owing to its quick response in plant growth. jeevamrut, vermiwash, cow urine, humic acid and EM solution are some of the liquid organic formulations used in organic farming. Liquid organic manures improve plant growth directly through nutrient mobilization, production of plant growth hormones and indirectly through suppression of plant pathogens or by inducing systemic resistance in plants. Liquid formulations add much needed organic and mineral matter to the soil and play an important role in the buildup of soil organic matter, beneficial microbes and enzymes besides improving physical and chemical properties of soil. Cow urine has got anti-fungal properties and also good source of plant nutrients. Jeevamrut is a plant growth promoting substance containing beneficial microorganisms which promotes growth and yield of crop also microorganisms are well activated in the soil by the addition of jeevamrut. Humic acid is considered to increase the permeability of plant membranes and enhance the uptake of nutrients. It also improve soil nitrogen uptake. When EM is applied to soil or plant leaf surfaces, the populations of photosynthetic bacteria and nitrogen fixing bacteria increase dramatically. This phenomenon is associated with the growth of more vigorous plants, higher plant yields and improved crop quality. Although many attempts have been made to study the role of inorganic fertilizers on onion crop however, study of different organic formulations for onion cultivation is needed particularly as the research work and technology on this aspect is very scanty in Maharashtra.

In view of above aspects the present investigation during *Rabi*, 2018 entitled “Effect of foliar applications of organic formulations on growth and yield of onion” has been carried out at AICRP on Integrated Farming Systems, MPKV, Rahuri. with following objectives

1. To study the effect of foliar applications of organic formulations on growth and yield of onion.
2. To find out the suitability of organic formulations for foliar applications in onion.
3. To work out the economics.

2. REVIEW OF LITERATURE

The important research work carried out on “Effect of foliar applications of organic formulations on growth and yield of onion.” and other crops by various researchers is summarized in this chapter.

2.1 Composition of Organic Formulations

2.1.1 Jeevamrut

Palekar (2006) defined jeevamrut as a fermented liquid product which is prepared by mixing cow dung (10 kg), cow urine (10 litre), jaggary (2 kg), legume flour (2 kg) and a handful of soil brought from the bunds of the cultivated lands. Jeevamrut also contains enormous amount of beneficial microbial load which on application enhances microbial activity in soil and ultimately ensuring the availability and uptake of nutrients by the crops.

Vasanthkumar (2006) opined that jeevamrut is not a source of nutrients, but it is a fermented liquid product which contains huge quantity of microbial load that enhances soil bio-mass upon its application to the soil even at very lesser rate as it acts as a tonic to the soil besides improving soil health.

Pathak and Ram (2007) reported that the jeevamrut contained *Azospirillum* (2×10^6 cfu), PSM (2×10^6 cfu), *Pseudomonas* (2×10^2 cfu), *Trichoderma* (2×10^6 cfu), yeast and moulds (2×10^7 cfu) per ml of sample, when the samples were analyzed after 5 days of incubation.

Devakumar *et al.* (2008) reported that maximum microbial population was observed between 9th and 12th day of the preparation of jeevamrut, which might have enhance the decomposition process in the soil and resulted in relatively quick release of nutrients from compost than without application of jeevamrut.

Sreenivasa *et al.* (2011) analyzed jeevamrut for the nutrient content and found that it contained major nutrients like nitrogen, phosphorous and potassium (770-1000, 166-175 and 126-194 ppm, respectively) and minor nutrients like zinc, copper, iron and manganese (1.27-4.29, 0.38-1.58, 29.7-282 and 1.8-10.7 ppm, respectively).

Aulakh *et al.* (2013) found that the pH of jeevamrut prepared from dung and urine of buffalo, Indian cow and hybrid cow was 3.86, 3.65 and 3.56, respectively after 5 days of incubation, which initially was 8.32, 7.89 and 7.71, respectively and this was attributed to the increased activity of acid producing microorganisms. The nutrient contents were 0.22, 0.04 and 0.60 g N, 0.11, 0.04 and 0.06 g P, 1.09, 0.28 and 0.75 g K and 0.46, 0.43 and 0.39 g S/l, respectively.

Devakumar *et al.* (2014) reported that jeevamrut formulation having a pH of 4.92, contained nutrients like nitrogen, phosphorus and potassium (1.96 %, 0.173 % and 0.280 %, respectively) and also Mg (46 ppm) and Cu (51 ppm). They also reported that there was less microbial load on the day of jeevamrut preparation and later it reached to maximum on the 10th day of its preparation.

After that it started to decline as the days passes. Maximum cfu/ml of jeevamrut recorded were bacteria (855×10^5), fungi (29×10^4), actinomycetes (8×10^3), N-fixers (69×10^4) and P-solubilizer (80×10^4) on the 10th day of its preparation. Further, they concluded that the presence of beneficial microorganisms in jeevamrut might be due to its constituent's viz., cow dung, cow urine, legume flour and jaggery which contain macro and micro nutrients, vitamins, essential amino acids, growth promoting substances like Indole Acetic Acid (IAA), Gibberlic Acid (GA) and beneficial microorganisms.

2.1.2 Vermiwash

Dkhar and Mishra (1986) reported that the vermiwash contained the microbial population (fungi, bacteria and actinomycetes) and physico-chemical characteristics of earthworm casts and the surrounding soil at ten days interval and observed increased microbial population and improved physico-chemical characteristics in the casts than that of the surrounding soils.

George *et al.* (2007) reported that the pH of vermiwash 8.77, EC 0.04, OC 1.06 %. They found the significantly higher content of organic carbon in the treatment of vermiwash + vermicompost followed by only vermicompost and only cow dung (100 g plant⁻¹). respectively.

Ansari (2008) reported that vermicompost and vermiwash formulations having of higher content of N, P, K, Ca, Mg, Fe, Mn, Zn and Cu were observed in the chemical fertilizer treatment followed by treatments of vermiwash + vermicompost.

Sathish and Paramaguru (2010) reported that the vermiwash contained higher nutrient content and uptake N (0.84 % 277.82 kg ha⁻¹), P (0.22 % 64.27 kg ha⁻¹) and K (0.88 % 270.52 kg ha⁻¹) in the treatment of foliar application of vermiwash @ 1 % as compared to foliar application of panchagavya (3 and 4 %), and EM (1 and 2 %).

Balpande *et al.* (2013) analyzed vermiwash that contain bacteria, fungi and actinomycetes count were higher (2.3 to 3.31×10^7 , 1.32 to 3.41×10^5 and 1.56 to 1.96×10^8 cfu g⁻¹ of soil respectively at CRI stage) in the soil treated with liquid organic manures along with low level of RDF over the soil treated with no manurial liquid and hence concluded that manurial liquids helps in maintaining higher microbial population in soil.

2.1.3. EM solution

Javaid (2006) reported that the effective microorganisms are cultures of coexisting beneficial microorganisms predominantly consisting of species of photosynthetic and lactic acid bacteria, yeast and actinomycetes, that could be used for alternative crop production. He studied the effect of soil and foliar application of these microorganisms on crop growth, yield and nodulation in pea (*Pisum sativum* L.).

Tomasz *et al.* (2012) reported that the effective microorganisms (EM-a) are microbial inoculants comprised mainly of lactic acid bacteria, photosynthetic bacteria, yeasts and

actinomycetes that are commonly found in soil. The diverse applications of EM include improving soil conditions for better plant growth, controlling pests and diseases and extending the shelf life of harvested crops.

Nibin *et al.* (2014) reported that EM consists of mixed cultures of naturally occurring beneficial microorganism (i.e. bacteria, fungi, actinomycetes and yeast) that are applied as inoculants to change the microbial diversity and interaction in soils and plants. In return, EM has been shown to improve soil health and the growth, yield and quality of crops over a wide range of agro-ecological conditions.

2.1.4 Cow urine

Bhadauria (2002) reported that cow urine contents 95% water, 2.5% urea, 2.5% minerals, salt, hormones and enzymes. It contains iron, calcium, phosphorus, potassium, urea, uric acid, amino acids, enzymes, cytokine and lactose etc.

Jain *et al.* (2010) reported that the biochemical estimation of cow urine has shown that it contains sodium, nitrogen, sulphur, vitamin A, B, C, D, E, minerals, manganese, iron, silicon, chlorine, magnesium, citric, succinic, calcium salts, phosphate, lactose, carbonic acid, enzymes, creatinine and hormones.

Jandaik *et al.* (2015) concluded that the cow urine has antifungal activities and the inhibitory activity can be used in the control of fungi. The use of cow urine provides a better alternative to synthetic chemical which are expensive and a potential danger to farmers, marketers, consumers and environment. The cow urine can be used as bio-pesticide.

Pathak and Ram (2013) reported that cow urine is a rich source of macro, micronutrients and has disinfectant and prophylactic properties thus purify the atmosphere and improve soil fertility.

2.1.5 Humic acid

Kononova (1961) reported that humic substances are mixtures of organic compounds differing in molecular weights and cation exchange capacity. The humic acids comprise a group of compounds, which are extracted from soil by alkaline solution and precipitated through acidification.

Arya *et al.* (1984) investigated some soils of Uttar Pradesh and they reported that humic acid in general contained organic phosphorus ranging from 0.5 to 12.8 ppm in surface layer (0-15 cm).

Gupta *et al.* (1989) reported that the elemental composition of humic acid of surface soils in respect of weight *vis-a-vis* atomic ratio of C:N, C:H and O:H.

Satishkumar (1997) observed that the humic acid extracted from lignite had higher carbon content of 34.51 per cent and wider carbon nitrogen ratio of 61.63.

Kadalli *et al.* (2001) reported that, carbon content of humic acid extracted from coir dust basal compost varied from 38.44 to 42.18 per cent and nitrogen content varied from 0.12 to 5.18 per cent.

2.2 Effect of Organic Formulations on Growth and Yield of Crops

Sivasubramanian and Ganeshkumar (2004) conducted a pot trial to study the effect of vermiwash (vermiwash, vermibed extract and vermicast extract) on growth and yield of marigold. The higher plant height, number of leaves, leaf area, flowers plant⁻¹ and weight of flower was observed in the treatment of vermiwash spray as compared to cow dung extract, cow urine and vermicast extract.

Sangeetha and Singaram (2007) observed that combine application of recommended dose of inorganic fertilizers (60:30:30 NPK ha⁻¹) and humic acid at 20 kg ha⁻¹ significantly increases plant height, number of leaves per plant and root length of onion.

Yildirim (2007) reported that the foliar and soil humic acid treatment positively affected fruit characteristics like fruit diameter, fruit height, mean fruit weight and fruit number per plant. Similarly, humic acid treatment increased the early yield of tomato compared to control. The yield of tomato was significantly influenced by soil and foliar application of humic acid. The highest yield obtained under foliar 20 ml L⁻¹ humic acid treatment. The study shows that 20 ml L⁻¹ concentration of humic acid sprayed could be successfully used to obtain better growth and yield of tomato.

Ansari (2008) concluded that the yield of spinach and onion was significantly higher in plots treated with vermiwash (1:5 vermiwash in water) and vermiwash (1:10 vermiwash in water) respectively, while yield of potato was higher in plots treated with vermicompost (6 t ha⁻¹) in a study conducted to know the effect of vermicompost and vermiwash on the productivity of spinach, onion and potato grown in reclaimed sodic soil of Lucknow (Uttar Pradesh).

Eyheraguibel *et al.* (2008) determined the effect of humic like substances (HLS) on plant physiology in order to consider their use in agriculture as organic fertilizers. The effect of HLS evaluated on cucumber seed germination, growth and development and mineral nutrition was studied on cucumber plants cultivated under hydroponic condition. The experimental results shows that HLS do not increase percentage and rate of germination but enhance elongation of roots of those treated. Positive effects are shown on whole plant growth as well as on roots, shoot and leaf biomass. These effect can be related to high water and mineral consumption of plant undergoing the treatment.

Kumar *et al.* (2008) studied the effect of organic (vermiwash, goat extract and panchagavya) and inorganic (urea, DAP and KCl) foliar nutrients application on the performance of black gram during summer (2002) at Coimbatore. The result revealed that the higher values of growth and yield parameter *viz.*, plant height, leaf area index, dry matter production, number of flower plant⁻¹, number of pods plant⁻¹, number of filled grain pod⁻¹ and grain yield were recorded in the treatment of 1 % urea or 2 % DAP spray followed by vermiwash spray at floral initiation and 15 days after flowering.

Patil (2008) revealed that in capsicum the number of seeds fruit⁻¹, seed yield plant⁻¹, seed yield plot⁻¹ and seed yield ha⁻¹ were higher in foliar application of NAA @ 10 ppm (128.78, 11.93 g, 280.67 g and 414.82 kg, respectively) which was at par with vermiwash 5 % spray (128.25, 236.60 g, 9.99 g, 277.82 g, 361.28 kg, respectively).

Patil *et al.*, (2008) reported that foliar spray of cow urine and water on green gram. In case of foliar spray of cow urine results the higher growth and yield contributing characters significantly. The grain (11.35 q ha⁻¹) and straw yield (13.80 q ha⁻¹) along with biological yield (25.15 q ha⁻¹), protein per cent in grains (19.67%).

Shwetha and Babalad (2008) reported that there was significantly higher LAI, plant height, number of branches, dry matter accumulation, seed yield and yield parameters like the number of pods plant⁻¹ with the application of organic manures in combination with liquid organic manures *viz.*, beejamrit, jeevamrut and panchagavya as compared with the application of organics alone in an experiment conducted to know the effect of nutrient management through organics in soybean-wheat cropping system.

Manjunatha *et al.* (2009) reported that application of FYM @ 7.5 t ha⁻¹ + 100 % RDF recorded significantly higher seed yield of sunflower (1774 kg ha⁻¹) which was on par with the application of FYM @ 7.5 t ha⁻¹ + jeevamrut (1733 kg ha⁻¹) and it was significantly superior over treatment FYM @ 3.75 t ha⁻¹ + jeevamrut application (1551 kg ha⁻¹).

Ansari and Sukhraj (2010) reported that combination of organic fertilizers vermicompost and vermiwash had great influence on plant growth parameters in okra than the chemical fertilizers. The average yield during trial showed a significantly greater response in comparison with the control by 64.27%. The treatment also found to have a significant influence on the biochemical characteristics of the soil with marked improvement in soil micronutrients.

Adil and Kumar (2010) reported that organic fertilizer combinations of vermiwash + vermicompost recorded significantly highest growth parameters *viz.*, number of leaves (13 ± 1.15), plant height (45.83 ± 5.62 cm), circumference of the stem (3.10 ± 0.17 cm), fresh (77.75 ± 6.92 g) and dry biomass (13.30 ± 1.26 g), number of fruits (4 ± 1) and length of the fruits (14.9 ± 0.56)

than chemical fertilizers in okra as the vermiwash and vermicompost is enriched with metabolites and vitamins that belongs to B group or provitamin D which helps to enhance the plant growth.

Bais *et al.* (2010) carried out investigation on the effect of foliar application of animal urine and panchagavya on desi cotton at Cotton Research Unit, PDKV, Akola and results revealed that foliar application of 6 % cow urine was superior in increasing the leaf area index (LAI) at 40 to 160 DAS.

Deshmukh *et al.* (2010) reported that application of jeevamrut @ 2000 l ha⁻¹ recorded statistical equivalent value of growth, yield parameters and yield to that of application of FYM @ 7 t ha⁻¹, VC 3.5 t ha⁻¹ and RDF in ashwagandha.

Hatti *et al.* (2010) studied the effect of vermiwash on the growth of *Vigna mungo*, *Vigna radiata* and *Sesamum indicum*. The root length (6.11 ± 0.59, 5.62 ± 0.58, 1.43 ± 0.06 inches), shoot length (12.26 ± 0.01, 12.7 ± 0.64, 9.26 ± 0.59 inches), number of twigs (7.70 ± 0.59, 8.59 ± 0.29, 5.00 ± 0.58), leaves (18.06 ± 0.58, 16.24 ± 0.46, 9.00 ± 0.63), biomass (3.08 ± 0.01, 4.00 ± 0.19, 3.62 ± 0.04 g) were increased significantly compared to that of control in all the plants treated with vermiwash and concluded that significant increase in the growth of vermiwash treated plants is due to high level of macro and micronutrients available in the vermiwash.

Khanal *et al.* (2011) carried out a field experiment in Nepal on farmer's field during 2009-2010, to test the efficacy of cattle urine alone and in combination with urea as a potential supplement to nitrogenous fertilizers in improving yield and quality of cauliflower *cv.* Kathmandu Local. The experiment was laid out in a randomized complete block design with eight treatments; 100 kg N ha⁻¹ supplied by urea, 100 kg N ha⁻¹ supplied by urine, 125 kg N ha⁻¹ supplied by urine, 75 kg N ha⁻¹ supplied by urine, 50 kg N ha⁻¹ supplied by urine, 100 kg N ha⁻¹ supplied by urea (75 kg) and urine (25 kg), 100 kg N ha⁻¹ supplied by urea (50 kg) and urine (50kg), 100 kg N ha⁻¹ supplied by urea (25 kg) and urine (75 kg) having three replications. Application of 125 kg N ha⁻¹ through urine significantly increased vegetative characters. Application of 100 kg N ha⁻¹ through urine significantly increased yield and quality characters as compared to application of either higher or lower dose of urine. Fifty percent substitution of urea by urine produced better morphological, yield and quality character than other combinations of urine and urea.

Venkataramana *et al.* (2010) studied the efficacy of foliar sprays of vermiwash and cow dung wash each of at 100, 150 and 200 mg L⁻¹ concentration on yield of mulberry (*Morus alba* L.). The experiment was conducted on clay loam soil of Vikarabad (AP). The results revealed that application of 200 mg L⁻¹ vermiwash spray recorded 24.3, 23.5, 85.7 and 29.2 per cent higher value of plant height, length of shoot, number of branches plant⁻¹ and number of leaves plant⁻¹, respectively over control.

