

**EFFECT OF LIQUID ORGANIC FORMULATIONS ON GROWTH,
YIELD AND QUALITY OF CHICKPEA (*Cicer arietinum* L.)**

by

Miss. Vidyashree Shidalingayya Hiremath
(Reg. No.2020/013)

A Thesis submitted to the
**MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413 722, DIST. AHMEDNAGAR
MAHARASHTRA, INDIA**

in partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRONOMY



DEPARTMENT OF AGRONOMY

**POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH
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MAHARASHTRA, INDIA.**

2023

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part
there of has not been submitted
by me or another person to any
other University or Institution
for a Degree or
Diploma

Place : MPKV, Rahuri

Date : / /2023

(V.S. Hiremath)

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CERTIFICATE

This is to certify that the thesis entitled, **“EFFECT OF LIQUID ORGANIC FORMULATIONS ON GROWTH, YIELD AND QUALITY OF CHICKPEA (*Cicer arietinum* L)”** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar (M.S.) in partial fulfillment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRONOMY**, embodies the results of a piece of *bona fide* research work carried out by **MISS. VIDYASHREE SHIDDALINGAYYA HIREMATH**, 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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ACKNOWLEDGEMENT

Acknowledgment in its true essence gives us an opportunity to remember and express our feelings for those whom we have revered. When the going gets tough and tougher, the helping hands offered by all the near and dear ones are always remembered with gratitude.

*I take this opportunity to express my deep sense of gratitude and indebtedness to my research guide **Dr. U.S. Surve**, Professor of Agronomy and Chief Agronomist, AICRP – IFS and Nodal officer, Organic Farming Research and Training Centre, MPKV, Rahuri for his versatile, untiring and scholastic guidance, prompt suggestions, valuable counsel, constant encouragement and immense sympathy. His unflinching courage and conviction will always inspire me and I hope to continue to work with his noble thoughts of living life to the fullest.*

*It is my proud privilege to offer sincere and well devoted thanks to **Dr. P.G. Patil**, Hon. Vice-chancellor, MPKV, Rahuri, for providing conducive administration during the course of study. I am highly obliged to **Dr. P.N. Rasal**, Dean and **Dr. U.D. Chavan**, Associate dean, Faculty of Agriculture, MPKV, Rahuri for granting permissions and providing the necessary facilities for the research work.*

*I take genuine pleasure to express my deepest feeling of gratitude to **Dr. A.V. Solanke**, Head, Department of Agronomy, MPKV, Rahuri, for his directives and help during the experimentation of research work.*

*I take genuine pleasure to express my deepest feeling of gratitude for round the clock help extended to me by my advisory committee members **Dr. A.V. Solanke** Head, Department of Agronomy, **Dr. S.R. Shelke**, Assistant Professor, Department of Soil Science and Argicultural Chemistry and **Dr. M.R. Patil**, Assistant Professor, Department of Statistics, MPKV, Rahuri for their worthy suggestions, and ever willing help throughout the research work.*

*I also take this opportunity to extend my gratitude to **Dr. V.S. Patil**, **Dr. A.G. Durgude** and **Dr. Kranti Patil** Department of Soil Science and Agricultural Chemistry, **Dr. N.J. Danwale**, Associate Professor, Department of Agronomy, **Dr. A.M. Navale**, Professor of Agricultural Microbiology, Department of plant pathology, MPKV, Rahuri for their guidance in completing the course work successfully.*

I am gratefull to all my friends, seniors, juniors and batchmates in PGI,MPKV Rahuri. Friends who have witnessed all my rise, fall, and sorrow, who are only cause to elevate myself from every hardship need to be unveiled. I am thankful to Sidram, Soni, Sushmita, Shekar, Aniket, Dinesh, Keshav, Komal, Megahraj, Prem, Rahul, Shital, Swathi, Pragati, Vikas, Vishal, Kashinath sir, Bharath sir, Shakil Patil sir, Bharath sir, Pooja, Shruthi, Aishu, Rupaali and Chandana for all their love and

affection throughout this journey. Also, I thank Shradha mam, Bidve sir, Patil sir and the field assistants of the organic farm for their assistance during the research.

*There are no words to express my feelings in fathomable depths which spring in the very core of my heart for my father **Shri. Shiddalingayya Hiremath**, who is my biggest support system for all time, my mother **Sau. Manjula Hiremath** who is the source of my motivation, my brother **Naveen** who constantly care me , and other family members for their moral and emotional support that gave me strength during my study and same will continue for my entire life.*

I am deeply obliged to all the authors whose literature has been cited. I bow my head before LORD VEERABHADRA and KALIKAMATA for giving me wisdom and strength.

This list is obviously incomplete but, while traveling on this path of education many hands pushed me forth, and learned hearts put me on the right track enlightened by their knowledge and experience. I ever rest thanks to all of them.