Vennila and Jayanthi (2010) reported that the effect of organic foliar spray (2% of microorganism, panchagavya and vermiwash spray) on growth and yield of okra, at TNAU, Tamil Nadu. They found that application of 100% RDF + panchagavya spray @ 2 % significantly increased the plant height (131.7 cm), fruit length (21.8 cm), fruit girth (4.66cm), fruit weight (13.9 g fruit⁻¹), fruit yield (12.7 q ha⁻¹), dry matter production (5.9 g plant⁻¹) and number of branches (3.2 plant⁻¹) as compared to 100% RDF.

Hiradeve *et al.* (2011) studied the effect of foliar spray of vermicompost wash on ground nut crop and data revealed that foliar spray of vermicompost wash 400 ppm followed by 350 ppm significantly increased the plant height, number of branches, leaf area plant⁻¹, total dry matter plant⁻¹, LAI, weight of 100 kernels, number of pods plant⁻¹, yield plot⁻¹, yield ha⁻¹ compared with control.

Tharmaraj *et al.* (2011) conducted an experiment to study the influence of vermicompost and vermiwash on growth and yield of rice at Annamalai Nagar (TN). They found higher number of leaves, leaf length, height of the plant and root length in the treatment of soil application of vermicompost and spray of vermiwash over control and its individual application.

Patil *et al.* (2012) observed that application of cow urine on chickpea at the rate of 10 % at flowering initiation and 15 days after flowering recorded higher plant height (35.78cm) at harvesting, number of branches at harvesting (4.82), leaf area index at 90 DAS (1.30), number of pod plant⁻¹ (60.86) and grain yield (2114 kg ha⁻¹) as compare to control.

Rajan and Murugesan (2012) studied the influence of vermiwash on germination and growth of cowpea. Three different concentrations of vermiwash such as 50 %, 75 % and 100 % were used. On 25th day 75% vermiwash significantly improved the growth parameters such as shoot length (20.53 ± 2.42 cm) and root length (4.86 ± 1.4 cm), number of branches (3.74 ± 0.57) and number of leaves (7.40 ± 1.04), leaf length (6.59 ± 0.43 cm) and leaf breadth (4.71 ± 0.34 cm) in cowpea.

Sajid *et al.* (2012) carried out an experiment at Pakistan Agricultural Research Council in winter 2010-2011 to investigate the "Humic acids affect the bulb production of onion cultivars" in which they reported that the growth and yield parameters of onion cultivars were significantly influenced by various levels of humic, as cultivar Parachinar Local showed more neck height (7.5 cm), plant height (80.9 cm), bulb weight (94.2 g), yield plot⁻¹ (22.9 kg) and total yield (36.1 t ha⁻¹) whereas 2 kg ha⁻¹ of humic significantly increased neck height (7.6 cm), plant height (75.3 cm), bulb weight (96.4 g), yield plot⁻¹ (22.4 kg) and total yield (35.86 t ha⁻¹).

Abolmaaty and Fawaz (2016) conducted experiment on effect of vermicompost treatments and EM1 on onion white rot disease at Agriculture Research Centre, Egypt and results showed that the combination between vermicompost and EM1 under greenhouse or open field conditions was significantly more effective in reducing the white rot disease more than single treatments.

Ayyobi *et al.* (2013) reported that plants treated with vermicompost and vermiwash were showed significantly highest plant height (74.5 cm) with more total plant fresh weight (12.68 g), leaf fresh weight (5.89 g) and total fresh yield (2,604.67 g) than control as the vermicompost and vermiwash combination favours the soil structure and nutrient availability, maintain quantity and quality of yield of peppermint.

Balpande *et al.* (2013) found that in the application of manurial liquids, the highest grain yield was obtained in vermiwash @ 50 l ha⁻¹. Significantly higher grain yield (23.69 t ha⁻¹) of wheat was recorded under application of 100% RDF (100:50:50 NPK kg ha⁻¹) with three sprays of amritpani at the rate of 200 l ha⁻¹. There was 13.83% increase in grain yield as compared to 100 % RDF alone.

Boraiah (2013) reported that application of jeevamrut resulted in 7.98 to 26.20 per cent increase in fruit yield of chili as compared to without jeevamrut application. This might be due to higher number of fruits plant⁻¹ (43.99 to 56.31), fruit length (6.82 to 7.43 cm), total dry matter plant⁻¹ (10.46 to 15.67 g), fruit girth (16.81 to 17.19 cm) and fruit weight (126.12 to 125.67 g).

Devan *et al.*, (2013) reported that vermiwash @ 15% exhibited growth promoting effects on the exo-morphological characters in okra such as plant height (32.46 cm), shoot length (10.2 cm) and diameter of the internodes (1.9 mm), number of leaves (6.8), leaf surface area (12.16), root length (18.15 cm), wet and dry weight of the shoot (44.49 g and 10.58 g) and root (4.70 g and 1.237 g). There by vermiwash can be exploited as a potent biofertilizer and foliar spray.

Kandil *et al.* (2013) carried out two field experiment at Agriculture Research Center, Gharbeia Governorate, Egypt during 2010-2011 and 2011-2012 seasons to study onion yield as affected by foliar application with amino and humic acids under nitrogen fertilizer levels. The obtained results showed that foliar spraying with humic acid resulted in highest growth characters, total and marketable yields, total culls and bulb weight as well as TSS %, dry matter and total weight loss percentages at storage period compared with the control treatment.

Laharia *et al.* (2013) conducted the field experiment with soybean on clayed soil of Akola to study the effect of organic sources on soil fertility, nutrient uptake and yield of soybean. They observed that the hydraulic conductivity, mean weight diameters, bulk density and available water capacity were recorded higher with the treatment, application of 100% RDN through vermicompost + jeevamrut.

Bag (2014) conducted field experiment on to study the effect of organic growth promoters on yield and quality of chick pea (*Cicer arietinum* L.) at Certified Organic Farm, Navsari Agricultural University, Navsari, during *rabi*, 2012-13 and reported that application of BC:VC:CC + Cow urine 2 % recorded significantly higher values of plant height, plant spread, number of

primary, secondary and tertiary branches per plant as well as number of pods per plant at 60 DAS as well as at harvest.

Devakumar *et al.* (2014) was conducted an experiment to study the influence of different levels of cow urine, panchagavya and fertility on maize. The grain and stover yield of maize varied significantly under different levels of fertility, panchagavya spray and cow urine levels. Maximum grain yield of 18.6 q ha⁻¹ and 17.6 q ha⁻¹ were recorded with application of cow urine and panchagavya and minimum was recorded in the plots without application of them. However, no significant difference was observed in stover yield but, higher stover yield of 42.7 q ha⁻¹ and 39.6 q ha⁻¹ were recorded in the plots with application of panchagavya and cow urine.

Sultana *et al.* (2014) carried out an experiment to assess the effect of integrated organic and inorganic nitrogen on growth and nutrient concentration in summer onion. Among the treatments, urea with cowdung treated plots gave higher plant height compared to urea with vermicompost treated plots. The highest plant height (39.25 cm) was recorded in T₅ (80 kg N ha⁻¹ supplied from urea with 40 kg N ha⁻¹ substituted by cowdung). In contrast, the lowest plant height (24.25 cm) was observed in the T₁ (control) plot receiving no organic or inorganic fertilizer. The highest number of leaves per plant (6.00) was observed in treatment T₂ (120 kg N ha⁻¹ supplied from urea). Alternatively, the minimum number of leaves (4.98) per plant was found in T₁ treated plots, where no fertilizer was applied.

Varghese and Prabha (2014) conducted field experiment on biochemical characterization of vermiwash and its effect on growth of *Capsicum frutescens* at Karunya University, Coimbatore and concluded that the application of vermiwash on day 30 after planting recorded maximum root length (9 cm), shoot length (45 cm) and leaf count (22) as compared to control.

Singh *et al.* (2015) reported that the application of cow urine on buckwheat recorded higher plant height (116.2 cm), stem girth (0.64 cm), leaves plant⁻¹ (13.5), root length (12.6 cm), seed plant⁻¹ (102) and test weight (22.4 g) as compared to control.

Boraiah *et al.* (2017) noted that maximum yield of capsicum per hectare were observed with application of cow urine (30.76, 38.0, 48.52, 117.73, 97.15, 84.33, 48.44 q ha⁻¹ at 60, 70, 80, 90, 100, 110 and 120 DAT respectively) whereas, minimum yield of capsicum per hectare were observed in without cow urine (28.05, 34.05, 41.58, 107.62, 87.61, 78.54, 43.24 q ha⁻¹ at 60, 70, 80, 90, 100, 110 and 120 DAT respectively).

Kumbar and Devakumar (2017) noted the higher green pod yield of frenchbean 134.3 and 156.9 q ha⁻¹ with the application of jeevamrut at 2000 l ha⁻¹ which was followed by the application of jeevamrut at 1500 l ha⁻¹ (115.0 and 136.5 q ha⁻¹) as compared to without jeevamrut application (99.8 and 112.8 q ha⁻¹) during 2014 and 2015, respectively. Same trend was observed with the application of panchagavya 6 % (124.4 and 142.8 q ha⁻¹) followed by panchagavya 3 % (116.1 and

134.1 q ha⁻¹) as compared to without panchagavya application (101.4 and 120.1 q ha⁻¹) during both the years.

Singh *et al.*, (2017) reported that the application of R.D.F + soil application of humic acid 10 kg ha⁻¹ + foliar application of humic acid 0.1 % + micronutrient mixture to polyhouse grown capsicum was found statistically higher to enhance plant height (103.91 cm), number of branches per plant (9.33), leaf area (391.30 cm²), fruit weight (174.28 g), number of fruit per plant (22.07) and yield per plant (3.85 kg).

Al-Fraihat *et al.* (2018) reported that the foliar application of humic acid significantly influenced vegetative growth of onion by increasing number of leaves, leaf length, leaf diameter, neck diameter and fresh weight of leaves by 88.7 %, 82.8 %, 115.6 %, 120 % and 139.1 %, respectively at 1000 mg L⁻¹ corresponding to untreated crops. Among different times of humic acid applications, Triple spray of humic acid (G3) was better than double (G2) or single spray (G1) in terms of having significantly higher number of leaves, leaf length, leaf diameter, neck diameter, fresh weight of leaves, root length, number of roots, bulb length, bulb diameter and fresh weight of plants.

Hafez and Geries (2018) conducted field experiments to study the effects of application of nitrogen fertilizer, biofertilizers and organic compounds on growth, yield and economics of onion production in 2014-2015 and 2015-2016 seasons. From the data it was found that combination of N fertilization of onion plants with 100 kg N fed.⁻¹ (hectare = 2.38 feddan) and foliar with humic acid at the rate of 1 kg fed.⁻¹ is the best in this study, for giving the highest bulb yield with the highest net returns and with a benefit:cost ratio (B:C ratio) of 2.35.

2.3 Effect of Organic Formulations on Crop Nutrient Content and Nutrient Uptake

Saunders (1982) reported that application of urine increased the N concentration of grass (particularly the nitrate fraction) and increased the potassium concentration of grass and clover. Increased pasture growth from urine patches has been observed even following high N fertilizer application which may be due to greater amount of N applied or to some interaction with one of the other elements in urine such as potassium or sulphur.

Xu and Xu (2000) reported that presence of naturally occurring, beneficially effective microorganisms (EMOs) predominately lactic acid bacteria (*Lactobacillus*), yeast (*Saccharomyces*), actinomycetes (*Streptomyces*), photosynthetic bacteria and certain fungi besides beneficial and proven bio-fertilizers such as *Azotobacter*, *Azospirillum* and Phosphobacterium were detected in panchagavya which improved soil quality, growth and yield of crops especially in corn.

Shanti *et al.* (2005) conducted the field experiment on onion and reported that bulb yields as well as uptake increased with increase application of FYM.

Lende *et al.* (2007) studied the effect of foliar spray vermiwash (VW) and cow dung wash @ 200 ppm on soybean and data revealed that yield parameter of soybean significantly increased number and dry weight of pods plant⁻¹, 100 seed weight and seed yield ha⁻¹ superior over control.

Shwetha and Babalad (2008) reported that in soybean higher uptake of nitrogen and potassium was recorded in the treatment compost + green leaf manure + beejamrit + jeevamrut + panchagavya (155.8 and 79.6 kg ha⁻¹, respectively), significantly higher phosphorous uptake was in the treatment that received RDF + FYM (13.6 kg ha⁻¹).

Gorakhnath and Singh (2009) reported that the maximum significant growth was observed in okra (38.0 + 5.2 cm), cluster bean (215.5 + 5.2 cm) and radish (20.4 + 1.4 cm) with 30 mg m⁻² concentration of vermiwash in combination of buffalo dung with rice bran and this is due to the microbial activity in vermiwash results in production of plant growth regulators like IAA, gibberellins, cytokinins and humic acid is also produced which have a positive influence on plant growth.

Harish *et al.* (2011) studied the effect of organic management practices on growth and yield parameters of brinjal at Hi-Tech Horticulture Unit, UAS, Dharwad. The results revealed that application of green leaf manure, FYM, VC and NC on N equivalent bases alone or in conjunction with biofertilizers recorded similar yield and yield attributes to that of RDF + FYM. However, application of only beejamrut and jeevamrut with mulching recorded significantly lower yield and yield attributes than RDF + FYM.

Khaled and Fawy (2011) reported that soil application of humus increases N uptake of corn while foliar application of humic acid increased the uptake of P, K, Mg, Cu, Zn and Na. although the interaction between salt and soil humus application was found statistically significant, the interaction effect of salt and foliar humic acid treatment was found non-significant under salt stress the first doses of both soil and foliar application of humic substances increases the nutrient uptake.

Phukan and Savapondit (2011) conducted experiment "Vermiwash-An effective organic nutrient amendment for foliar spray in tea cultivation" and results revealed that foliar application of vermiwash (5-10 %) has been found to be effective on growth, productivity of young and unpruned mature tea over control treatment.

Azin and Dhumal (2012) studied the effect of organic manure on growth, yield and nutrient quality of tomato at Pune. Two different farms were selected, for organic farm, jeevamrut was used which contains neem cake (2 kg), magnesium sulphide (3 kg), cow dung (10 kg), jaggery (2 kg) and cow urine (5 litre). The organic manure like FYM and compost were added as per the recommended dose before preparation of land. For inorganic farm only chemical fertilizers were added. Tomato grown under organic farm recorded significantly higher protein, carbohydrates, total sugars, energy value and vitamin C than tomato grown under inorganic farm.

Da-Bing *et al.* (2012) reported that application of humic like substances stimulated auxin like activity and increased chlorophyll content and nitrogen accumulation in plants. The positive auxin like activity of humic like substances could be attributed to relative distribution of special carbon groups such as those with large amount of peptidic and carbohydritic groups or with a low content of phenolic groups.

Chadha *et al.* (2012) noticed that that Vedic Krishi: sustainable livelihood option for small and marginal farmers and result revealed that foliar application of vermiwash gave 65, 10, 26 and 27 % higher yields in knol-khol (153.25 q ha⁻¹), onion (184.1 q ha⁻¹), french bean (14.5 q ha⁻¹ seed yield) and paddy (18.4 q ha⁻¹), respectively over control treatment.

Chadha *et al.* (2012) reported that application of liquid manures (10 % concentration) when applied at 30, 45 and 60 DAT in onion gave significantly higher bulb yield plot⁻¹ than control. The maximum bulb yield (184.1 q ha⁻¹) was recorded in the application of vermiwash as against (167.34 q ha⁻¹) in control.

Osvalde *et al.* (2012) reported that the effect of Humic Substances (HS) treatment on nutrient uptake in the onion leaves differed under the organic farming system. Leaf concentrations of N, K, Ca, Mg and S were significantly reduced after the first foliar spray in twofold application method. Bulblet soaking had negative effect on N and S accumulation. In contrast, the uptake of P was positively affected by HS treatment, except in the threefold foliar application method.

Ravi *et al.* (2012) studied the effect of integrated nutrient management on growth and yield of quality protein maize and results revealed that integration of 75 per cent RDF + *in situ* green manuring of sunnhemp, biofertilizers (*Azospirillum* + PSB) and liquid manures like panchagavya foliar spray @ 3 percent and soil application of jeevamrut helps to save 25 per cent of RDF by producing grain yield on par with that of 100% RDF.

Jadhav and Kulkarni (2013) studied that effect of foliar spray of nutrients on productivity of green gram (*Vigna radiata*) in North Eastern transitional zone of Karnataka, India. Data revealed that foliar application of liquid organic fertilizer like panchagavya 5 per cent, vermiwash 5 per cent and cow urine 5 per cent are increases the growth and yield parameter of green gram crop over control treatment.

Denre *et al.* (2014) conducted field experiment on effect of humic acid application on accumulation of mineral nutrition and pungency in garlic (*Allium sativum* L.) at Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal and reported that the maximum concentration of Ca, Fe and S were shown when plant were treated with 400 ppm humic acid, while maximum concentration of Mg, P and Zn were shown when plant treated with 200 ppm humic acid.

Kapase *et al.* (2014) found that foliar spray humic acid (HA) and NAA through vermicompost wash (VCW) on chick pea at 25 and 40 DAS. Foliar spray of 50 ppm NAA + 400

ppm HA through VCW significantly enhance growth parameters and seed yield ha^{-1} of chick pea over control treatment.