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Date : / /2023

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LIST OF ABBREVIATIONS

%	: Per cent
/	: Per
@	: the rate of
₹	: Rupees
⁰ C	: Degree Celsius
B:C ratio	: Benefit cost ratio
C.D.	: Critical difference
cm	: Centimeter
DAS	: Days after sowing
dSm ⁻¹	: Deci Siemen per meter
EC	: Electrical conductivity
<i>et al.</i>	: and others(etalli)
Even.	: Evening
Fig.	: Figure
g	: gram
GKVK	: Gandhi Krishi vignana kendra
GRDF	: General Recommended dose of fertilizers
ha	: hectare (s)
hr	: hour (s)
i.e.,	: Id est (that is)
ICAR	: Indian Council of Agricultural Research
K	: Potassium
Kg	: Kilogram (s)
max.	: Maximum
mg	: Milligram
min.	: Minimum
mm	: Millimeter (s)
Mor.	: Morning
MPKV	: Mahatma Phule Krishi Vidyapeeth

MT	: Metric tonne (s)
N	: Nitrogen
NS	: Non-significant
P	: Phosphorous
PDKV	: Panjabroa Deshmukh Kriśi Vidyapeeth
ppm	: parts per million
PSB	: Phosphate Solubilizing Bacteria
q	: Quintile (s)
RBD	: Randomized Block Design
RDF	: Recommended dose of fertilizers
S.E _m (±)	: Standard error of mean
t	: Tonne (s)
T ha ⁻¹	: Tons per hectare
TNAU	: Tamilnadu Agricultural University
TOC	: Total Organic Carbon
UAS	: University of Agricultural Sciences
<i>viz.</i>	: Videlicet (Namely)
Wt.	: Weight

ABSTRACT

“EFFECT OF LIQUID ORGANIC FORMULATIONS ON GROWTH , YIELD AND QUALITY OF CHICKPEA”

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Miss. VIDYASHREE SHIDDALINGAYYA HIREMATH

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2023

Research Guide	:	Dr. U.S. Surve
Department	:	Agromony

The field experiment entitled, “**Effect of liquid organic formulations on growth, yield and quality of chickpea**” was conducted during *rabi* season 2021-2022 at Organic farming Research and Training Centre, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra.

The soil of the experimental field has saline pH (7.70), moderate organic carbon (0.45 %) and electrical conductivity (0.35 dSm⁻¹). The soil was low in available nitrogen (171.43 kg ha⁻¹), medium in available phosphorus (16.13 kg ha⁻¹) and very high in available potassium (384.53 kg ha⁻¹) respectively. Microbial load of soil comprises of bacteria (14×10^{-7} cfu g⁻¹ of soil), fungi (11.6×10^{-5} cfu g⁻¹ of soil) and actinomycetes (8.3×10^{-4} cfu g⁻¹ of soil).

The field experiment was laid out in a randomized block design with 9 treatments replicated three times. Treatments consist of T₁ - Control, T₂ - Foliar spray of cow urine @ 10 %, T₃ - Foliar spray of vermiwash @ 10 %, T₄ - Foliar spray of panchagavya @ 3 %, T₅ - Foliar spray of waste decomposer @ 25 %, T₆ - Foliar spray of jeevamrut @ 10 %, T₇ - Foliar spray of cow urine @ 10 % + vermiwash @ 10 %, T₈ - Foliar spray of cow urine @ 10 % + waste decomposer @ 25 % and T₉ – Foliar spray of vermiwash @ 10 % + waste decomposer @ 25 %. Foliar application of these treatments carried out at the branching, flowering and pod initiation stage.

The growth parameters of chickpea *viz.*, plant height (50.15 cm), number of branches plant⁻¹ (20.03), plant spread (36.24 cm), dry matter plant⁻¹ (18.19 g) at

harvest, nodule count plant⁻¹ (6.73) and nodule weight plant⁻¹ (29.54 mg) at 60 DAS were observed to be significantly higher in treatment T₇ i.e., application of Cow urine @ 10% + Vermiwash @ 10 % as compared to rest of foliar treatments. yield attributing characters viz., number of pods plant⁻¹ (44.63), number of seeds pod⁻¹ (1.27), weight of pods plant⁻¹ (11.75 g), seed yield plant⁻¹ (8.44 g), test weight (178.84 g), seed yield (24.81 q ha⁻¹), haulm yield (29.87 q ha⁻¹), biological yield (54.68 q ha⁻¹), harvest index (45.39 %) were observed to be significantly higher in treatment T₇ i.e., application of Cow urine @ 10 % + Vermiwash @ 10 %.

Highest total nitrogen uptake (153.96 kg ha⁻¹), total phosphorus uptake (24.78 kg ha⁻¹), total potassium uptake (47.76 kg ha⁻¹ and also highest amount of available nitrogen (188.59 kg ha⁻¹), available phosphorus (18.59 kg ha⁻¹) and available potassium (399.28 kg ha⁻¹) is observed in treatment T₇ i.e., application of Cow urine @ 10 % + Vermiwash @ 10 %.

Higher population of bacteria (28.06 x 10⁻⁷ cfu g⁻¹ of soil), fungi (24.08 x 10⁻⁵ cfu g⁻¹ of soil) and actinomycetes (28.90 x 10⁻⁴ cfu g⁻¹ of soil) at harvest was found in treatment T₇ i.e., application of Cow urine @ 10 % + Vermiwash @ 10 %.

The chickpea crop applied with treatment T₇ i.e., application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited remarkably higher gross monetary returns (139458.10 ₹ ha⁻¹), net monetary returns (77874.14 ₹ ha⁻¹) and benefit cost ratio (2.26) than other foliar applications during study.

Plant count, days to 50 % flowering, days to maturity, protein content, test weight, pH, EC and OC of soil are found non-significant by foliar treatments.

It was concluded that the treatment T₇ i.e., application of Cow urine @ 10 % + Vermiwash @ 10 % is the best option for chickpea in organic farming for increasing productivity, profitability, beneficial microbial load and fertility status of soil. Treatment T₄ i.e., application of Panchagavya @ 3 % is at par. We can say that instead of commercial and conventional farming, organic farming which is eco-friendly leads to sustainable development.

1. INTRODUCTION

Chickpea (*Cicer arietinum* L.), which belongs to the plant family of legumes, Fabaceae. It is the third important legume crop in the world after peas and dry beans. Chickpea is an important seed legume in Asia, and is grown and consumed in large quantities from south east Asia to India, in the Middle East and Mediterranean regions. Chickpea has a great nutritive value as it contains a high percentage of protein, carbohydrates and minerals thereby helps people in improving nutritional quality of their diets. 100 g of chickpea seed provides 180 calories of energy, 2.99 g of fat, 29.98 g of carbs and 9.54 g of protein. Per gram of chickpea have Lysine (0.44 mg), Thiamine (0.30 mg), Riboflavin (0.15 mg) and Niacin (2.9 mg), which accounts to 20-21 per cent protein. It is also rich in soluble dietary fibre (Raffinose - 8.6 g), Na (243 mg), K (433 mg) and others like P, Ca, Mg, Fe, Cu and β -carotene (Fatsecret.co.in). Chickpea seeds are good source of vitamin C, mainly germinated seeds are recommended against scurvy disease. The tender leaves of chickpea are rich source of malic acid and oxalic acid, produces sour taste which is locally known as 'Aamb' has medicinal value and controls intestinal disorders so chickpea leaves are used as vegetable. The dried part of chickpea called as "Bhoosa" contains good quantity of proteins so, used as valuable animal feed, also plays a key role in improving and sustaining soil productivity by addition of huge amount of organic matter and on account of biological nitrogen fixation with help of bacterial *Rhizobium* sp., Under better management practices, chickpea fix up to 135 kg nitrogen ha⁻¹ year⁻¹ (Herridge, 2015). Chickpea seeds are eaten fresh as green vegetables, boiled, fried, roasted, and parched. Among different seed legumes under cultivation in India, chickpea is the leading and grown during *Rabi* season. There are two types of chickpeas, the brown-coloured "Desi" and the white-coloured "Kabuli". Desi type seeds have thicker seed coat and are relatively smaller in size, while the Kabuli chickpeas have thinner seed coat and relatively bigger in size. The Desi type chickpea contributes around 81 per cent and the Kabuli type around 19 per cent to the total production. It is widely used in different types of foods and recipes. India, imports chickpea from other countries even though it is the largest producer for which concern given to improve the area under cultivation and production practices.