Maheswari *et al.* (2017) studied influence of vermiwash and panchagavya on lablab beans under pot experimental conditions and result revealed that different concentrations of vermiwash and panchagavya (5:2 %, 10:3 % and 15:4 %) were applied to the bean plants once in every week for six weeks. The exo-morphological characters such as shoot length, internode length, diameter of the internode, number of leaves and leaf surface area were recorded prior to every treatment in all the groups. Interestingly, 10:3 % vermiwash and panchagavya treated lablab beans showed better growth promoting effects than the other plants.

2.4 Effect of Organic Formulations on Soil Microbial Activity

Lee and Bartlett (1976) reported that humic acid have many beneficial effects on soil structure and soil microbial populations as well as increase modify mechanisms involved plant growth stimulation.

Jenkinson and Ludd (1981) reported that soil micro-organisms play an important role in soil fertility not only because of their ability to carry out bio-chemical transformation but also due to their importance as a source and sink for mineral nutrients.

Sharif *et al.* (2002) reported effect of humic acid on soil biological and physicochemical properties showed that the addition of 0.5 and 1.0 kg ha^{-1} HA promoted CO_2 evolution, increased bacterial population by 355 % to 476 %, fungi 610 to 716 %, and cation exchange capacity of the soil by 13.8 to 28.9 %.

Yadav and Mowade (2004) found that the use of fermented liquid organics (panchagavya, jeevamrut, beejamrit, sasyamrit, vermiwash, amrutpani etc.) prepared from cow dung, urine, leguminous leaves or vermiwash are effective in rapid build-up of soil fertility through enhanced activity of soil micro-flora and fauna.

Bi *et al.* (2005) reported that the application of humic bio-active fertilizer could promote the multiplication of soil beneficial microorganism, because the quantity of soil microbial population obvious increase, enhances activities of soil urease, the sucrase, the phosphatase and hydrogen peroxidase.

Shwetha and Babalad (2008) found significantly higher microbial activity *viz.*, bacteria, fungi and actinomycetes in treatments given organic manures such as compost, vermicompost and green leaf manure along with fermented organics *viz.*, beejamrit, jeevamrut and panchagavya (7 to 8.33×10^7 , 3 to 3.6×10^2 and 5.1 to 5.9×10^2 cfu g^{-1} of soil respectively) over RDF + FYM (1.67×10^7 , 1.33×10^2 and 3.4×10^2 cfu g^{-1} of soil respectively) and fermented organics alone (3×10^7 , 1.5×10^2 and 3.1×10^2 cfu g^{-1} of soil respectively) after harvest of soybean.

Meenatchi *et al.* (2008) reported that application of vermicompost at 3 t ha⁻¹ + four vermiwash (1:3) sprays in soybean were effective in reducing the incidence of defoliators (34.66 %) and pod borers (5.89) and significantly highest seed yield (30.00 q ha⁻¹) was observed compared to untreated control (59.00 %, 10.44, 10.53 q ha⁻¹) as the vermicompost and vermiwash on translocation into the plant system may alter the physiological processes including enzyme activity leading to greater accumulation of plant metabolites results in induced resistance against pests and increases the seed yield.

Sreenivasa *et al.* (2010) reported that the microbial population load of bacteria (81.3x10⁵ cfu g⁻¹ of soil), fungi (18.0 x 10⁴ cfu g⁻¹ of soil) and actinomycetes (47.3 x 10³ cfu g⁻¹ of soil) were significantly highest with foliar sprays of panchagavya + jeevamrut + beejamruth in the soil sample of chili as these organics energize the living microorganisms of the soil, involved in the biochemical activity of importance to soil fertility and plant nutrition.

Rajanna *et al.* (2011) conducted a field experiment during *kharif* on aerobic rice (*Oryza sativa* L.) to study the effect of different sources and time of application of organic manures on microbial population. The results revealed that the application of vermicompost equivalent to 10 t of FYM + 100 % N equivalent through jeevamrut recorded significantly higher microbial population, being at par with poultry manure equivalent to 10 t FYM + jeevamrut at 100 % N equivalent basis for total bacteria, actinomycetes, nitrogen fixers and P solubilizers.

Aulakh *et al.* (2013) studied the effect of jeevamrut on soil biological properties in rice-wheat and maize-wheat cropping system at PAU, Ludhiana. They observed that application of jeevamrut @ 2000 l ha⁻¹ in four equal split increase bacterial and fungal population in soil as compared to control.

Veerasha and Gopakkali (2014) reported significantly higher soil microbial population *viz.*, bacteria (47.0 × 10⁵ cfu g⁻¹), fungi (34.6×10⁴ cfu g⁻¹) and actinomycetes (40.0×10³ cfu g⁻¹) were obtained with the application of FYM 12.5 t ha⁻¹ + cattle urine at 34300 l ha⁻¹ as compared to control.

Siddappa (2015) reported that in a field experiment where influence of jeevamrut and FYM on growth and yield of field bean was studied, reported that FYM @ 200 per cent N equivalent and jeevamrut at 1500 l ha⁻¹ recorded significantly higher population of bacteria, fungi and actinomycetes (55.51×10⁶, 13.00×10⁴ and 40.66×10³ cfu g⁻¹) after the harvest of crop.

Biradar *et al.* (2017) reported that the population of bacteria, fungi, actinomycetes, N fixer and PSB at different growth stages of frenchbean were significantly higher with the soil application of jeevamrut 2000 l acre⁻¹ at 15, 30 and 45 DAS + foliar application of GMX soil pro max at 15, 30 and 45 DAS + foliar application of panchagavya 5 % at 15, 30 and 45 DAS along with the

recommended package of practices (37.67×10^6 , 23×10^4 , 35.33×10^3 , 29.67×10^3 , and 28.00×10^3 cfu g^{-1} respectively at harvest).

Boraiah *et al.* (2017) reported that maximum nitrogen fixers were observed with application of cow urine (23.18, 25.03 at 60 DAT and 16.48, 18.27 at harvest during *kharif* and summer, respectively) whereas, minimum nitrogen fixers were observed in without cow urine (21.33, 23.83 at 60 DAT and 15.28, 14.73 at harvest during *kharif* and summer, respectively).

Raut (2019) conducted an experiment on “Effect of soil and foliar application of organic formulations on growth and yield of *kharif* soybean”. In which results revealed that application of EM solution application through IW @100 l ha^{-1} at branching and flowering stage + foliar application of EM-solution @ 1 % at branching and flowering stage resulted in significantly higher soil available N ($271.05 \text{ kg } ha^{-1}$), P ($15.64 \text{ kg } ha^{-1}$) and K ($255.24 \text{ kg } ha^{-1}$). Similarly, this treatment received significantly higher bacteria ($39.8 \text{ CFU } \times 10^{-6} \text{ g}^{-1} \text{ soil}$), fungi ($32.00 \text{ CFU } \times 10^{-5} \text{ g}^{-1} \text{ soil}$) and actinomycetes ($31.3 \text{ CFU } \times 10^{-3} \text{ g}^{-1} \text{ soil}$) population at 50 DAS. Highest uptake of N ($171.10 \text{ kg } ha^{-1}$), P ($25.23 \text{ kg } ha^{-1}$) and K ($70.21 \text{ kg } ha^{-1}$) observed with application of recommended of EM solution application through IW @100 l ha^{-1} at branching and flowering stage + foliar application of EM-solution @ 1% at branching and flowering stage.

2.5 Effect of Organic Formulations on Soil Nutrient Status

Upperi *et al.* (2008) studies on the use of jeevamrut with the recommended dose of fertilizer for the production and management of leaf spot diseases in pomegranate and groundnut were conducted in farmer's field at two locations in Karnataka. Application of jeevamrut increase mean yield of both the crops as compared to control.

Zambare *et al.* (2008) reported that vermiwash is a liquid leachate collected by allowing excess water to saturate vermicomposting substrate in such a way that the water washes the nutrients from the vermicast excreted by the earthworms feeding on the substrate as well as the earthworm's body surface. Vermiwash is rich in nutrients and plant growth hormones and seems to possess an inherent property of acting not only as a fertilizer but also as a mild biocide. The N, P and K content of vermiwash is 0.01, 0.08 and 0.13 %, respectively. This vermiwash would have enzymes, secretions of earthworms which would stimulate the growth and yield of crops and also develop resistance. Microbes in the vermiwash influences the biogeochemical cycle of phosphorus and these compounds are decomposed and mineralized by enzymatic complexes like phosphatases produced by microbes and effectively utilized by the crops.

Gosavi *et al.* (2009) carried out an experiment on organic farming in soybean-wheat cropping sequence found that with regards to jeevamrut application for both the crops, reduction in available nitrogen, phosphorus and potassium was observed. This might be due to non-availability of nutrients for the crops by jeevamrut application alone, which might have resulted in nutrient

mining from the soil to accomplish their life cycle. Similar trend of nutrient mining was also noticed in case of cow urine spray for both the crops.

Ansari and Kumar (2010) studied on effect of vermiwash (100 ml plant⁻¹), vermicompost (100 g plant⁻¹) and cow dung (100 g plant⁻¹) on yield of okra and soil parameters. They found the significantly higher content of organic carbon in the treatment of vermiwash + vermicompost followed by only vermicompost and only cow dung (100 g plant⁻¹). However, higher content of N, P, K, Ca, Mg, Fe, Mn, Zn and Cu were observed in the chemical fertilizer treatment followed by treatments of vermiwash + vermicompost.

Sathish and Paramaguru (2010) conducted trial to study the response of bioregulators on nutrient uptake pattern of turmeric cultivar BSR. They use different bioregulators like panchagavya, vermiwash, humic acid, effective microorganism and recommended dose of fertilizer and found higher content and uptake of N (0.84 %, 277.82 kg ha⁻¹), P (0.22 %, 64.27 kg ha⁻¹) and K (0.88 %, 270.52 kg ha⁻¹) in the treatment of foliar application of humic acid @ 0.05 % as compared to foliar application of panchagavya (3 and 4 %), vermiwash (10 and 20 %), EM (1 and 2 %) and control.

Manyuchi *et al.* (2013) carried out an experiment to know effect of vermicompost, vermiwash and application time on soil micronutrients composition. They found that increasing the vermicompost quantity resulted in increased soil zinc, manganese and iron content, whereas increased vermiwash quantities resulted in increased soil iron content but resulted in decreased copper content.

Khan *et al.* (2014) studied on foliar spray with vermiwash modifies arbuscular mycorrhizal dependency and nutrient stoichiometry of bhut jolokia (*Capsium assamicum*) and analysis showed that physico-chemical properties of vermiwash, pH 8.77, EC 0.04, OC 1.06 % and available N 338.8 mg kg⁻¹, P 57.2 mg kg⁻¹, and K 154.94 mg kg⁻¹.

Veerasha and Gopakkali (2014) carried out an experiment on effect of organic production practices on yield and soil health of irrigated maize (*Zea mays* L.) as influenced by various levels of FYM and cattle urine application and analysis showed that significantly high soil organic carbon (0.58 %), available nitrogen (272.4 kg ha⁻¹), phosphorus (23.5 kg ha⁻¹) and potassium (199.9 kg ha⁻¹) were obtained with the application of FYM 12.5 t ha⁻¹ + cattle urine at 34300 l ha⁻¹ as compared to control.

Nwite (2015) studied the effect of different urine sources on soil chemical properties and maize yield in Abakaliki, Southeastern Nigeria and noted that higher total nitrogen, available phosphorus, Ca, Mg, organic carbon, pH, exchangeable K and Na were obtained under human and cattle urine treatments as compared to control.

2.6 Effect of Organic Formulations on Economics of Onion

Gupta and Yadav (2006) conducted field trial in *kharif* season for evaluating cow urine efficacy against stem borers and cost benefit in soybean production. There was reduction in percent stem tunneling at almost all levels of cow urine. The yield data indicates that cow urine at 25, 50 and 75 % concentration recorded significantly higher yield than control. Highest cost benefit ratio (1: 18.9) was obtained from 75 % cow urine.

Pandey *et al.* (2006) reported that irrespective of application rates, FYM and poultry manure noticed marked increase in the net returns and benefit : cost ratio. FYM @ 20 t ha⁻¹ gave the highest net returns (₹ 74202 ha⁻¹), followed by 15 t ha⁻¹ (₹ 70718 ha⁻¹). Whereas 50 per cent NPK + vermicompost 1.5 t ha⁻¹ resulted in significantly lower economic returns and gave negative B:C ratio which was mainly attributed to higher price of vermicompost coupled with lower green pod yield of garden pea.

Rajamani *et al.* (2007) conducted field experiment on the effect of bio-regulants on growth and yield of turmeric yield of turmeric (var. BSR-2) at Horticulture College and Research Institute, TNAU, Coimbatore and reported that the application of humic acid 0.05 % foliar spray found higher BCR of 2.25 as compare to control treatment.

Patil *et al.* (2008) studied foliar spray of cow urine and water on green gram. In case of foliar spray of cow urine results the higher gross (₹ 22504 ha⁻¹) and net returns (₹12558 ha⁻¹) with B:C ratio (2.32) per hectare due to foliar application of cow urine.

Shwetha and Babalad (2008) reported that the net returns in soybean was significantly higher with combined application of organic and fermented liquid manures over no fermented liquid manures and recorded significantly higher B:C ratio (2.9) with the application of compost + vermicompost + green leaf manure followed by compost + green leaf manure + beejamrit + jeevamrut + panchagavya (2.6).

Venkanna (2008) reported that FYM @ 10 t ha⁻¹ along with 100 per cent RDF recorded significantly higher gross returns (₹ 47103 ha⁻¹) which was on par with glyricidia + FYM + amrutpani (₹ 43030 ha⁻¹), glyricidia + FYM + jeevamrut (₹ 40926 ha⁻¹) and crop residue mulch + FYM + amrutpani (₹ 41542 ha⁻¹). The same trend was followed in case of net returns (₹ 29914 ha⁻¹, ₹ 26710 ha⁻¹, ₹ 25040 ha⁻¹ and ₹ 24045 ha⁻¹ respectively) in cultivation of chilli.

Sekhar and Rajashree (2009) recorded significantly higher B:C ratio (2.9) with the application of compost + vermicompost + GLM over rest of the treatments, except RDF + FYM (2.3) followed by compost + GLM + Beejamruth + Jeevamrut + Panchagavya (2.6) in soybean.

Manjunatha *et al.* (2009) conducted a field experiment at the Agricultural Research Station, Bheemarayanagudi, Karnataka, India during *kharif* season to study the effect of RDF, FYM and jeevamrut on yield of sunflower and income. Application of FYM @ 7.5 t ha⁻¹ + jeevamrut

recorded highest gross return of ₹ 27384 ha⁻¹. The income under RDF, FYM @ 7.5 t ha⁻¹ and jeevamrut @ 500 l ha⁻¹ was ₹ 25475, ₹ 26131 and ₹ 19830 ha⁻¹, respectively indicated that combine application of FYM and jeevamrut was more remunerative than its individual application.

Khanal *et al.* (2011) carried out a field experiment in Nepal on farmer's field during 2009-2010, to test the efficacy of cattle urine alone and in combination with urea as a potential supplement to nitrogenous fertilizers in improving yield and quality of cauliflower cv. Kathmandu Local. The highest curd yield and the highest benefit cost ratio (5.84) were observed by application of 100 kg N ha⁻¹ through urine.

Ravikumar *et al.* (2011) studied the effect of organic sources of nutrients on economics of groundnut at UAS, Bangaluru during *kharif* season. They recorded net return of ₹ 42693 ha⁻¹ with BC ratio 2.37 under the treatment, application of FYM @ 7.5 t ha⁻¹ + jeevamrut (N equivalent) + Rhizobium + PSB which was higher than that recorded under application of FYM only (Net return ₹ 24803 ha⁻¹, BC ratio 1.81).

Singh and Grover (2011) studied the economic viability of organic farming : an empirical experience of wheat cultivation in Punjab and showed that with one per cent increase in expenditure on FYM + jeevamrut, biodynamic and machine labour, the organic wheat productivity would increase by 0.114 per cent, 0.703 %, 0.556 %, respectively, showing significant impact on value productivity.

Deotale (2014) Conducted research on effect of foliar spray of humic acid through cowdung and vermicompost wash on biochemical parameters and yield of green gram. It can be concluded that foliar application of 250 ppm vermiwash at 20 and 35 DAS enhanced biochemical and yield contributing parameters and ultimately increased yield by 30 % over control. Benefit : cost ratio of the same treatment was 1.96.

Hafez and Geries (2018) conducted field experiments to study the effects of application of nitrogen fertilizer, biofertilizers and organic compounds on growth, yield and economic of onion production in 2014-2015 and 2015-2016 seasons. From the data it was found that combination of N fertilization of onion plants with 100 kg N fed.⁻¹ (hectare = 2.38 feddan) and foliar with humic acid at the rate of 1 kg fed.⁻¹ is the best in this study, for giving the highest bulb yield with the highest net returns and with a benefit : cost ratio (B:C ratio) of 2.35.

3. MATERIALS AND METHODS

The present investigation entitled, “Effect of foliar applications of organic formulations on growth and yield of onion.” was conducted during *rabi* season of 2018. The details of the material used and methods adopted during the period of investigation are given in this chapter under the following heads.

3.1 Details of the Experimental Material

3.1.1 Experimental site

The present investigation was carried out at All India Co-ordinated Research Project on Integrated Farming Systems, Mahatma Phule Krishi Vidyapeeth, Rahuri

3.1.2 Preparation of land

A well levelled and with uniform fertility land was selected for conducting the experiment. Before laying out the experiment, the field was first prepared by removing stubbles and debris of the previous crop. To make a fine tilth, the field was ploughed once and harrowed once.