One among the oldest pulses chickpeas are known cultivated from ancient times both in Asia and Europe. It is assumed that chickpea is originated either from Mediterranean region or Himalayas. It is grown in almost all continents - Asia (83 %), Africa (5 %), Oceania (6 %) Americas (4 %) and Europe (2 %)] and other more than 50 countries like India, Greece, Egypt, Italy, Russia, Pakistan, Rumania, North Africa and many other countries of world (FAO 2019). India is major Chickpea producing country, in which area of 9.85 Mha producing 11.99 Mt with 1217 kg ha⁻¹ productivity during 2020-2021. In India, Maharashtra leads in chickpea cultivated area (2.15 Mha - 21.78 %) followed by Rajasthan (2.11 Mha - 21.45 %), Madhya Pradesh (2.10 Mha - 21.35 %), Gujarat (0.82 Mha – 8.29 %), Uttar Pradesh (0.61 Mha – 6.20 %), Karnataka (0.72 Mha - 7.26 %), Andhra Pradesh (0.47 Mha - 4.76 %), Jharkhand (0.27 Mha - 2.70 %), Chhattisgarh (0.30 Mha - 3.06 %) and others (0.31 Mha - 3.16 %). Coming to production Madhya Pradesh (3.13 Mt - 26.09 %) stands first followed by Maharashtra (2.37 Mt - 19.77 %), Rajasthan (2.32 Mt - 19.37 %), Gujarat (1.28 Mt - 10.67 %), Uttar Pradesh (0.84 Mt – 7.01 %), Andhra Pradesh (0.53 Mt – 4.44 %), Karnataka (0.50 Mt - 4.17 %), Jharkhand (0.33 Mt – 2.79 %), Chhattisgarh (0.27 Mt – 2.23 %) and others being (0.41 Mt – 3.46 %). Which wholly accounts for highest productivity in Gujarat - 1568 kg ha⁻¹ (Agricultural Statistics at Glance, 2021). The yield, yield components and protein content of chickpea were compared between traditional and organic production systems shows organic farming has many advantages on environment, animal and human health over traditional production systems.

Organic farming have a more sustainable impact on the health of eco-systems, as well as the health of people and communities. Healthy soil produces healthy crops, and in turn, healthy produce leads to healthy animals and humans. It also increases our immunity and allows our body to regenerate. organic farms are based on an ecological system that balances with the environment and nature, including recycling and taking care of the eco-system. Air, water, biodiversity, climate and land needs to be protected and can be done through the use of high-tech organic farming systems. This is where the principle of care comes in. Many organic farmers aim to increase their production, with care to ensure the future health of the planet is taken care of.

Livestock is the oldest and richest resource for mankind, with small-scale farming and small holdings, involving cattle in farming system is better option. At farm level, enormous quantity of cattle waste i.e. cow dung, urine and waste bedding material are available. These waste to be continuously applied to soil to ensure a balanced supply of plant nutrients. Composting of biodegradable matter with the help of earthworms produces stabilized product known as vermicompost and vermiwash which are soil amendment with great nutrient potential. Cattle based products like cow urine, panchagavya, jeevamruth are organic soil conditioners rich in N, P and K, calcium, magnesium, chloride, sulphates, growth hormones with sufficient load of microbial mobilisers and solubilizers. Cattle-based products applied to soil increases microbial populations and their activities which further gear up nutrient cycling, production of plant growth-promoting materials and build up plant tolerance to micro-biotic attacks. These liquids can also be applied through fertigation and spraying which becoming common in most of the crops (Pradhan *et al.*, 2018).

To combat increasing human, soil, and environmental health hazard due practicing the economical farming it is proven beneficial fact that shifting to organic farming i.e. utilizing cattle based bioproducts keeps the soil healthy and maintains environment integrity thereby, promoting the health of consumers. Moreover, organic produce market is now the fastest growing market all over the world including India due to its broad benefits. As chickpea is major pulse crop of India, it is necessary to cultivate with appropriate technologies like water and nutrient management with efficient resource utilization. The supply of nutrients through the roots is restricted in some soil conditions like high pH and high lime content. To overcome such problems, is to supply the plant nutrients through foliar fertilization. Foliar fertilization is capable of quickly, cheaply, economically, overcoming various deficiency symptoms (Alexander, 1986). Various high yielding varieties of chickpea are responsive to fertilizer. As the ammonium nitrogen losses from dairy operations begin to occur immediately after feces and urine are excreted from the animal and continue through manual handling, storage and land the application; it was thought to use foliar spray of cow urine, vermiwash, panchagavya, waste decomposer, jeevamrut and their combinations as an organic source to get optimum yield and quality.

The review of literature clearly indicate that yield of crop can be boosted by applying foliar spray of cow urine, vermiwash, panchagavya, waste decomposer, jeevamrut and their combinations. In view of the above consideration the present investigation entitled, “Effect of liquid organic formulations on growth, yield and quality of chickpea” was planned and conducted during *Rabi* season of 2021, with following objectives

1. To study the effect of different liquid organic formulations on growth, yield and quality of chickpea.
2. To study the effect of different liquid organic formulations on soil properties and availability of nutrients.
3. To study the economics of different treatments.

2. REVIEW OF LITERATURE

The present investigation was conducted at Organic Farming Research and Training Centre MPKV, Rahuri to study the “Effect of liquid organic formulations on growth, yield and quality of chickpea”. The review of the work done on these aspects have been collected and presented under the following heads:

- 2.1 Effect of cow urine
- 2.2 Effect of vermiwash
- 2.3 Effect of panchagavya
- 2.4 Effect of waste decomposer
- 2.5 Effect of jeevamruth
- 2.6 Effect of combinations of organic formulations

2.1 Effect of Cow Urine on Growth, Yield and Quality of Chickpea

Sagar and Ray (1989), studied on “Levels of use of organic manure and productivity in farming” showed that, organic manures as an important variable in determining the productivity in farming and emphasized the need in agricultural extension work to obtain higher yield from the crops.