3.1.3 Soil

The soil of the experimental plot was clay loam and well drained. Representative and composite soil sample was collected from experimental site for assessing the initial soil fertility status of the soil. The soil sample was analysed in laboratory for determination of physical and chemical properties of soil by adopting standard analytical methods.

It was observed that the soil of the experimental site was clay in texture. The chemical composition according to criteria laid by Muhr *et al.* (1965) indicates that the soil was low in available nitrogen ($187.32 \text{ kg ha}^{-1}$), medium in available phosphorus (14.12 kg ha^{-1}) and medium available potassium ($395.10 \text{ kg ha}^{-1}$) and alkaline reaction with pH 8.25, electrical conductivity of 0.26 dsm^{-1} and organic carbon 0.79 %. The data regarding physical and chemical properties of experimental plot are presented in Table 3.1.

3.1.4 Climatic conditions

The Mahatma Phule Krishi Vidyapeeth, Rahuri is situated between $19^{\circ} 47'$ and $19^{\circ} 57'$ North latitude and between $74^{\circ} 32'$ and $74^{\circ} 1' 9$ East longitude. It is situated about 525 m above mean sea level. This tract lying on the eastern side of Western Ghats, falls under rain shadow area.

Climatically this area falls under semi-arid, subtropical zone with an annual rainfall being 520 mm. The rainfall is erratic and uneven distributed and coupled with frequent droughts of the total rainfall, about 40 per cent is received during July to September from south west monsoon, while the rest is received during October and November. Very scanty and occasional rain received during December and January. The annual mean temperature is 30°C . The experimental plot was irrigated at regular intervals as per the requirement of crops. Generally, weather conditions were favourable for the growth of the onion crop.

Table 3.1 Physico-chemical and biological properties of experimental soil

Sr.No	Characteristics	Composition	Method used	Reference(s)
A.	Physical composition			
1.	Particle size distribution		International pipette method	Piper (1966)
	Sand (%)	22.3		
	Silt (%)	26.4		
	Clay (%)	51.3		
	Textural class	Clay loam		
2.	Bulk density (g cm ⁻³)	1.24	Core sampler	Dastane (1972)
3.	Moisture at -1/3 rd bar	37.30	Pressure plate apparatus	Black (1965)
4.	Moisture at -15 bar	18.10		
5.	Available soil moisture (%)	19.20	Gravimetric	Dastane (1972)
B.	Chemical composition			
1.	Soil pH (1:2.5)	8.25	Potentiometry	Piper (1966)
2.	EC (dSm ⁻¹)	0.26	Conductometry	Piper (1966)
3.	Organic carbon (%)	0.79	Wet oxidation	Nelson and Sommer (1982)
4.	Available N (kg ha ⁻¹)	187.32	Alkaline potassium permanganate	Subbiah and Asija (1965)
5.	Available P (kg ha ⁻¹)	14.12	0.5M NaHCO ₃ (pH 8.5)	Olsen <i>et al.</i> , (1954)
6.	Available K (kg ha ⁻¹)	395.10	Flame Photometer	Knudsen <i>et al.</i> , (1982)
C	Biological properties			
1.	Bacteria (CFU x 10 ⁻⁶ g ⁻¹ soil)	23.66	Serial dilution and pour plate technique	Chonkar <i>et al.</i> , (2007)
2.	Fungi (CFU x 10 ⁻⁵ g ⁻¹ soil)	18.33		
3.	Actinomycetes (CFU x 10 ⁻³ g ⁻¹ soil)	19.66		

Table 3.2 Analytical methods for plant analysis

Sr. No.	Particular	Method adopted	Reference(s)
A.	Plant analysis		
a.	Nitrogen	Micro-Kjeldhal's	Jackson (1973)
b.	Phosphorus	Vanadomolybdate phosphoric yellow colour method in nitric acid system	Jackson (1973)
c.	Potassium	Flame photometric	Champman and Pratt (1961)

Table 3.3 Meteorological data recorded during experimental period.

Met. week	Date	Temp ° C		Humidity %		Sunshine (hrs)	Wind speed (km hr ⁻¹)	Evapo-ration (mm)
		Max.	Min.	Morn.	Even.			
October, 2018								
41	08 to 14	34.0	18.4	55	30	08.8	01.6	07.0
42	15 to 21	33.5	18.6	50	30	08.2	01.3	06.6
43	22 to 28	34.4	16.8	46	30	08.5	01.0	06.6
44	29 to 04	31.7	14.4	58	39	09.4	01.9	06.5
November, 2018								
45	05 to 11	33.1	16.8	59	37	08.1	00.8	06.4
46	12 to 18	32.5	12.9	43	23	09.9	00.8	05.9
47	19 to 25	31.7	16.3	61	46	07.7	01.3	05.7
48	26 to 02	30.1	11.3	58	32	09.2	00.8	05.6
December, 2018								
49	03 to 09	30.3	15.0	60	35	06.6	01.5	04.9
50	10 to 16	28.1	11.3	55	35	05.6	00.7	04.9
51	17 to 23	26.5	09.1	64	36	09.1	00.5	04.4
52	24 to 31	27.8	08.9	51	30	08.8	00.6	04.6
January, 2019								
1	01 to 05	29.5	8.4	42.5	22.5	9.3	0.2	4.40
2	06 to 12	28.7	11.4	56.3	26.7	8.6	0.3	4.30
3	13 to 19	29.3	11.1	59.5	32.3	7.9	0.3	4.50
4	20 to 26	27.5	10.6	61.8	41.3	8.6	0.8	4.90
5	26 to 02	29.0	9.9	51.5	29.8	6.7	0.8	4.20
February, 2019								
6	03 to 09	28.8	9.1	53.8	29.5	7.4	1.1	4.60
7	10 to 16	32.2	14.4	55.2	28.3	8.3	0.6	5.30
8	17 to 23	34.7	16.5	51.3	25.5	8.2	0.9	5.90
9	24 to 02	31.7	12.7	46.0	20.7	9.5	1.2	6.10
March, 2019								
10	03 to 09	32.9	14.1	44.8	21.2	9.6	0.9	6.40
11	10 to 16	35.2	16.1	51.5	16.7	9.2	0.8	6.50
12	17 to 23	36.4	15.8	45.3	14.8	8.5	1.6	7.20
13	24 to 30	39.4	18.3	40.2	12.8	8.9	1.4	8.40
April, 2019								
14	31 to 06	39.51	19.64	36.57	14.57	8.0	2.3	9.13
15	07 to 13	40.37	20.26	36.43	12.43	9.9	2.3	9.56
16	14 to 20	37.39	20.11	45.29	19.57	9.0	2.6	8.93
17	21 to 27	40.66	23.13	32.86	11.86	9.4	2.4	10.89

3.1.5 Cropping history of experimental plot

The cropping history of the experimental field for the previous three years is presented in Table 3.4.

From the cropping history of the experimental plot it was observed that the present investigation was carried out on plot preceded by *kharif* soybean.

Table 3.4 Cropping history of the experimental plot

Sr. No.	Year	Season		
		<i>Kharif</i>	<i>Rabi</i>	Summer
1.	2016-17	Soybean	Onion	Fallow
2.	2017-18	Soybean	Chickpea	Fallow
3.	2018-19	Soybean	Present investigation	-

3.2. Methods

3.2.1 Experimental details

The field experiment was carried out in *rabi* season of 2018. The experiment was laid out in randomized block design with 8 treatments replicated 3 times with gross plot size 7.30 m x 4.50 m and net plot 7.10 m x 4.20 m as per the plan of layout of the experimental plot given in Fig. 3.1. The various field operations were carried out in the experimental field during *rabi* season 2018 are presented in Table 3.6.

3.2.2 Experimental layout

A.	Design	:	Randomized Block Design
B.	Treatments	:	Eight (8)
C.	Replications	:	Three (3)
D.	Season	:	<i>Rabi</i> , 2018
E.	Plot size	:	Gross plot : 7.30 m x 4.50 m Net plot : 7.10 m x 4.20 m
F.	Variety	:	N-2-4-1
G.	Spacing	:	15 cm x 10 cm
H.	Seed rate	:	10 kg ha ⁻¹
I.	Sowing method	:	Transplanting
J.	Place of Research	:	AICRP-IFS, MPKV, Rahuri
K.	Date of nursery sowing	:	12-10-2018
L.	Date of transplanting	:	06-12-2018
M.	General Recommended Dose of Fertilizers (GRDF)	:	15 t ha ⁻¹ FYM + 100:50:50 N:P ₂ O ₅ :K ₂ O kg ha ⁻¹

3.2.3 Treatments details:

Treatment number	Treatment
T ₁	Control (no foliar spray)
T ₂	Water spray at 30 and 60 DAT
T ₃	Foliar application of cow urine @ 6% at 30 and 60 DAT
T ₄	Foliar application of jeevamrut @ 5% at 30 and 60 DAT
T ₅	Foliar application of EM-solution @ 1% at 30 and 60 DAT
T ₆	Foliar application of humic acid @ 2% at 30 and 60 DAT
T ₇	Foliar application of vermiwash @ 5% at 30 and 60 DAT
T ₈	Foliar application of EM-solution @ 5% at 30 and 60 DAT

(All treatments are supplied with GRDF)

Table 3.5 Chemical composition of different organic formulations

Sr. No.	Sources of formulations	Nutrient Content (%)			
		N	P ₂ O ₅	K ₂ O	S
1.	Cow urine	1.67	0.11	2.55	-
2.	Jeevamrut	1.96	0.17	0.28	-
3.	Humic acid	0.86	-	-	1.40
4.	Vermiwash	0.84	0.22	0.88	-
5.	EM-solution	-	-	-	-

3.2.4 Variety

The seed of onion Cv. N-2-4-1 for present investigation was procured from the Chief Scientist (Seed), Breeder Seed Production Unit, Mahatma Phule Krishi Vidyapeeth, Rahuri.

Characteristics of Cv. N-2-4-1 variety

It has distinguishing characters like average bulb diameter 4-6 cm, red brick colour, shade globular, pungent in taste, good keeping quality, plant mature in 135-145 days after transplanting having TSS is about 12-13 % and average yield is 30-35 t ha⁻¹ and is also suitable for export purpose.

3.2.5 Cultural operations

3.2.5.1 Field preparation

The field was prepared with one ploughing followed by harrowing by rotavator so as to make the soil well pulverized and free from weeds. The field was laid out for the trial as per given in plan of layout.

3.2.5.2 Raising of nursery

The seedlings were raised in the nursery for transplanting. The raised beds of 2.5 m x 1.5 m x 0.15 m size were prepared and 15 kg of FYM + 25 g of Blitox to each beds was mixed thoroughly in the soil. The onion seeds were sown on raised beds by line sowing, keeping the distance 15 cm between two successive row. Irrigation was applied by surface method. In nursery two preventive sprayings of Dithane M-45 @ 2.5 g L⁻¹ and NSKE @ 5 % were carried out at 15 days and 30 days after sowing.

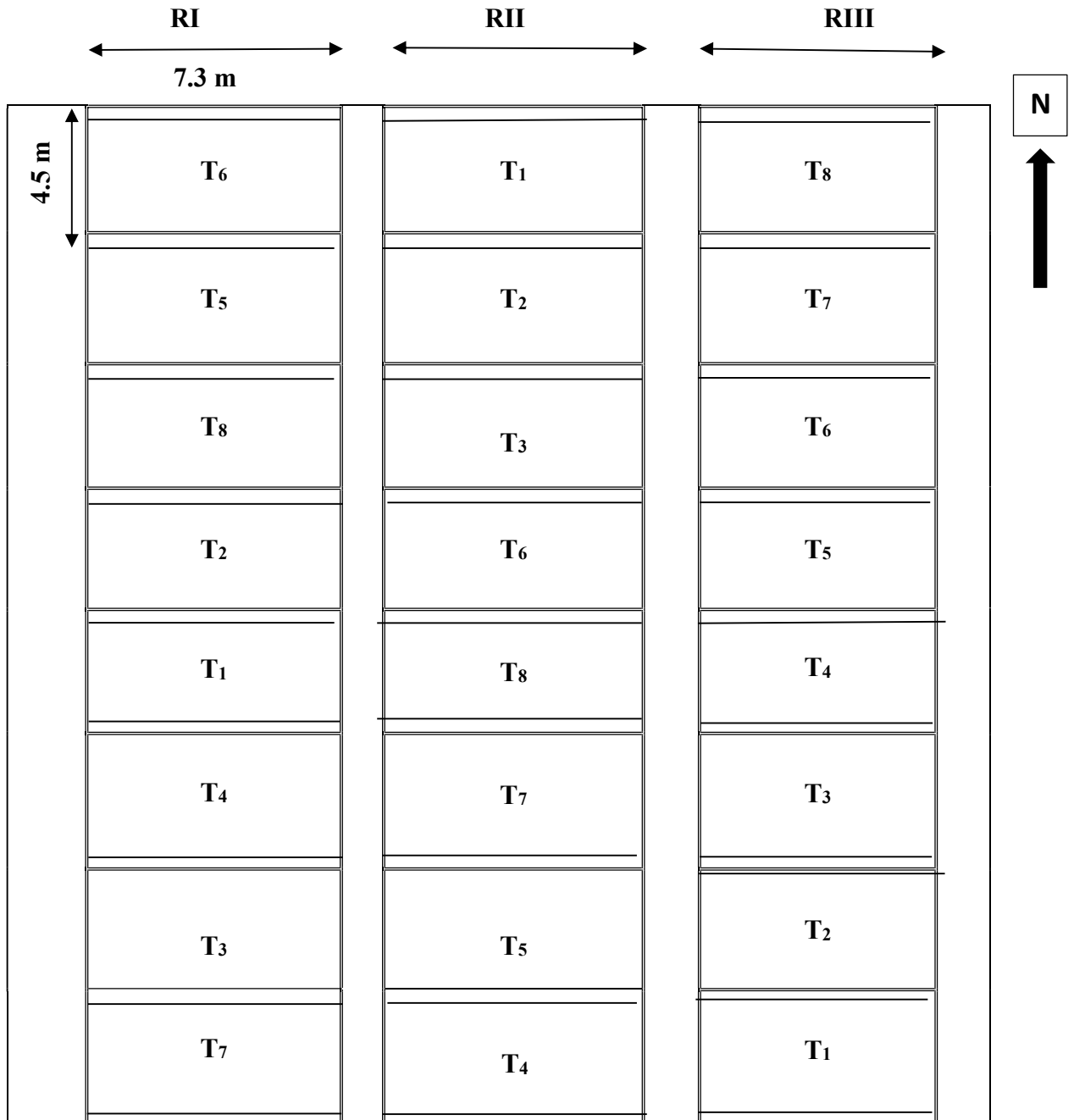


Fig. 3.1 Plan of experimental layout

Table 3.6 Details of cultural operations performed in the experiment

Sr.No.	Operations	Frequency	Date of operation
A	Raising of nursery in seedlings		
1	Preparation of bed	1	10.10.2018
2	Seed sowing	1	12.10.2018
3	Plant protection		
	Spraying of Dithane M-45	2	26.10.2018
	Spraying of NSKE @ 5%		10.11.2018
4	Irrigation	5	12.10.2018, 28.10.2018 12.11.2018, 28.11.2018, 04.12.2018
B	Presowing operations		
	Field Preparation	1	25.11.2018
	Soil sample	1	27.11.2018
	Layout, preparation of beds and channel	1	30.11.2018
C	Transplanting		
	Application of F.Y.M	1	01.12.2018
	Application of fertilizer (Basal dose)	1	06.12.2018
	Transplanting of seedling	1	06.12.2018
D	Post transplanting operation		
	Top dressing	1	04.01.2019
E	Plant protection		
	Spraying of NSKE @ 5%	2	25.12.2018, 14.01.2019
F	Spraying of organic formulations		
	I Spray	1	04.01.2019
	II Spray	1	03.02.2019
G	Irrigation	9	06.12.2018, 20.12.2018 02.01.2019, 20.01.2019, 01.02.2019, 25.02.2019, 14.03.2019, 31.03.2019, 21.04.2019
H	Weeding	3	04.01.2019, 10.02.2019, 12.03.2019
I	Harvesting	1	23.04.2019

3.2.5.3 Manures and Fertilizer application

The farmyard manures (FYM) has applied common to all the treatment @ 15 t ha⁻¹. The 100:50:50 N:P₂O₅:K₂O kg ha⁻¹ was applied in the form of urea, single super phosphate and murriate of potash, respectively. Half dose of nitrogen and full dose of phosphorus and potassium was applied as a basal dose at the time of transplanting and remaining half dose of nitrogen was applied one month after transplanting.

3.2.5.4 Transplanting of seedlings

Eight weeks old, healthy and uniform seedlings having about 15-20 cm height were used for transplanting. After uprooting the seedlings, two third portions of the leaves were cut by sickle and then transplanted in flat beds of 7.30 m x 4.50 m size at a spacing of 15 cm x 10 cm. Transplanting was done on 06 December, 2018.

3.2.5.5 Irrigation

A first irrigation was applied during the transplanting and subsequent irrigation were given when it required depending upon the soil condition.

3.2.5.6 Weeding

In order to control the weeds and to avoid competition between plants three hand weedings were given on 04.01.2019, 10.02.2019 and 12.03.2019, respectively.

3.2.5.7 Plant protection

After transplanting, insect pests were controlled by spraying 5 % Neem Seed Kernel Extract (NSKE). Spraying of NSKE @ 5 % was carried out at 20 days and 40 days after transplanting to minimize the incidence of sucking pests.

3.2.6 Harvesting

Harvesting of onion bulbs was done when the leaves turned yellow, becoming dry at the top and more than 50 per cent tops fall was observed. Harvesting was done on 23.04.2019. Harvested bulbs were field cured for about four days and then tops were cut leaving 2.5-3.0 cm neck length and then bulbs were kept for shade curing for 21 days.

3.3 Biometric Observation

The various biometric observations of five randomly selected plants in each net plot were recorded. Demarcation and labeling of selected plant was done with the help of wooden pegs near the observational plants for easy allocation. The details of observations recorded during course of investigation are presented in Table 3.7.

Table 3.7 Details of the biometric observations recorded during course of investigations

Sr. No.	Particular	Frequency	Sample size	Period
1.	Growth studies			
1	Initial and final plant population (%)	At 15 DAT (initial) and at harvest (final)		
2	Plant height (cm)	4	5	30,60,90 and at harvest
3	Number of leaves plant ⁻¹	4	5	30,60,90 and at harvest
4	Neck thickness (cm)	4	5	30,60,90 and at harvest
5	Number of days to maturity	-	Net plot	-
2.	Yield studies			
1.	Average bulb weight (g)	1	5 bulb	At harvest
2.	Dry matter bulb ⁻¹ (g)	1	5 bulb	At harvest
3.	Total bulb yield (t ha ⁻¹)	1	Net plot	At harvest
4.	Yield of leaves (dry /green) (t ha ⁻¹)	1	Net plot	At harvest
5.	Polar diameter of bulb (cm)	1	5 bulb	At harvest
6.	Equatorial diameter of bulb (cm)	1	5 bulb	At harvest
7.	Number of twin bulbs %	-	-	At harvest
8.	Number of bolters %	-	-	At harvest
9.	Grading of bulbs (on the basis of size small, medium, large) as per treatment.	-	-	After harvest
10.	Marketable bulb yield (t ha ⁻¹)	1	Net plot	At harvest
3.	Chemical studies			
1	Initial soil analysis (N, P, K)	1	Composite sample	Before transplanting
2	Final soil analysis (N, P, K)	1	Sample from each net plot	After harvest
4.	Plant analysis			
1	NPK concentration in plant	1	5	At harvest
5.	Microbial Studies			
1	Rhizosphere population of soil i.e. total bacteria, fungi and actinomycetes	1	One sample from each plot	Before spraying and after spraying (60 DAT).

3.4. Method of observations

3.4.1 Growth Studies

3.4.1.1 Plant population

The initial and final plant population was recorded by counting the number of plants from each net plot 15 days after transplanting and just before harvesting, respectively.

3.4.1.2 Plant height (cm)

Plant height was recorded from five randomly selected plants by measuring the length of shoot from its base near the ground level upto the tip of longest leaf with the help of meter scale. The height was recorded at successive stages *viz.* 30, 60, 90 days after transplanting and at harvest.

3.4.1.3 Number of leaves plant⁻¹

The total number of leaves of five selected plants were counted and average was worked out at 30, 60, 90 days after transplanting and at harvest.

3.4.1.4 Neck thickness (cm)

Neck thickness of five randomly selected plants was recorded at 30, 60, 90 days after transplanting and at harvest with the help of vernier caliper.

3.4.1.5 Number of days to crop maturity

The number of days taken from transplanting to the days when more than half of population in each plot reached to neck fall or leaf yellowing stage.

3.4.2 Yield Studies

3.4.2.1 Average bulb weight (g)

The weight of five bulbs were measured separately from each net plot and single bulb weight was calculated on mean basis and expressed in grams.

3.4.2.2 Dry matter bulb⁻¹ (g)

After recording fresh weight of bulb in each treatment these were chopped and dried in sunlight for two days. Then above samples were kept in an oven at 60 °C for 24 hours and mean weight of dry matter was recorded.

3.4.2.3 Polar diameter of bulb (cm)

The polar diameter of randomly selected five bulbs was measured by vernier caliper from the junction of root plate to the top of the bulb and the mean polar diameter was worked out.

3.4.2.4 Equatorial diameter of bulb (cm)

The equatorial diameter is the maximum distance between opposite side at right angles to the polar diameter and it was measured using vernier caliper in cm from the same randomly selected five bulbs which were used for recording polar diameter. The mean equatorial diameter of the bulb was worked out.

3.4.2.5 Total bulb yield ($t\ ha^{-1}$)

The weight of total harvested bulbs including marketable and non-marketable bulbs such as bolters and twin bulbs in kg from each plot was recorded. The yield obtained was converted into tonnes per hectare basis.

3.4.2.6 Yield of leaves (green/ dry) ($t\ ha^{-1}$)

After harvesting of crop and cutting of tops, weight of remaining green leaves was recorded from each plot and then it was left for sun drying. After drying in sun, the dry leaves weight was recorded from each plot.

3.4.2.7 Number of bolters (%)

All bolted bulbs from each net plot were separated and recorded the weight per net plot. Then its percentage was worked out on weight basis by dividing total weight of bolted bulbs to the weight of total bulb yield from each net plot.

3.4.2.8 Number of twin bulbs (%)

All the twin bulbs from each net plot were separated and recorded weight per plot. By dividing weight of twin bulbs to the weight of total bulb yield from each plot, its percentage was worked out.

3.4.2.9 Grading of bulbs

The bulbs harvested from each plot were categorized into three grades on the basis of equatorial diameter of bulb.

Grade	Diameter of bulb (mm)
A	> 65
B	45-65
C	< 45

The weight of A, B and C grade bulbs were recorded grade wise in kg plot⁻¹. Percentage of each grade in each plot was computed on weight basis.

3.4.2.10 Marketable bulb yield (t ha⁻¹)

The marketable bulb yield was calculated on weight basis by subtracting the total weight of bolted bulbs and twin bulbs from total bulb yield and expressed as tonnes per hectare (t ha⁻¹).

3.4.3 Microbial Studies

3.4.3.1 Rhizosphere population of soil bacteria, fungi and actinomycetes

The microbial count was taken by using the method suggested by Chonkar *et al.* 2007. The rhizosphere soil samples collected at 60 DAT and were analysed for population of soil bacteria, fungi and actinomycetes by the standard serial dilution plate count method using Nutrient agar for bacteria, Krustose agar for actinomycetes and Rose Bengal agar for fungi. Plates were incubated at 28⁰C in an incubator and colony counts were recorded after six days of incubation. The population was expressed as number of colony forming units per gram (g) dry weight of soil.

3.4.4 Chemical Analysis

3.4.4.1 Soil analysis at harvest

Immediately after harvest of onion crop, soil samples from each treatment plots were taken. These samples were air dried, grinded and finely sieved (2 mm sieve). These samples were analyzed for available nitrogen, available phosphorus, available potassium, pH, EC and organic carbon % as per the methods given in Table 3.1.

3.4.5 Plant Analysis

To study the nutrient uptake *viz.*, nitrogen, phosphorus and potassium by onion crop, the onion plant with bulb from each treatment were collected and separated the bulbs and leaves. The bulbs and leaves were cut into small pieces and dried in hot air oven at 65⁰C. The dried plant samples were grinded to fine powder. The fine powder was used for estimation of nutrients content in onion bulbs and leaves. The total uptake of nutrients by onion crop was worked out by multiplying nutrient content with dry matter of onion. The methods used for analysis given in table 3.2.

3.4.5.1 Uptake of nutrient by the crop

The uptake of nitrogen, phosphorus and potassium (kg ha^{-1}) was worked out by multiplying the percentage of these nutrients in leaves/bulb with the corresponding yields of the respective constituent.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{\% nutrient content in bulb/leaves}}{100} \times \text{Dry matter yield (leaves/bulb) (kg ha}^{-1}\text{)}$$

3.4.6 Economic Evaluation

Several economic indices are available to evaluate the profitability of cropping systems. No single index is capable of giving good comparison of different treatments and therefore, number of indices were used together to assess the economic viability of the system. Since, the price of farm products fluctuating from year to year and season to season and also place to place, the profitability of the system also changes accordingly.

3.4.6.1 Gross monetary returns (₹ ha^{-1})

Gross returns are the total monetary value of economic produce and by products obtained from the crop raised in the different treatments was calculated based on the local market prices.

3.4.6.2 Cost of cultivation (₹ ha^{-1})

Cost of cultivation is the total expenditure incurred for raising crop in a treatment. The cost included for this purpose consists of own or hired human labour, value of seed, manures, fertilizers, pesticides and irrigation charges.

3.4.6.3 Net monetary returns (₹ ha^{-1})

It is computed by subtracting cost of cultivation from gross returns. It is good indicator of suitability of a cropping system since this represents the actual income of the farmer. Monetary returns for different treatments were calculated with the help of prevailing market rates of produce and different inputs used in the experiments. Net Monetary Returns (₹ ha^{-1}) = Gross return (₹ ha^{-1}) – Cost of cultivation (₹ ha^{-1})

3.4.6.4 Benefit cost ratio

It is the ratio of gross returns to cost of cultivation. It is expressed as returns per rupee invested. This index provides an estimate of the benefit a farmer derives for the expenditure he incurs in adopting a particular cropping system.

$$\text{BCR} = \frac{\text{Gross return (₹ ha}^{-1}\text{)}}{\text{Total cost of cultivation (₹ ha}^{-1}\text{)}}$$

3.5 Statistical Analysis

The statistical methods given by Panse and Sukhatme (1985) were used for analysis and interpretation of experimental results. In order to evaluate comparative performance of various treatments, the data was analyzed by the technique of analysis of variance given by Fisher (1950). To judge the significance of the differences between two treatments, critical difference (C.D.) was worked out by following formula:

$$\text{C.D.} = \frac{\sqrt{\text{Error variance}}}{n} \sqrt{2} \times \text{'t' value at 5\%}$$

Where, C.D. = Critical difference.

n = number of replication of that factor for which C.D. is to be calculated.

t = the value from Fischer's (1950) table for error degree of freedom at 5 per cent level of significance.

4. RESULTS AND DISCUSSION

An experiment entitled “Effect of foliar applications of organic formulations on growth and yield of onion” was conducted during *Rabi* season of 2018-19.

The data were statistically analyzed and interpreted in this chapter in the appropriate heads and sub heads.

4.1 Biometric Observations

4.1.1 Growth studies

The observations on various growth characters *viz.*, plant height, number of leaves plant⁻¹, neck thickness plant⁻¹ and days required to maturity were recorded on five observational plants from each net plot and recorded on mean plant basis. The details regarding observations on growth characters are as under. The research findings of these aspects are presented in Table 4.1 to 4.16.

4.1.1.1 Plant population

Data regarding the initial and final plant population of onion as influenced by applications of different organic formulations are presented in Table 4.1.

A. Initial plant population

Data pertaining to the initial plant population at 15 DAT in various treatments under study are presented in Table 4.1. From data it was observed that initial plant population of onion was 6,59,666 plants ha⁻¹ which was 98.95 per cent of theoretical plant population.

The initial plant population ha⁻¹ was affected significantly might be due to environmental factor. However, the plant population ranges between 6,57,975 to 6,60,938 ha⁻¹ which was 98.95 per cent of the theoretical plant population. Although the highest initial plant population obtained in treatment GRDF with foliar application of humic acid @ 2% at 30 and 60 DAT (T₆) i.e. 6,60,938 and followed by treatment GRDF with T₂- Water spray at 30 and 60 DAT, GRDF with T₃- Foliar application of cow urine @ 6 % at 30 and 60 DAT, GRDF with T₄- Foliar application of jeevamrut @ 5 % at 30 and 60 DAT and GRDF with T₈- Foliar application of EM-solution @ 5 % at 30 and 60 DAT.

B. Final plant population

Data pertaining to the final plant population at harvest ha⁻¹ in various treatments under study are presented in Table 4.1. From data it was observed that final plant population of onion was 6,46,728 plants ha⁻¹ which was 97.01 per cent of theoretical plant population.

The final plant population ha⁻¹ was affected significantly due to applications different organic formulations. However, the plant population ranges between 6,42,765 to 6,48,888 ha⁻¹ which was 97.01 per cent of the theoretical plant population. The highest plant population 6,48,888 was recorded in treatment GRDF with foliar application of humic acid @ 2 % at 30 and 60 DAT (T₆) with 6,48,888 followed by treatment GRDF with T₇- foliar application of vermiwash @ 5 %

at 30 and 60 DAT, GRDF with T₈- foliar application of EM-solution @ 5 % at 30 and 60 DAT, GRDF with T₃- Foliar application of cow urine @ 6 % at 30 and 60 DAT, GRDF with T₄- Foliar application of jeevamrut @ 5 % at 30 and 60 DAT and GRDF with T₅- Foliar application of EM-solution @ 1 % at 30 and 60 DAT.

Table 4.1 Effect of foliar applications of organic formulations on initial and final plant population of onion.

Treatment	Initial plant population (ha ⁻¹)		Final plant population (ha ⁻¹)	
	Actual	Per cent	Actual	Per cent
T ₁ : Control (no foliar spray)	657975	98.70	642765	96.41
T ₂ : Water spray at 30 and 60 DAT	660740	99.11	646024	96.90
T ₃ : Foliar application of cow urine @ 6% at 30 and 60 DAT	659654	98.95	647012	97.05
T ₄ : Foliar application of jeevamrut @ 5% at 30 and 60 DAT	660049	99.01	646518	96.98
T ₅ : Foliar application of EM-solution @ 1% at 30 and 60 DAT	658962	98.84	646518	96.98
T ₆ : Foliar application of humic acid @ 2% at 30 and 60 DAT	660938	99.14	648888	97.33
T ₇ : Foliar application of vermiwash @ 5% at 30 and 60 DAT	659160	98.87	648395	97.26
T ₈ : Foliar application of EM-solution @ 5% at 30 and 60 DAT	659851	98.98	647703	97.16
S.Em ±	563.82	0.09	913.34	0.14
CD at 5%	1710	0.27	2770.33	0.42
General mean	659666	98.95	646728	97.01

4.1.1.2 Plant height (cm)

Data on plant height at various growth stages as influenced by different organic formulations are presented in Table 4.2 and graphically through Fig. 4.1. The mean plant height was 27.49, 56.02, 59.06 and 51.12 cm at 30, 60, 90 DAT and at harvest, respectively.

It was revealed that the differences in mean plant height due to applications of different organic formulations were observed to be statistically significant except at 30 DAT. A critical examination of the data revealed that plant height was comparatively lower at the initial stage (30 DAT) and their after increased up to 90 DAT.

Table 4.2 Effect of foliar applications of organic formulations on plant height of onion.

Treatment	Plant height (cm)			
	30 DAT	60 DAT	90 DAT	At Harvest
T ₁ : Control (no foliar spray)	27.11	49.33	52.65	47.07
T ₂ : Water spray at 30 and 60 DAT	26.35	54.33	55.53	47.42
T ₃ : Foliar application of cow urine @ 6% at 30 and 60 DAT	28.20	56.33	59.00	48.73
T ₄ : Foliar application of jeevamrut @ 5% at 30 and 60 DAT	27.52	57.78	62.27	51.27
T ₅ : Foliar application of EM-solution @ 1% at 30 and 60 DAT	27.71	55.33	58.14	50.80
T ₆ : Foliar application of humic acid @ 2% at 30 and 60 DAT	27.07	60.00	63.15	55.79
T ₇ : Foliar application of vermiwash @ 5% at 30 and 60 DAT	27.83	57.67	62.08	54.20
T ₈ : Foliar application of EM-solution @ 5% at 30 and 60 DAT	28.15	57.33	59.67	53.67
S. Em ±	0.54	1.04	0.89	0.79
C.D. at 5 %	NS	3.16	2.72	2.39
General mean	27.49	56.02	59.06	51.12

The plant height at 30 DAT was numerically found non-significant among treatment, whereas it was found lowest plant height (26.35 cm) under treatment GRDF with T₂ - Water spray at 30 and 60 DAT and highest plant height (28.20 cm) in treatment GRDF with T₃ - Foliar application of cow urine @ 6 % at 30 and 60 DAT.

At the stage of 60 DAT, the treatment GRDF with T₆ - Foliar application of humic acid @ 2 % gave significantly highest plant height (60.00 cm) followed by treatment GRDF with T₄- Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (57.78 cm), GRDF with T₇- Foliar application of vermiwash @ 5 % at 30 and 60 DAT (57.67 cm) and GRDF with T₈- Foliar application of EM- solution @ 5 % at 30 and 60 DAT (57.33 cm). However, lowest height of plant (49.33 cm) was recorded under treatment GRDF with T₁ - Control (no foliar spray).

At the stage of 90 DAT, The treatment GRDF with T₆-Foliar application of humic acid @ 2 % at 30 and 60 DAT gave significantly highest plant height (63.15 cm) followed by treatment GRDF with T₄- Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (62.27cm) and GRDF with T₇ -Foliar application of vermiwash @ 5 % at 30 and 60 DAT (62.08 cm). However, lowest plant height (52.65 cm) was recorded under treatment GRDF with T₁- Control (no foliar spray).

Finally at harvest, mean plant height varied between 47.07 cm to 55.79 cm due to different treatments. The treatment GRDF with T₆-Foliar application of humic acid @ 2 % at 30 and 60 DAT gave significantly highest plant height (55.79 cm) followed by treatment GRDF with T₇ -Foliar application of vermiwash @ 5 % at 30 and 60 DAT (54.20 cm) and GRDF with T₈-Foliar application of EM- solution @ 5 % at 30 and 60 DAT (53.67 cm). However, lowest plant height (47.07 cm) was recorded under treatment GRDF with T₁- Control (no foliar spray).

The stem grows in height by the addition of cell files at the base of shoot apical meristem. Elongation of central pith cells below the leaf tip and spreads down the length of the unifacial blade. These cells are smaller and more densely staining in the early phase of leaf morphogenesis (Brewster and Rabinowitch, 1990).