Rahate *et al.* (1990) found that, the the application of biogas effluent slurry in combination with urea to supply nitrogen on 50:50 per cent basis favourably and significantly influenced the growth, nodulation, dry matter, pod number and yield per plant and as a result gave significantly higher pod yield per ha over all treatments.

Dwiwarni (1993) at Penelitian Tanaman Industries, Indonesia conducted investigation on “Effect of cow urine and foliar fertilizer on the growth of *Vanilla pemberitaan*, showed that, soaking seeds in cow urine (5-10 %) for a period of 10 minutes increase the percentage of shoot growth, the length and the number of roots. Foliar fertilization increased the number of roots and the length of shoots. There was interaction effects of cow urine and foliar fertilization on the roots and growth of plant.

Sankara *et al.* (1994) published information in *Indian Horticulture*, they studied “Effect of cow urine on germination of tamarind”. Tamarind seeds have a hard seed coat that causes slow germination. Soaking the seeds in 10 per cent cow urine or in

cow dung solution for 24 hr. increased the germination percentage from 37 to 72.6 per cent and 82.8 per cent, respectively.

Verma and Pathak (1998) conducted experiments to determine the most effective brine and cow urine concentration for *Claviceps fusiformis* sclerotia removal from pearl millet (cv. BJ-104) seeds. The treatments were brine (2, 10, 20 and 30 %) and cow urine, (1:3 seed to liquid ratio). The highest sclerotia removal (93.53 %) was obtained with 2:3 (brine: cow urine). A significantly high seed germination and seedling growth was recorded in cow urine treated seeds.

Gadelha *et al.* (2002) conducted an experiment on “Effect of cow-urine the applications in pineapple” to test the five dilutions of cow urine (0, 2.5, 5.0, 7.5 and 10.0) on pineapple cv. Perola in red-yellow podzolic soil. Treatment with urine at 2.5 per cent produced fruits with an average weight of 1370 g, while weight of the ones not treated with cow urine was 1141 g. Treatment with urine at 2.5 per cent increased the fruit weight by 20.07 per cent and the fruit yield by 20.12 per cent.

Mishra *et al.* (2002) collected one year old seeds of asparagus which were subjected to treatments with cow urine. The newly collected seeds germinated earlier and recorded a higher germination percentage (80-95 %) than that of year-old seeds (45-75 %). Seed treatment with cow urine resulted in earlier germination and higher germination percentage than the other treatments.

Ingle (2007) conducted experiment at P. D. K. V., Akola on “Physiological responses of black gram to foliar sprays of cow urine and NAA”, applied 50 ppm NAA and 6 per cent cow urine on black gram as foliar spray and found that, 6 per cent cow urine, 50 ppm NAA increased plant height, number of branches, plant leaf area, total dry matter, RGR and NAR, number and dry weight of root nodules, number of pod plant⁻¹, number of seeds pod⁻¹, 100 seed weight, seed yield plant⁻¹, plot⁻¹, ha⁻¹, harvest index, chlorophyll, nitrogen, phosphorus and potassium content in leaves and protein content in seeds of black gram over control.

Bagde (2008) conducted an experiment at P. D. K. V. Akola and investigated the “effect of foliar spray of cow urine of different breeds on cotton cv. PKV, Hy-4” and observed that 12 per cent cow urine of Holstein Friesian breed increased N, P and K content in leaves of cotton as compared to cow urine of other breeds.

Deotale *et al.* (2008) conducted an experiment to study the effect of two foliar sprays of cow urine @ 4, 6, 8 and 10 per cent and NAA 50 ppm alone or in combination on groundnut. Significant increase in number and total dry weight of root nodules, plant height, number of branches, leaf area, dry matter production, NAR and RGR were observed with 4 per cent cow urine + 50 ppm NAA spraying.

Pawar *et al.* (2008) conducted an experiment on “Influence of foliar sprays of cow urine and NAA on chemical and biochemical parameters of groundnut”. Reported that, 6 per cent cow urine + 10 ppm NAA gave significantly a higher number of pods plant⁻¹, higher shelling percentage and 100 kernels weight, over control and also, 4 per cent cow urine + 50 ppm NAA when sprayed on groundnut increased total N, P and K content in leaves and oil content in kernel over control (RDF).