The mean height of plants was very fast upto 60 days, relatively slow during 60-90 days and partially stopped and decreased after 100 days as the plants turned towards maturity. The results obtained are in close agreement with the observations recorded by Sultana *et al.* (2014).

4.1.1.3 Number of leaves plant⁻¹

The data pertaining to the mean number of leaves per plant as influenced by different organic formulations are presented in Table 4.3 and graphically depicted in Fig. 4.2. Number of leaves per plant was recorded at various growth stages *viz.*, 30, 60 and 90 days after transplanting and at harvest. A critical examination of the data revealed that number of leaves per plant was comparatively lower at the initial stage (30 DAT) and their after increased up 90 DAT.

Table 4.3 Effect of foliar applications of organic formulations on number of leaves of onion.

Treatment	Number of leaves plant ⁻¹			
	30 DAT	60 DAT	90 DAT	At Harvest
T ₁ : Control (no foliar spray)	4.73	9.13	9.47	9.40
T ₂ : Water spray at 30 and 60 DAT	4.70	9.27	10.00	9.80
T ₃ : Foliar application of cow urine @ 6% at 30 and 60 DAT	4.80	8.93	10.47	9.60
T ₄ : Foliar application of jeevamrut @ 5% at 30 and 60 DAT	4.93	9.57	12.00	11.40
T ₅ : Foliar application of EM-solution @ 1% at 30 and 60 DAT	4.77	9.33	11.87	11.33
T ₆ : Foliar application of humic acid @ 2% at 30 and 60 DAT	4.87	10.22	14.07	12.13
T ₇ : Foliar application of vermiwash @ 5% at 30 and 60 DAT	4.80	9.87	12.87	12.00
T ₈ : Foliar application of EM-solution @ 5% at 30 and 60 DAT	4.93	9.60	12.13	11.80
S. Em ±	0.14	0.17	0.51	0.44
C.D. at 5 %	NS	0.54	1.56	1.32
General mean	4.82	9.49	11.57	10.93

At 30 DAT, number of leaves per plant was numerically found non-significant between treatment, while highest number of leaves plant⁻¹ (4.93) was recorded under the treatment GRDF with T₄-Foliar application of jeevamrut @ 5 % at 30 and 60 DAT and treatment GRDF with T₈ -Foliar application of EM-Solution @ 5 % at 30 and 60 DAT, whereas lowest number of leaves plant⁻¹ (4.70) was recorded under treatment GRDF with T₂-Water spray.

At the stage of 60 DAT, the treatment GRDF with T₆-Foliar application of humic acid @ 2 % at 30 and 60 DAT gave significantly highest number of leaves plant⁻¹ (10.22) followed by treatment GRDF with T₇-Foliar application of vermiwash @ 5 % at 30 and 60 DAT (9.87) whereas, treatment GRDF with T₁-Control (no foliar spray) recorded lowest number of leaves plant⁻¹ (9.13).

At 90 DAT, the treatment GRDF with T₆-Foliar application of humic acid @ 2 % at 30 and 60 DAT gave significantly highest number of leaves plant⁻¹ (14.07) followed by treatment GRDF with T₇-Foliar application of vermiwash @ 5 % at 30 and 60 DAT (12.87) whereas, the lowest number of leaves plant⁻¹ (9.47) was recorded under treatment GRDF with T₁-Control (no foliar spray).

Finally at harvest, the treatment GRDF with T₆-Foliar application of humic acid @ 2 % at 30 and 60 DAT gave significantly highest number of leaves plant⁻¹ (12.13) followed by treatment GRDF with T₇-Foliar application of vermiwash @ 5 % at 30 and 60 DAT (12.00), GRDF with T₈-Foliar application of EM- solution @ 5 % at 30 and 60 DAT (11.80), GRDF with T₄-Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (11.40) and GRDF with T₅-Foliar application of EM- solution @ 1 % at 30 and 60 DAT (11.33) whereas, the lowest number of leaves plant⁻¹ (9.40) was recorded under treatment GRDF with T₁-Control (no foliar spray).

The mean number of leaves plant⁻¹ increased up to 90 days and stopped there after due to maturity. Foliar application of organic formulations at different levels exhibited a significant increase in number of leaves plant⁻¹.

Onion leaves possesses a uniseriate epidermis with thickened outer walls adcrusted with a cuticular layer. Peridinal divisions and enlargement of the central cells in the leaf axis in combination with adaxial meristematic activity contributes to the increase in thickness in the central portion of the leaf. These activities are rapidly performed in early growth stages of crop (up to 60-65 days) (Jones and Mann, 1963). These findings are in conformity with Sangeetha and Singaram (2007) and Kandil *et. al.* (2013).

4.1.1.4 Neck thickness (cm)

The data pertaining to the mean neck thickness of onion plants as significantly influenced by applications of different organic formulation are presented in Table 4.4 and graphically depicted in Fig. 4.3. Neck thickness was recorded at various growth stages *viz.*, 30, 60 and 90 days after transplanting and at harvest. A critical examination of the data revealed that neck thickness was comparatively lower at the initial stage (30 DAT) and found non-significant and their after increased up to (90 DAT) and decreases at harvest.

Table 4.4 Effect of foliar applications of organic formulations on neck thickness of onion.

Treatment	Neck thickness plant ⁻¹ (cm)			
	30 DAT	60 DAT	90 DAT	At Harvest
T1 : Control (No foliar spray)	0.36	1.61	1.56	0.99
T2 : Water spray at 30 and 60 DAT	0.37	1.42	1.66	0.97
T3 : Foliar application of cow urine @ 6% at 30 and 60 DAT	0.36	1.77	1.68	1.23
T4 : Foliar application of jeevamrut @ 5% at 30 and 60 DAT	0.38	1.87	1.93	1.39
T5 : Foliar application of EM-solution @ 1% at 30 and 60 DAT	0.37	1.82	1.92	1.31
T6 : Foliar application of humic acid @ 2% at 30 and 60 DAT	0.36	2.05	2.07	1.48
T7 : Foliar application of vermiwash @ 5% at 30 and 60 DAT	0.38	1.89	1.95	1.45
T8 : Foliar application of EM-solution @ 5% at 30 and 60 DAT	0.37	1.85	1.83	1.36
S. Em ±	0.01	0.05	0.09	0.07
C.D. at 5 %	NS	0.17	0.27	0.21
General mean	0.37	1.79	1.83	1.27

At 30 DAT, neck thickness of onion plants found non-significant between treatments and recorded lowest neck thickness (0.36) under treatment GRDF with T₁- Control (no foliar spray), GRDF with T₃ -Foliar application of cow urine @ 6% at 30 and 60 DAT and GRDF with T₆ -Foliar application of humic acid @ 2 % at 30 and 60 DAT whereas, highest neck thickness of onion plants (0.38 cm) was recorded under treatment GRDF with T₄ -Foliar application of jeevamrut @ 5 % at 30 and 60 DAT and treatment GRDF with T₇ -foliar application of vermiwash @ 5 % at 30 and 60 DAT.

At the stage of 60 DAT, treatment GRDF with T₆- Foliar application of humic acid @ 2% at 30 and 60 DAT gave significantly highest (2.05 cm) neck thickness of onion plants followed by treatment GRDF with T₇ -Foliar application of vermiwash @ 5% at 30 and 60 DAT (1.89 cm)

whereas, the treatment GRDF with T₂ -Water spray at 30 and 60 DAT recorded lowest neck thickness (1.42 cm) of onion plants.

At the stage of 90 DAT, the treatment GRDF with T₆ -Foliar application of humic acid @ 2 % at 30 and 60 DAT gave significantly highest (2.07 cm) neck thickness of onion plants, followed by treatment GRDF with T₇ -foliar application of vermiwash @ 5 % at 30 and 60 DAT (1.95 cm), treatment GRDF with T₄ -Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (1.93 cm), treatment GRDF with T₅ -Foliar application of EM-solution @ 1 % at 30 and 60 DAT (1.92 cm) and treatment GRDF with T₈- Foliar application of EM-solution @ 5 % at 30 and 60 DAT (1.83 cm) whereas, minimum neck thickness (1.56 cm) was observed in treatment GRDF with T₁ -Control (no foliar spray).

At harvest, treatment GRDF with T₆ -Foliar application of humic acid @ 2 % at 30 and 60 DAT gave significantly highest (1.48 cm) neck thickness of onion plants, followed by treatment GRDF with T₇ -Foliar application of vermiwash @ 5 % at 30 and 60 DAT (1.45 cm), GRDF with T₄ -Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (1.39 cm), GRDF with T₈- Foliar application of EM-solution @ 5 % at 30 and 60 DAT (1.36 cm) and GRDF with T₅ -Foliar application of EM-solution @ 1 % at 30 and 60 DAT (1.31 cm) whereas, lowest mean neck thickness of onion plants (0.97 cm) was recorded under treatment GRDF with T₂ -Water spray at 30 and 60 DAT.

Mean neck thickness of the plants increased slowly in first month, rapidly in 30-60 days period and slowly reduced between 60-90 days and rapidly reduced after 90 days upto maturity. These findings are in conformity with Sajid *et. al.* (2012).

4.1.1.5 Number of days to crop maturity.

The number of days required to crop maturity was not significantly influenced by foliar application of organic formulations are presented in Table 4.5 and graphically through Fig. 4.4.

The mean days required for maturity of onion was 137.21 days. Minimum number of days required for maturity (135 days) recorded in treatment GRDF with T₁ - Control (no foliar spray), However, it was maximum (138.67 days) in treatment GRDF with T₄ -Foliar application of jeevamrut @ 5 % at 30 and 60 DAT.

Table 4.5 Effect of foliar applications of organic formulations on number of days to crop maturity of onion.

Treatment	Days to crop maturity
T ₁ : Control (no foliar spray)	135.00
T ₂ : Water spray at 30 and 60 DAT	136.67
T ₃ : Foliar application of cow urine @ 6% at 30 and 60 DAT	138.00
T ₄ : Foliar application of jeevamrut @ 5% at 30 and 60 DAT	138.67
T ₅ : Foliar application of EM-solution @ 1% at 30 and 60 DAT	136.67
T ₆ : Foliar application of humic acid @ 2% at 30 and 60 DAT	138.33
T ₇ : Foliar application of vermiwash @ 5% at 30 and 60 DAT	137.33
T ₈ : Foliar application of EM-solution @ 5% at 30 and 60 DAT	137.00
S. Em ±	1.11
C. D at 5%	NS
General mean	137.21

4.1.2 Yield contributing characters

The data pertaining to yield contributing characters *viz.*, average bulb weight (g), dry matter of bulb⁻¹ (g), yield of leaves (green/dry) (t ha⁻¹), polar diameter (cm), equatorial diameter (cm), total bulb yield (t ha⁻¹), marketable bulb yield (t ha⁻¹), number of twin bulbs (%), number of bolters (%) and grading of bulb (on the basis of size of bulb) was recorded during the present investigation and results are summarized character wise as below.

4.1.2.1 Average bulb weight (g)

The data on average bulb weight of onion as influenced by different organic formulations are presented in Table 4.6 and shown graphically in Fig. 4.5. The average bulb weight of onion plays an important role in increasing onion yield. The average bulb weight of onion was varied in the range of 67.33 g to 99.00 g.

Table 4.6 Effect of foliar applications of organic formulations on weight of bulb.

Treatment	Average bulb weight (g)
T₁ : Control (no foliar spray)	67.33
T₂ : Water spray at 30 and 60 DAT	76.67
T₃ : Foliar application of cow urine @ 6% at 30 and 60 DAT	81.00
T₄ : Foliar application of jeevamrut @ 5% at 30 and 60 DAT	91.33
T₅ : Foliar application of EM-solution @ 1% at 30 and 60 DAT	85.33
T₆ : Foliar application of humic acid @ 2% at 30 and 60 DAT	99.00
T₇ : Foliar application of vermiwash @ 5% at 30 and 60 DAT	92.33
T₈ : Foliar application of EM-solution @ 5% at 30 and 60 DAT	83.67
S. Em ±	4.40
C. D at 5%	13.36
General mean	84.58

Among the different organic formulations, treatment GRDF with T₆- Foliar application of humic acid @ 2 % at 30 and 60 DAT recorded significantly highest average bulb weight (99.00 g) followed by treatment GRDF with T₇- Foliar application of vermiwash @ 5 % at 30 and 60 DAT (92.33 g) and GRDF with T₄-Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (91. 33 g), However, the minimum average bulb weight (67.33 g) was found under treatment GRDF with T₁ -Control (no foliar spray). These findings are in conformity with Al-Fraihat *et al.* (2018) and Hafez and Geris (2018).

4.1.2.2 Dry matter bulb⁻¹ (g)

The data on dry matter bulb⁻¹ (g) as affected by different organic formulations are presented in Table 4.7 and shown graphically in Fig. 4.6. The mean dry matter bulb⁻¹ (g) was varied in the range of 7.70 g to 10.67 g.

Table 4.7 Effect of foliar applications of organic formulations of dry matter bulb⁻¹.

Treatment	Dry matter bulb⁻¹ (g)
T₁ : Control (no foliar spray)	7.90
T₂ : Water spray at 30 and 60 DAT	7.70
T₃ : Foliar application of cow urine @ 6% at 30 and 60 DAT	8.87
T₄ : Foliar application of jeevamrut @ 5% at 30 and 60 DAT	9.47
T₅ : Foliar application of EM-solution @ 1% at 30 and 60 DAT	9.00
T₆ : Foliar application of humic acid @ 2% at 30 and 60 DAT	10.67
T₇ : Foliar application of vermiwash @ 5% at 30 and 60 DAT	10.23
T₈ : Foliar application of EM-solution @ 5% at 30 and 60 DAT	8.17
S. Em ±	0.45
C. D at 5%	1.38
General mean	9.00

Among the different organic formulations, treatment GRDF with T₆- Foliar application of humic acid @ 2 % at at 30 and 60 DAT recorded significantly highest dry matter bulb⁻¹ (10.67 g) and followed by treatment GRDF with T₇-Foliar application of vermiwash @ 5 % at 30 and 60 DAT (10.23 g) and GRDF with T₄- Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (9.47 g) However, the lowest dry matter bulb⁻¹ (7.70 g) was recorded under treatment GRDF with T₂ - Water spray at 30 and 60 DAT.

4.1.2.3 Polar diameter of bulb (cm)

The data in regard to mean polar diameter of bulb as influenced by different organic formulations are presented in Table 4.8 and graphically depicted in Fig. 4.7.

Among the different organic formulations, treatment GRDF with T₆ -Foliar application of humic acid @ 2 % at 30 and 60 DAT recorded significantly highest polar diameter (5.74 cm) and followed by treatment GRDF with T₇ –foliar application of vermiwash @ 5 % at 30 and 60 DAT (5.56 cm) and GRDF with T₄- Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (5.34 cm).

The lowest polar diameter (4.85 cm) was recorded under treatment GRDF with T₁ - Control (no foliar spray).

4.1.2.4 Equatorial diameter of bulb (cm)

The data pertaining to mean equatorial diameter of bulb are presented in Table 4.8 and graphically depicted in Fig. 4.7.

Among the different organic formulations, treatment GRDF with T₆ -Foliar application of humic acid @ 2% at 30 and 60 DAT recorded significantly highest equatorial diameter (6.64 cm) and followed by treatment GRDF with T₇ –Foliar application of vermiwash @ 5 % at 30 and 60 DAT (6.32 cm), GRDF with T₄– Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (6.28 cm) and GRDF with T₃– Foliar application of cow urine @ 6 % at 30 and 60 DAT (6.27 cm). The minimum equatorial diameter (5.74 cm) was recorded under treatment GRDF with T₁ - Control (no foliar spray). These findings are in conformity with Al-Fraihat *et. al.* (2018) and Hafez and Geris (2018).

Table 4.8 Effect of foliar applications of organic formulations on diameter of bulb.

Treatment	Diameter of bulb (cm)	
	Polar	Equatorial
T ₁ : Control (no foliar spray)	4.85	5.74
T ₂ : Water spray at 30 and 60 DAT	4.90	6.03
T ₃ : Foliar application of cow urine @ 6% at 30 and 60 DAT	5.15	6.27
T ₄ : Foliar application of jeevamrut @ 5% at 30 and 60 DAT	5.34	6.28
T ₅ : Foliar application of EM-solution @ 1% at 30 and 60 DAT	5.31	6.08
T ₆ : Foliar application of humic acid @ 2% at 30 and 60 DAT	5.74	6.64
T ₇ : Foliar application of vermiwash @ 5% at 30 and 60 DAT	5.56	6.32
T ₈ : Foliar application of EM-solution @ 5% at 30 and 60 DAT	4.82	6.08
S. Em ±	0.14	0.12
C.D at 5%	0.42	0.37
General mean	5.21	6.18

4.1.2.5 Total bulb yield (t ha⁻¹)

The data regarding to total bulb yield (t ha⁻¹) as influenced by different organic formulations presented in Table 4.9 and graphically depicted in Fig. 4.8. The mean total bulb yield of onion was (33.10 t ha⁻¹)

Among the different organic formulations, treatment GRDF with T₆-Foliar application of humic acid @ 2 % at 30 and 60 DAT recorded significantly highest total bulb yield (35.13 t ha⁻¹) and followed by treatment GRDF with T₈- Foliar application of EM-solution @ 5 % at 30 and 60 DAT (34.66 t ha⁻¹) and GRDF with T₄- Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (34.43 t ha⁻¹). The lowest total bulb yield (29.30 t ha⁻¹) was observed under the treatment GRDF with T₁- Control (no foliar spray). These findings are in conformity with Sajid *et al.* (2012), Singh *et al.* (2017) and Al-Fraihat *et al.* (2018).