Bais *et al.* (2009) studied the “Effect of foliar the application of animal urine and panchagavya on auxin content and IAA oxidase enzyme activity in desi cotton (AKDH-5)”. The treatment tried were cow urine (2, 4, 6 %), buffalo urine (2, 4, 6 %) panchagavya (2, 4, 6 %) and control. The foliar the application of 6 per cent cow urine followed by panchagavya 6 per cent recorded in stimulating the better growth, increasing number of sympodial branches, higher productivity, highest nitrate reductase activity and soluble protein content in shoot tip of cotton at all the growth stages right from vegetative to boll formation stage.

Deogirkar (2010) experimented at P.D.K.V., Akola noted that, the foliar sprays of cow urine (4, 6, 8 and 10 %) and NAA (0.36, 0.55, 1.03 and 2.31 ppm) on the morphophysiological parameters of chickpea, the results showed that, two foliar sprays of 6% cow urine significantly increased the plant height, number of branches, leaf area, dry matter production, NAR and RGR over control.

Devakumar *et al.* (2014) conducted a field experiment at Budling Organic Briges on organic farming to study the “Influence of different levels of cow urine, panchagavya on fertility of maize” concluded maximum seed yield of 18.6 and 17.6 q/ha were recorded with the the application of cow urine and panchagavya and minimum was recorded in the plots without the application them.

Indu *et al.* (2015) conducted experiment during *Rabi* 2012-13 at Haryana Agricultural University, Hisar, Haryana. Which studies on nodulation of chickpea

cultivars as influenced by sowing time and seed rate, to evaluate the effect of sowing time and seed rate on nodulation of chickpea cultivars. Higher value of dry weight of nodule at 60 and 90 DAS was recorded in early sown, as compared to late sown chickpea. Among various chickpea cultivars H09-23 recorded highest number of nodules per plant at both the stages. Varying seed rate of chickpea cultivars fail to influence numbers of nodules and its dry weight.

Jandaik *et al.* (2015) conducted experiment on “Efficacy of cow urine as plant growth enhancer and antifungal agent” reported that 10 per cent cow urine worked as an effective fungicide and suppressed about 80 per cent of mycelial growths of *Fusarium oxysporum*, *Rhizoctonia solani*, and *Sclerotium rolfsii*.

Sadhukhan *et al.* (2018) conducted field experiment in the *Rabi* season on Integrated Farming System at BHU, Varanasi to evaluate the “Effect of different level of fertility and cow urine foliar spray on growth, yield and yield attributes of wheat (Var-HUW 234)”. The seed yield and haulm yield of wheat varied significantly under varying levels of fertility and cow urine foliar sprays.

Pradhan *et al.* (2018) conducted experiment on bio-efficacy of cow urine on crop production and they concluded that cow urine spray results increased uptake of N, P, K in mustard.

Onte *et al.* (2019) conducted investigation on “Impact of organic nutrient management on crop quality, yield and soil health” and concluded that, organic nutrient are proven things that improved crop productivity, quality and yield which in turn enhance the quality and richness of the soil properties and make way for the healthier environment for the beneficial soil micro-organism.

2.2 Effect of vermiwash on Growth, Yield and Quality of Chickpea.

Ismail (1995) conducted investigation on UPASI Kottayam and reported that, vermiwash was very effective for foliar the application in nurseries, lawns and orchids for obtaining maximum crop growth.

Vijayananthan *et al.* (2004) studied the “Effect of different organic extract sprays of vermiwash type-I, vermiwash type-II, Vermicast extract, cow dung extract on growth and biomass production of two important multipurpose trees i.e. *Tectona grandis* and *casuarinas equisetifolia*”. Spraying of vermiwash exerted the maximum influence on

the growth parameters in teak seedlings while vermicast extract produced maximum growth parameters on casuarinas.

Mahto and Yadav (2005) conducted a pot culture experiment in Dholi, Bihar (India) during winter season on “Effect of vermicompost alone and in combination with chemical fertilizer on stem fly incidence and yield attributes in vegetable peas under Bahar conditions” reported that, manuring with vermicompost or in combination with foliar spray of vermiwash (5 or 10 %) recorded higher number of pods plant⁻¹ as compared to that in untreated plot, positively influenced nodulation and plant growth, and significantly increased number of pods plant⁻¹, number of seeds pod⁻¹. Soil the application of vermicompost (25 q ha⁻¹ equivalence) and foliar spray of vermiwash (10 %) at 30 days after sowing by reducing the pest infestation to the extent of 24.26 per cent.

Prabhu (2006) conducted an experiment on “Coconut leaf vermiwash stimulates crop yield” reported the presence of large number of beneficial microorganisms in vermiwash that helped to increase the growth of the plants.

George *et al.* (2007) did an investigation on “Utility of vermiwash for the management of thrips and mites on chilli (*Capsicum annuum* L.) amended with soil organics” showed a result that, the effect of vermiwash spray on dry chili yield and concluded that weekly vermiwash the applications increased chili yield by 7.3 per cent.

Karuppaiah and Balasankari, (2008) conducted an investigation on “Effect of tillage system and nutrients on growth, yield on snake gourd and residual soil fertility under rice fallow condition” and reported the effect of treatments including zero tillage, minimum (conservative) tillage and normal tillage with organic FYM manures (25-liter ha⁻¹) inorganic NPK fertilizers in combination with vermiwash (1:5) dilution, panchagavya (3 %) and humic acid (0.2 %) on snake gourd. The results revealed that the combination of normal tillage +25 t ha⁻¹ of FYM with RDF + foliar the application of vermiwash (1:5 dilution) was found to be the best treatment with a total yield of 19.21 t ha⁻¹ and a cost benefit ratio of 3.76 which was at par to the combination of conservative (minimum) tillage+25 t ha⁻¹ of FYM with RDF + foliar spray of vermiwash (1:5 dilution) having a total yield of 19.06 t ha⁻¹ and benefit cost ratio of 4.14.

Rai and Bansiwal (2008) carried out an experiment “Vermiwash: An excellent source of nutrition for plant growth” and opinioned that, vermiwash is a nutrient

rich liquid produced by earthworms, feeding on organic waste material and plants residues. It is also non-toxic and ecofriendly, which arrests bacterial growth and forms a protective layer for their survival and growth. Vermiwash contains N, P, K, Ca and hormones such as auxin, cytokinin, some other secretions and many useful microbes like heterotrophic bacteria, fungi etc. The quality of vermiwash produced by earthworms depends on the vermicompost and its maturity that is used.

Zambare *et al.* (2008) conducted an experiment titled “Vermiwash: Biochemical and microbiological approach as eco-friendly soil conditioner”. This study revealed that, vermiwash contains nitrogen fixing bacteria (*Agrobacterium*, *Rhizobium*, *Azotobacter*) and phosphorus solubilizing bacteria. Cowpea plant treated with vermiwash showed supplemented growth as compared to non-treated one.

Nath and Singh (2009) conducted an experiment on “Utilization of vermiwash potential on certain summer vegetable crops” reported that, vermiwash elevated growth and productivity significantly and dropped off flowering period. In okra, utmost growth (38.0 ± 1.3 cm) was determined in combination of buffalo dung with rice bran at 30 mg m^{-2} concentration. The significant early start of flowering and increase in productivity was found in all treated groups with regard to control.

Ansari and Kumar (2010) investigated the “Effect of vermiwash and vermicompost on the chemical properties of soil in okra crop”. Vermiwash and vermicompost was prepared from dried grass and cattle dung by using culture of *Eisenia fetida* species of earthworm, results revealed that were organic carbon (%), magnesium (ppm), calcium (ppm) and zinc (ppm) were 0.73, 1, 5 and 15.62, respectively, in soil treated with the combination of vermiwash and vermicompost (VC+ VM), followed by vermicompost alone have high quantity of organic carbon, magnesium, calcium and zinc (0.64 %, 0.64 ppm, 3.4 ppm and 10.24 ppm, respectively) as compared with the control.

Gopal *et al.* (2010) experimented on coconut leaf vermiwash (CLV) produced by *Eudrilus* species from the vermicomposting of coconut leaf litter + cow dung substrate (10:1 w/w). The nutrient content in CLV were nitrogen (2.8 ppm), phosphorus (10.28 ppm), potash (205 ppm), calcium (37.9 ppm) and magnesium (6.4 ppm) which was far less than the vermiwash prepared from pure cow dung i.e. nitrogen (61 ppm), phosphorus (18 ppm), potash (55 ppm), calcium (14 ppm) and magnesium

(198 ppm). They indicated that, potash content in CLV was 4 times higher than the vermiwash prepared from pure cow dung.

Hatti *et al.* (2010) conducted experiment on “Effect of *perionyx excavatus* vermiwash on the growth of plants”. The foliar spray of vermiwash of *Perionyx excavate* has increased the root length of *Sesamum indicum* significantly. But significant increase in root length ($P < 0.01$) and highly significant ($P < 0.001$) increase in shoot length was seen when vermiwash was sprayed for 20 and 40 days respectively. The number of twigs were increased significantly ($P < 0.01$) when compared to respective controls in both the groups. Also, vermiwash prepared from microbial infested old dampened cow dung recorded N (10.24 %), P_2O_5 (0.56 %), K_2O (1.65 %), Ca (0.58 %), S (0.057 %) and micronutrients (0.063, 0.498, 3.193 and 0.159 ppm of Cu, Zn, Fe and Mn, respectively), content.