Table 4.9 Effect of foliar applications of organic formulations on yield of onion.

Treatment	Bulb yield (t ha ⁻¹)	
	Total	Marketable
T ₁ : Control (no foliar spray)	29.30	27.78
T ₂ : Water spray at 30 and 60 DAT	30.35	28.83
T ₃ : Foliar application of cow urine @ 6% at 30 and 60 DAT	33.03	31.80
T ₄ : Foliar application of jeevamrut @ 5% at 30 and 60 DAT	34.43	32.91
T ₅ : Foliar application of EM-solution @ 1% at 30 and 60 DAT	33.61	31.98
T ₆ : Foliar application of humic acid @ 2% at 30 and 60 DAT	35.13	33.91
T ₇ : Foliar application of vermiwash @ 5% at 30 and 60 DAT	34.31	32.80
T ₈ : Foliar application of EM-solution @ 5% at 30 and 60 DAT	34.66	33.61
S. Em ±	0.25	0.37
C.D at 5%	0.77	1.11
General mean	33.10	31.70

4.1.2.6 Marketable bulb yield (t ha^{-1})

The data regarding to marketable bulb yield of onion (t ha^{-1}) as influenced by different organic formulations presented in Table 4.9 and graphically depicted in Fig. 4.8. The mean marketable bulb yield of onion was (31.70 t ha^{-1}).

Among the different organic formulations, treatment GRDF with T₆ -Foliar application of humic acid @ 2 % at 30 and 60 DAT recorded significantly highest marketable bulb yield (33.91 t ha^{-1}) and followed by treatment GRDF with T₈ -Foliar application of EM-solution @ 5 % at 30 and 60 DAT (33.61 t ha^{-1}), GRDF with T₄-Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (32.91 t ha^{-1}) and GRDF with T₇ -Foliar application of vermiwash @ 5 % at 30 and 60 DAT (32.80 t ha^{-1}). The lowest marketable bulb yield (27.78 t ha^{-1}) was observed in the treatment GRDF with T₁ - Control (no foliar spray). These findings are in conformity with Hafez and Geries (2018).

4.1.2.7 Yield of leaves (green/dry) (t ha^{-1})

The data regarding yield of onion leaves (green/dry) (t ha^{-1}) presented in Table 4.10 and data regarding yield of green leaves and dry leaves graphically depicted in Fig 4.9 and 4.10, respectively.

Among the different organic formulations, treatment GRDF with T₆ -Foliar application of humic acid @ 2 % at 30 and 60 DAT recorded significantly highest yield of green leaves (12.11 t ha^{-1}) and followed by treatment GRDF with T₄ -Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (12.08 t ha^{-1}), GRDF with T₇ -Foliar application of vermiwash @ 5 % at 30 and 60 DAT (11.56 t ha^{-1}) and GRDF with T₃- Foliar application of cow urine @ 6 % at 30 and 60 DAT (11.50 t ha^{-1}). The lowest yield of green leaves (10.81 t ha^{-1}) was observed in the treatment GRDF with T₁ - Control (no foliar spray).

Among the different organic formulations, treatment GRDF with T₆ -Foliar application of humic acid @ 2 % at 30 and 60 DAT recorded significantly highest yield of dry leaves (1.52 t ha^{-1}) and followed by treatment GRDF with T₇ -Foliar application of vermiwash @ 5 % at 30 and 60 DAT (1.48 t ha^{-1}), GRDF with T₄- Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (1.46 t ha^{-1}), GRDF with T₅ -Foliar application of EM-solution @ 1 % at 30 and 60 DAT (1.41 t ha^{-1}) and GRDF with T₃- Foliar application of cow urine @ 6 % at 30 and 60 DAT (1.41 t ha^{-1}). The lowest yield of dry leaves yield (1.27 t ha^{-1}) was observed in the treatment GRDF with T₁ -Control (no foliar spray).

Table 4.10 Effect of foliar applications of organic formulations on yield of leaves of onion.

Treatment	Total green leaves yield (t ha⁻¹)	Total dry leaves yield (t ha⁻¹)
T₁ : Control (no foliar spray)	10.81	1.27
T₂ : Water spray at 30 and 60 DAT	11.14	1.30
T₃ : Foliar application of cow urine @ 6% at 30 and 60 DAT	11.50	1.41
T₄ : Foliar application of jeevamrut @ 5% at 30 and 60 DAT	12.08	1.46
T₅ : Foliar application of EM-solution @ 1% at 30 and 60 DAT	11.37	1.41
T₆ : Foliar application of humic acid @ 2% at 30 and 60 DAT	12.11	1.52
T₇ : Foliar application of vermiwash @ 5% at 30 and 60 DAT	11.56	1.48
T₈ : Foliar application of EM-solution @ 5% at 30 and 60 DAT	11.23	1.31
S. Em ±	0.22	0.04
C.D at 5%	0.68	0.12
General mean	11.47	1.40

4.1.2.8 Number of bolters (%)

The data in regard to number of bolters (%) as influenced by different organic formulations are presented in Table 4.11 and graphically depicted in Fig. 4.11. The mean number of bolters (%) was 1.80 %.

The lowest percentage of number of bolters (1.23 %) was recorded in treatment GRDF with T₃ - Foliar application of cow urine @ 6 % at 30 and 60 DAT. The treatment GRDF with T₅ -Foliar application of EM-solution @ 1 % at 30 and 60 DAT recorded highest percentage number of bolters (2.51 %).

The temperature and photoperiod both are important environmental factors affecting onion bolting. The increased percentage of number of bolters was might be due to fluctuation of average temperature (Brewster, 1997). Other factor affecting bolting includes nitrogen and phosphorus fertilization (Brewster, 1983 and Paterson *et al.* 1960)

4.1.2.9 Number of twin bulbs (%)

The data in regard to number of twin bulbs (%) as influenced by different organic formulations are presented in Table 4.11 and graphically depicted in Fig. 4.11.

The lowest percentage of twin bulbs (2.02 %) recorded in treatment GRDF with T₆ -Foliar application of humic acid @ 2 % at 30 and 60 DAT. The treatment GRDF with T₂ -Water spray at 30 and 60 DAT recorded highest twin bulb percentage (4.31 %). The solar heating significantly increased proportion of twin bulbs (Rabinowitch *et al.* 1981).

Table 4.11 Effect of foliar applications of organic formulations on number of bolters and twin bulbs in onion.

Treatment	Number of bolters (%)	Number of twin bulbs (%)
T ₁ : Control (no foliar spray)	2.06	3.00
T ₂ : Water spray at 30 and 60 DAT	2.21	4.31
T ₃ : Foliar application of cow urine @ 6% at 30 and 60 DAT	1.23	2.53
T ₄ : Foliar application of jeevamrut @ 5% at 30 and 60 DAT	1.92	2.82
T ₅ : Foliar application of EM-solution @ 1% at 30 and 60 DAT	2.51	3.98
T ₆ : Foliar application of humic acid @ 2% at 30 and 60 DAT	1.27	2.02
T ₇ : Foliar application of vermiwash @ 5% at 30 and 60 DAT	1.68	2.69
T ₈ : Foliar application of EM-solution @ 5% at 30 and 60 DAT	1.55	2.25
S. Em ±	0.33	0.49
C.D. at 5 %	NS	NS
General mean	1.80	2.95

4.1.2.10 Grading of bulbs (on the basis of size of onion)

The data pertaining to mean percentage of A grade bulb, B grade bulbs and C grade bulb are presented in Table 4.12. The mean of A grade bulb %, B grade bulbs % and C grade bulbs % was 6.88 %, 88.37 % and 4.75 %, respectively.

Table 4.12 Effect of foliar applications of organic formulations on A, B and C grade bulbs of onion.

Treatment	Grade wise bulb yield (%)		
	A (> 65 mm)	B (45-65 mm)	C (<45 mm)
T ₁ : Control (no foliar spray)	7.45	87.10	5.45
T ₂ : Water spray at 30 and 60 DAT	4.43	90.76	4.81
T ₃ : Foliar application of cow urine @ 6% at 30 and 60 DAT	5.14	89.62	5.24
T ₄ : Foliar application of jeevamrut @ 5% at 30 and 60 DAT	6.14	88.57	5.28
T ₅ : Foliar application of EM-solution @ 1% at 30 and 60 DAT	11.57	84.15	4.28
T ₆ : Foliar application of humic acid @ 2% at 30 and 60 DAT	8.11	89.05	2.84
T ₇ : Foliar application of vermiwash @ 5% at 30 and 60 DAT	8.76	86.91	4.33
T ₈ : Foliar application of EM-solution @ 5% at 30 and 60 DAT	3.40	90.80	5.80
S. Em ±	1.18	1.43	0.99
C.D. at 5 %	3.57	NS	NS
General mean	6.88	88.37	4.75

Among the different organic formulations, treatment GRDF with T₅- Foliar application of EM-Solution @ 1 % at 30 and 60 DAT recorded significantly highest percentage of A grade bulbs (11.57 %) and followed by treatments GRDF with T₇- Foliar application of vermiwash @ 5 % at 30 and 60 DAT (8.76 %) and GRDF with T₆- Foliar application of humic acid @ 2 % at 30 and 60 DAT (8.11%). The lowest percentage of A grade bulbs (3.40 %) was observed in treatment GRDF with T₈- Foliar application of EM-Solution @ 5 % at 30 and 60 DAT.

The highest percentage of B grade bulbs (90.80 %) were recorded in the treatment GRDF with T₈- Foliar application of EM-solution @ 5 % at 30 and 60 DAT. However, the lowest percentage of B grade bulbs (84.15 %) were recorded in treatment GRDF with T₅- Foliar application of EM-solution @ 1 % at 30 and 60 DAT.

The highest percentage of C grade bulb (5.80 %) was observed in the treatment GRDF with T₈- Foliar application of EM-solution @ 5 % at 30 and 60 DAT. However, the lowest percentage of C grade bulbs (2.84 %) were recorded in treatment GRDF with T₆- Foliar application of humic acid @ 2 % at 30 and 60 DAT.

4.1.3 Microbial Studies

The data regarding the microbial population in soil observed at before spraying and after spraying i.e. after 60 DAT of *rabi* onion in various treatments are presented in Table 4.13 and graphically depicted in Fig. 4.12. The mean bacterial count (CFU x 10⁻⁶ g⁻¹soil), fungal count (CFU x 10⁻⁵ g⁻¹ soil) and actinomycetes count (CFU x 10⁻³ g⁻¹soil) also calculated.

4.1.3.1 Rhizosphere microbial population of bacteria (CFU x 10⁻⁶ g⁻¹soil)

The data pertaining to microbial population of bacteria are presented in Table 4.13. The mean microbial population of bacteria was 28.21 (CFU x 10⁻⁶ g⁻¹soil).

The bacterium forms characteristic colonies on nutrient agar when incubated for six days. Plates were observed for typical small milky white dense colonies with undulated margins.

Among the different organic formulations, treatment GRDF with T₈- Foliar application of EM-solution @ 5 % at 30 and 60 DAT recorded significantly highest microbial population of bacteria 40 (CFU x 10⁻⁶ g⁻¹soil). The lowest microbial population of bacteria (21.33 CFU x 10⁻⁶ g⁻¹ soil) was recorded in treatment GRDF with T₁- Control (no foliar spray). These results are close conformity with the findings of Sreenivasa *et al.* (2010), and Balpande *et al.* (2013).

4.1.3.2 Rhizosphere microbial population of fungi (CFU x 10⁻⁵ g⁻¹ soil)

The data on microbial fungal population are presented in Table 4.13. The mean microbial population of fungi was 21.79 (CFU x 10⁻⁵ g⁻¹ soil).

The fungal population forms the characteristic colonies on Rose Bengal Agar when incubated for six days. Plates were observed for typical velvety, green to dark colonies and the

green colonies becoming almost black and spreading in due course of time and finally become colourless.

Among the different organic formulations, treatment GRDF with T₈- Foliar application of EM-solution @ 5 % at 30 and 60 DAT recorded significantly highest microbial population of fungi 27.67 (CFU x 10⁻⁵ g⁻¹ soil). However, the lowest microbial population of fungi (17.67 CFU x 10⁻⁵ g⁻¹ soil) was recorded in treatment GRDF with T₁- Control (no foliar spray). These results are close conformity with the findings of Jenkinson and Ludd (1981), Sreenivasa *et al.* (2010) and Siddappa (2015).

Table 4.13 Microbial population at 60 DAT as influenced by foliar applications of different organic formulations.

Treatment details	Microbial population at 60 DAT		
	Bacteria (CFUx10 ⁻⁶ g ⁻¹ soil)	Fungi (CFU x 10 ⁻⁵ g ⁻¹ soil)	Actinomycetes (CFU x 10 ⁻³ g ⁻¹ soil)
T ₁ : Control (no foliar spray)	21.33	17.67	21.00
T ₂ : Water spray at 30 and 60 DAT	21.67	18.00	22.67
T ₃ : Foliar application of cow urine @ 6% at 30 and 60 DAT	26.67	20.00	27.00
T ₄ : Foliar application of jeevamrut @ 5% at 30 and 60 DAT	32.67	21.00	37.67
T ₅ : Foliar application of EM-solution @ 1% at 30 and 60 DAT	25.00	23.00	31.00
T ₆ : Foliar application of humic acid @ 2% at 30 and 60 DAT	27.67	23.33	24.67
T ₇ : Foliar application of vermiwash @ 5% at 30 and 60 DAT	30.67	23.67	31.67
T ₈ : Foliar application of EM-solution @ 5% at 30 and 60 DAT	40.00	27.67	43.33
S. Em ±	1.50	1.00	1.41
C. D at 5%	4.55	3.05	4.28
General mean	28.21	21.79	29.88
Initial status	23.66	18.33	19.66

4.1.3.3 Rhizosphere microbial population of actinomycetes (CFU x 10⁻³ g⁻¹soil)

The data on microbial population of actinomycetes are presented in Table 4.13. The mean microbial population of actinomycetes was 29.88 (CFU x 10⁻³ g⁻¹ soil).

The actinomycetes population forms the characteristic colonies on Krustose agar when incubated for six days. Plates were observed with dry, flat, brittle pigmented round colonies.

Among the different organic formulations, treatment GRDF with T₈- foliar application of EM-solution @ 5 % at 30 and 60 DAT recorded significantly highest microbial population of actinomycetes 43.33 (CFU x 10⁻³g⁻¹ soil). However, the lowest microbial population of actinomycetes (21 CFU x 10⁻³g⁻¹ soil) was recorded in treatment GRDF with T₁- Control (no foliar spray). These results are close conformity with the findings of Jenkinson and Ludd (1981), Sreenivasa *et al.* (2010) and Siddappa (2015).

4.1.4 Plant analysis

4.1.4.1 Total uptake of N, P, K

The data in respect of total uptake of nutrients (kg ha⁻¹) by *rabi* onion are presented in Table 4.14 and graphically depicted in Fig. 4.13. The mean total uptake of N, P and K by onion plants at harvest was 30.68 kg ha⁻¹, 9.44 kg ha⁻¹ and 21.05 kg ha⁻¹, respectively.

Among the different organic formulations, treatment GRDF with T₆- Foliar application of humic acid @ 2 % at 30 and 60 DAT recorded significantly highest uptake of nitrogen (35.50 kg ha⁻¹) at after harvest and followed by treatment GRDF with T₄-Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (34.23 kg ha⁻¹) and GRDF with T₃- Foliar application of cow urine @ 6 % at 30 and 60 DAT (33.76 kg ha⁻¹). The lowest uptake of nitrogen (24.15 kg ha⁻¹) was recorded in treatment GRDF with T₁- Control (no foliar spray).

The significantly highest phosphorus uptake was noted under treatment GRDF with T₆- Foliar application of humic acid @ 2 % at 30 and 60 DAT (10.81 kg ha⁻¹) followed by treatment GRDF with T₄ - Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (10.67 kg ha⁻¹), GRDF with T₈- Foliar application of EM-solution @ 5 % at 30 and 60 DAT (10.38 kg ha⁻¹) and GRDF with T₇- Foliar application of vermiwash @ 5 % at 30 and 60 DAT (10.34 kg ha⁻¹). The lowest uptake of phosphorus (6.84 kg ha⁻¹) was recorded in treatment GRDF with T₁- Control (no foliar spray).

Among the different organic formulations, treatment GRDF with T₆- Foliar application of humic acid @ 2 % at 30 and 60 DAT recorded significantly highest uptake of potassium (24.81 kg ha⁻¹) at after harvest and followed by treatment GRDF with T₄- Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (23.56 kg ha⁻¹). The lowest uptake of potassium (15.84 kg ha⁻¹) was recorded in treatment GRDF with T₁- Control (no foliar spray).

Table 4.14 Effect of foliar applications of organic formulations on nutrient uptake of onion.

Treatment	Nutrient uptake (kg ha ⁻¹)		
	Nitrogen	Phosphorus	Potassium
T ₁ : Control (no foliar spray)	24.15	6.84	15.84
T ₂ : Water spray at 30 and 60 DAT	25.98	8.36	18.21
T ₃ : Foliar application of cow urine @ 6% at 30 and 60 DAT	33.76	8.94	20.72
T ₄ : Foliar application of jeevamrut @ 5% at 30 and 60 DAT	34.23	10.67	23.56
T ₅ : Foliar application of EM-solution @ 1% at 30 and 60 DAT	28.77	9.19	20.45
T ₆ : Foliar application of humic acid @ 2% at 30 and 60 DAT	35.50	10.81	24.81
T ₇ : Foliar application of vermiwash @ 5% at 30 and 60 DAT	31.17	10.34	22.33
T ₈ : Foliar application of EM-solution @ 5% at 30 and 60 DAT	31.86	10.38	22.49
S. Em ±	1.02	0.35	0.71
C.D. at 5 %	3.07	1.05	2.17
General mean	30.68	9.44	21.05

4.1.5 Chemical Studies

4.1.5.1 Soil pH, EC and organic carbon content

The data pertaining to soil pH, EC, organic carbon % as influenced by different organic formulations at harvest of onion are presented in Table 4.15. The initial values of soil pH, EC and organic carbon % before transplanting are also depicted in Table 4.15.

The lowest soil pH (8.00) was recorded in treatment GRDF with T₆-Foliar application of humic acid @ 2 % at 30 and 60 DAT and the significantly highest soil pH (8.47) was recorded in

the treatment GRDF with T₁- Control (no foliar spray) followed by treatment GRDF with T₈ - Foliar application of EM-Solution @ 5 % at 30 and 60 DAT (8.37).

The EC of soil was recorded highest (0.39 dSm⁻¹) in treatment GRDF with T₂- Water spray at 30 and 60 DAT and GRDF with T₇- Foliar applications of vermiwash @ 5 % at 30 and 60 DAT and the lowest EC of the soil (0.24 dSm⁻¹) recorded in treatment GRDF with T₅- Foliar application of EM-Solution @ 1 % at 30 and 60 DAT.

Among the different organic formulations, treatment GRDF with T₄- Foliar application of jeevamrut @ 5% at 30 and 60 DAT recorded significantly highest organic carbon % (1.20 %) and followed by treatment GRDF with T₈-Foliar application of EM-Solution @ 5 % at 30 and 60 DAT (1.13%), GRDF with T₇ - Foliar application of vermiwash @ 5 % at 30 and 60 DAT (1.11%), GRDF with T₅- Foliar application of EM-Solution @ 1 % at 30 and 60 DAT (1.09%), GRDF with T₃- Foliar application of cow urine @ 6 % at 30 and 60 DAT (1.06 %) and GRDF with T₆- Foliar application of humic acid @ 2 % at 30 and 60 DAT (1.00 %). The lowest organic carbon % (0.85%) was recorded in treatment GRDF with T₁- Control (no foliar spray).

4.1.5.2 Soil Available nutrients (kg ha⁻¹)

The data regarding the soil available nutrients *viz.*, nitrogen, phosphorous and potassium (kg ha⁻¹) in soil after harvest of onion in various treatments are presented in Table 4.15 and graphically depicted in Fig. 4.14.

The mean available nitrogen, phosphorous and potassium in soil after harvest of crop were 173.54 kg ha⁻¹, 16.52 kg ha⁻¹ and 357.00 kg ha⁻¹ respectively.

4.1.5.2.1 Soil available nitrogen (kg ha⁻¹)

Among the different organic formulations, treatment GRDF with T₇ - Foliar application of vermiwash @ 5 % at 30 and 60 DAT recorded significantly highest available nitrogen (188.55 kg ha⁻¹) at after harvest, and followed by treatment GRDF with T₅- Foliar application of EM-solution @ 1 % at 30 and 60 DAT (184.33 kg ha⁻¹), GRDF with T₃-Foliar application of cow urine @ 6 % at 30 and 60 DAT (183.28 kg ha⁻¹), GRDF with T₆-Foliar application of humic acid @ 2 % at 30 and 60 DAT (174.85 kg ha⁻¹) and GRDF with T₈- Foliar application of EM-Solution @ 5 % at 30 and 60 DAT (174.85 kg ha⁻¹). The lowest available nitrogen (153.79 kg ha⁻¹) was recorded in treatment GRDF with T₁ – Control (no foliar spray).

4.1.5.2.2 Soil available phosphorus (kg ha⁻¹)

Among the different organic formulations, treatment GRDF with T₄ - Foliar application of jeevamrut @ 5 % at 30 and 60 DAT and GRDF with T₈- Foliar application of EM-solution @ 5 % at 30 and 60 DAT recorded significantly highest available phosphorus (19.19 kg ha⁻¹) at after harvest. However, the lowest available phosphorus (12.61 kg ha⁻¹) was recorded in treatment GRDF with T₁ – Control (no foliar spray).

Table 4.15 Soil chemical properties and available nutrients affected by foliar applications of different organic formulations at harvest.

Treatment	Soil chemical properties			Available nutrients (kg ha ⁻¹)		
	pH	EC (dSm ⁻¹)	OC (%)	N (kg ha ⁻¹)	P (kg ha ⁻¹)	K (kg ha ⁻¹)
T ₁ : Control (no foliar spray)	8.47	0.36	0.85	153.79	12.61	321.07
T ₂ : Water spray at 30 and 60 DAT	8.13	0.39	0.92	161.16	12.80	347.20
T ₃ : Foliar application of cow urine @ 6% at 30 and 60 DAT	8.20	0.29	1.06	183.28	16.10	369.60
T ₄ : Foliar application of jeevamrut @ 5% at 30 and 60 DAT	8.07	0.31	1.20	167.48	19.19	362.13
T ₅ : Foliar application of EM-solution @ 1% at 30 and 60 DAT	8.13	0.24	1.09	184.33	16.44	358.40
T ₆ : Foliar application of humic acid @ 2% at 30 and 60 DAT	8.00	0.29	1.00	174.85	18.29	350.93
T ₇ : Foliar application of vermiwash @ 5% at 30 and 60 DAT	8.03	0.39	1.11	188.55	17.55	380.80
T ₈ : Foliar application of EM-solution @ 5% at 30 and 60 DAT	8.37	0.37	1.13	174.85	19.19	365.87
S. Em ±	0.08	0.05	0.07	5.67	0.21	9.09
C.D. at 5 %	0.25	NS	0.20	17.20	0.63	27.57
General mean	8.18	0.33	1.04	173.54	16.52	357.00
Initial status	8.40	0.35	0.79	224.35	22.96	392

4.1.5.2.3 Soil available potassium (kg ha⁻¹)

Among the different organic formulations, treatment GRDF with T₇ - Foliar application of vermiwash @ 5 % at 30 and 60 DAT recorded significantly highest available potassium (380.80 kg ha⁻¹) at after harvest and followed by treatment GRDF with T₃- Foliar application of cow urine @ 6 % at 30 and 60 DAT (369.60 kg ha⁻¹), GRDF with T₈- Foliar application of EM-Solution @ 5 % at 30 and 60 DAT (365.87 kg ha⁻¹), GRDF with T₄ - Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (362.13 kg ha⁻¹) and GRDF with T₅- Foliar application of EM-Solution @ 1 % at 30 and 60 DAT (358.40 kg ha⁻¹). The lowest available potassium (321.07 kg ha⁻¹) was recorded in treatment GRDF with T₁ – Control (no foliar spray).

Foliar application is credited with the advantage of quick and efficient utilization of nutrients, elimination of losses through leaching and fixation and regulating the uptake of nutrient by plants. Similar results were also observed by Zambare *et al.* (2008), Sathish and Paramaguru (2010) and Khan *et al.* (2014).

4.1.6 Economics of onion.

The data regarding the economic studies *viz.*, gross monetary returns, total cost of cultivation, net monetary returns and B:C ratio of onion as influenced by different organic formulations, are presented in Table 4.16.

4.1.6.1 Gross monetary returns (₹ ha⁻¹)

The data with respect to gross monetary returns (₹ ha⁻¹) of onion crop are presented in Table 4.16 and graphically depicted in Fig. 4.15.

Among the different organic formulations, treatment GRDF with T₆- Foliar application of humic acid @ 2 % at 30 and 60 DAT recorded significantly highest gross monetary returns (₹ 339052 ha⁻¹) at after harvest and followed by treatment GRDF with T₈- foliar application of EM-solution @ 5 % at 30 and 60 DAT (₹ 336134 ha⁻¹) and GRDF with T₄- foliar application of jeevamrut @ 5 % at 30 and 60 DAT (₹ 329131 ha⁻¹). The lowest gross monetary returns (₹ 277777 ha⁻¹) was recorded by treatment GRDF with T₁- Control (no foliar spray).

4.1.6.2 Cost of cultivation (₹ ha⁻¹)

The data with respect to cost of cultivation (₹ ha⁻¹) of onion crop are presented in Table 4.16.

Among the different organic formulations, treatment GRDF with T₈- Foliar application of EM-solution @ 5 % at 30 and 60 DAT at after harvest recorded highest cost of cultivation (₹ 106309 ha⁻¹) and followed by treatment GRDF with T₄ - Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (₹ 105900 ha⁻¹) and GRDF with T₇- Foliar application of vermiwash @ 5 % at 30 and 60 DAT (₹ 105867 ha⁻¹). The lowest cost of cultivation (₹ 102354 ha⁻¹) was recorded by treatment GRDF with T₁- Control (no foliar spray).

Table 4.16 Economics of onion as influenced by foliar applications of different organic formulations.

Treatment details	Gross monetary returns (₹ ha⁻¹)	Cost of cultivation (₹ ha⁻¹)	Net monetary returns (₹ ha⁻¹)	B:C Ratio
T₁ : Control (no foliar spray)	277777	102354	175423	2.71
T₂ : Water spray at 30 and 60 DAT	288281	103753	184528	2.77
T₃ : Foliar application of cow urine @ 6% at 30 and 60 DAT	318043	104653	213390	3.03
T₄ : Foliar application of jeevamrut @ 5% at 30 and 60 DAT	329131	105900	223231	3.10
T₅ : Foliar application of EM-solution @ 1% at 30 and 60 DAT	319794	105107	214687	3.04
T₆ : Foliar application of humic acid @ 2% at 30 and 60 DAT	339052	105783	233269	3.20
T₇ : Foliar application of vermiwash @ 5% at 30 and 60 DAT	327964	105867	222097	3.09
T₈ : Foliar application of EM-solution @ 5% at 30 and 60 DAT	336134	106309	229825	3.16

4.1.6.3 Net monetary returns (₹ ha⁻¹)

The data with respect to net monetary returns (₹ ha⁻¹) of onion crop are presented in Table 4.16 and graphically depicted in Fig. 4.15.

Among the different organic formulations, treatment GRDF with T₆- Foliar application of humic acid @ 2 % at 30 and 60 DAT at after harvest recorded highest net monetary returns (₹ 233269 ha⁻¹) and followed by treatment GRDF with T₈- Foliar application of EM-solution @ 5 % at 30 and 60 DAT (₹ 229825 ha⁻¹) and treatment GRDF with T₄- Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (₹ 223231 ha⁻¹). The lowest net monetary returns (₹ 175423 ha⁻¹) was recorded by treatment GRDF with T₁- Control (no foliar spray).

4.1.6.4 Benefit cost ratio

The data with respect to B:C ratio of onion crop are presented in Table 4.16.

Among the different organic formulations, treatment GRDF with T₆- Foliar application of humic acid @ 2 % at 30 and 60 DAT recorded highest B:C ratio (3.20) at after harvest, and followed by treatment GRDF with T₈- Foliar application of EM-solution @ 5 % at 30 and 60 DAT (3.16) and GRDF with T₄- Foliar application of jeevamrut @ 5 % at 30 and 60 DAT (3.10). The lowest B:C ratio (2.71) was recorded by treatment GRDF with T₁- Control (no foliar spray).

5. SUMMARY AND CONCLUSIONS

5.1 Summary

An experiment on “Effect of foliar applications of organic formulations on growth and yield of onion” was carried out during *rabi* season, 2018-19 at All India Co-ordinated Research Project on Integrated Farming Systems, Mahatma Phule Krishi Vidyapeeth, Rahuri. The experiment was laid out in randomized block design with three replications and eight treatment. The treatment consisted of different organic formulation applications to onion, *viz.*, T₁- Control (no foliar spray), T₂- Water spray at 30 and 60 DAT, T₃- Foliar application of cow urine @ 6 % at 30 and 60 DAT, T₄- Foliar application of jeevamrut @ 5 % at 30 and 60 DAT, T₅- Foliar application of EM-solution @ 1 % at 30 and 60 DAT, T₆- Foliar application of humic acid @ 2 % at 30 and 60 DAT, T₇- Foliar application of vermiwash @ 5 % at 30 and 60 DAT and T₈- Foliar application of EM-solution @ 5 % at 30 and 60 DAT, The General Recommended Dose of Fertilizer i.e. 15 t ha⁻¹ FYM + 100:50:50 N:P₂O₅:K₂O kg ha⁻¹ has applied.

The soil of the experimental field was black clay in texture with low in available nitrogen (187.32 kg ha⁻¹) and medium in available phosphorus (14.12 kg ha⁻¹), high in available potassium (395.10 kg ha⁻¹) with slightly alkaline in reaction (pH 8.25). The electrical conductivity of soil was 0.26 dSm⁻¹ and organic carbon content was 0.79 %.

The crop was sown in nursery on 12th October, 2018 and transplanted on 06th December, 2018. The irrigation was given as per requirement by surface method. The cultural operations and were carried out timely.

The important findings emerged out are summarized below.

5.1.1 Effect of Organic Formulations

The initial and final plant population of onion were significantly influenced by different organic formulations during the experimentation.

The applications of GRDF with foliar application of humic acid @ 2 % at 30 and 60 DAT (T₆) resulted significantly increased growth attributes *viz.*, plant height (55.79 cm), number of leaves plant⁻¹ (12.13) and neck thickness (1.48 cm).

In case of some important yield contributing characters, applications of GRDF with foliar application of humic acid @ 2 % at 30 and 60 DAT (T₆) showed maximum values in average bulb weight (99.00 g), dry matter bulb⁻¹ (10.67 g), total bulb yield (35.13 t ha⁻¹), marketable bulb yield (33.91 t ha⁻¹), yield of green leaves (12.11 t ha⁻¹), yield of dry leaves (1.52 t ha⁻¹), polar diameter (5.74 cm) and equatorial diameter (6.64 cm).

Onion under GRDF with foliar application of humic acid @ 2 % at 30 and 60 DAT (T₆) obtained higher gross monetary return (₹ 339052 ha⁻¹), net monetary return (₹ 233269 ha⁻¹) and high B:C ratio (3.20).

Applications of GRDF with foliar application of humic acid @ 2 % at 30 and 60 DAT (T₆) resulted in significantly higher total uptake of N (35.50 kg ha⁻¹), P (10.81 kg ha⁻¹) and K (24.81 kg ha⁻¹).

The applications of GRDF with foliar application of vermiwash @ 5 % at 30 and 60 DAT (T₇) resulted in significantly highest available nitrogen (188.55 kg ha⁻¹) and highest available potassium (380.80 kg ha⁻¹) at after harvest. While, applications of GRDF with foliar application of jeevamrut @ 5 % at 30 and 60 DAT (T₄) and GRDF with foliar application of EM-solution @ 5 % at 30 and 60 DAT (T₈) resulted in significantly highest available phosphorus (19.19 kg ha⁻¹).

While applications of GRDF with foliar application of EM-solution @ 5 % at 30 and 60 DAT (T₈) resulted in highest microbial population of bacteria 40 (CFU x 10⁻⁶ g⁻¹ soil), fungi 27.67 (CFU x 10⁻⁵ g⁻¹ soil) and actinomycetes 43.33 (CFU x 10⁻³ g⁻¹ soil).

5.2 Conclusions

1. Applications of GRDF with foliar application of humic acid @ 2 % at 30 and 60 DAT (T₆) to onion recorded significantly higher growth attributes *viz.*, plant height, number of leaves plant⁻¹ and neck thickness.
2. Applications of GRDF with foliar application of humic acid @ 2 % at 30 and 60 DAT (T₆) to onion recorded significantly highest values of yield contributing characters *viz.* average bulb weight, dry matter bulb⁻¹, polar diameter, equatorial diameter, total bulb yield, marketable bulb yield and yield of green and dry leaves.
3. The maximum gross monetary returns, net monetary returns and B:C ratio was obtained with applications of GRDF with foliar application of humic acid @ 2 % at 30 and 60 DAT (T₆).
4. Applications of GRDF with foliar application of humic acid @ 2 % at 30 and 60 DAT (T₆) recorded the highest growth attributes as well as yield contributing character therefore, foliar application of humic acid @ 2 % at 30 and 60 DAT (T₆) found to be most suitable organic formulation among all investigated formulations.
5. Based on one season study, it is concluded that applications of GRDF with foliar application of humic acid @ 2 % at 30 and 60 DAT (T₆) just two days after irrigation found best option to onion for the productivity and profitability of *rabi* onion.

The above conclusion, however based on one season results, for confirmation of these results, the investigation needs to be repeated.

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7. Appendix -I

Cost of cultivation of onion depends upon following prices

Sr. No.	Type of operations	Unit	Rate (₹)
1	Ploughing	(₹ ha ⁻¹)	4000/-
2	Cost of seed	(₹ kg ⁻¹)	1200 /-
3	Male labour	(₹ /day)	250 / -
4	Female labour	(₹ /day)	250 / -
5	Jeevamrut : Cow urine	(₹ / litre)	20 / -
6	Cow dung	(₹ kg ⁻¹)	04 / -
7	Vermiwash	(₹ / litre)	20 / -
8	EM solution	(₹ / litre)	600 / -
9	Irrigation and electricity charges	(₹ Irrigation ⁻¹)	1000 /-
10	NSKE	(₹ / litre)	80/-
11	FYM	(₹ / tonnes)	1200/-
12	Humic acid	(₹ / litre)	110/-
13	Selling rate		
i	Price of onion	(₹ / qtl)	1000 / -

8. VITAE

Mr. BARDE KRUNAL GAJANAN
MASTER OF SCIENCE (AGRICULTURE)
IN
AGRONOMY
2020

Title of thesis		:	“Effect of foliar applications of organic formulations on growth and yield of onion”
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