Tharmaraj *et al.* (2010) did an experiment on “Influence of vermicompost and vermiwash on physico-chemical properties of black gram cultivated soil” ascertained that, the vermi-product treated plants exhibited faster and higher growth rate and productivity than the control plants in black gram. it was found that, the growth rate among the treated group was high in the mixture of vermicompost and vermiwash treated plants than untreated plants. The maximum range of some plant parameters, such as number of leaves (33.1 ± 0.21), leaf length (4.1 ± 0.03 cm), plant height (9.5 ± 0.42 cm) and root length of plant (7.1 ± 0.10 cm) were recorded in the vermicompost and vermiwash mixture.

Karuppaiah *et al.* (2011) studied the “Effect of foliar the application of organic nutrients (vermiwash, panchagavya, humic acid and tender coconut water) on growth, flowering and flower quality of *Dendrobium* orchid”. The results revealed that, foliar spray of vermiwash 1 percent at 4 days interval found to be optimum for flower quality of *Dendrobium* orchid. An the application of RDF recorded higher values in vegetative growth and flowering characters however, it was at par with the plants treated with vermiwash 1 percent at 4 days interval.

Tharmaraj *et al.* (2011) investigated the, “Effect of vermiwash prepared by using leaf litter and cow dung as substrate by *Lampito mauritii*, *Eisena fetida* and *Eudrilus euginea* earthworm species on soil chemical properties in rice”. Soil samples

collected after two months showed that, pots treated with the combination of vermicompost and vermiwash have maximum nitrogen (69 ppm), phosphorus (77 ppm), potassium (195 ppm), calcium (50 ppm) and magnesium (4 ppm) followed by vermicompost having nitrogen (64 ppm), phosphorus (73 ppm), potassium (189 ppm), calcium (2.5 ppm) and magnesium (3 ppm) when compared with control.

Chadha *et al.* (2012) did experiment on “Sustainable livelihood option for small and marginal farmers” and revealed that, vermiwash contains N (0.894 %), P₂O₅ (0.026 %), K₂O (0.084 %), and micronutrients (0.5, 5, 18 and 4 ppm of Cu, Zn, Fe and Mn, respectively).

Quaik *et al.* (2012) did investigation on “Effect of vermiwash and vermicomposting leachate in hydroponics culture of Indian Borage (*Plectranthus amboinicus*) plantlets” recorded effect of vermicompost leachate and vermiwash prepared from pre composted cow dung in hydroponic culture on growth of Indian Borage plantlets. Results showed that 10 % (v/v) of vermiwash solution showed superior growth in hydroponic crops as it showed an increase in root growth (15.73 cm), total chlorophyll content (0.37 mg g⁻¹ dry wt.) followed by root growth of vermicompost leachates (13.75 cm), total chlorophyll content (0.32 mg g⁻¹ dry wt.) compared to control.

Rajan and Murugesan (2012) did an experiment on “Influence of vermiwash on germination and growth of cowpea (*Vigna unguiculata*) and rice (*Oryza sativa*)”, experimented on *Vigna unguiculata* and *Oryza sativa* sown in mud pots filled with mix 3:2:1 ratio of clay soil, red soil and sand. The vermiwash at 50, 75 and 100 per cent concentration are sprayed over the two crop plants and results were analyzed. Results concluded that, at different concentrations of vermiwash increased vigour index in *Oryza sativa* and 75 and 100 per cent of sprayed vermiwash affect the growth parameters in *Vigna unguiculata*.

Karuppasamy and Lourdu (2013) conducted an investigation on “Effect of vermiwash on the growth of mulberry cuttings” observed that, foliar spray of vermiwash prepared from composting materials such as cow dung and waste leaf material on mulberry increased the physical parameters like number of buds, number of leaves and weight of leaves.

Manyuchi *et al.* (2013) conducted an experiment on “Comparison of vermicompost and vermiwash bio-fertilizers”, in which vermiwash was obtained from vermicomposting of maize pulp blended with cow dung manure. Results revealed that the pH and electrical conductivity were higher in the vermicompost compared to the vermiwash. The nitrogen and potassium content were 57 and 79.6 per cent higher in the vermicompost as compared to the vermiwash respectively. However, the phosphorous content was 84 per cent higher in the vermiwash as compared to the vermicompost. The vermiwash was 89.1 and 97.6 per cent richer in Ca and Mg as compared to the vermicompost. Furthermore, the vermiwash was 97.8 per cent rich in sodium content compared to the vermicompost.

Rekha *et al.* (2013) did experiment on “Influence of vermicompost and vermiwash on the growth and productivity of black gram (*Vigna mungo*)”. They observed that, the vermicompost and vermiwash affected the growth and productivity of black gram (*Vigna mungo*). The quality of the soil improved considerably, with vermiwash 10 % and vermiwash 10%. The yield and growth of black gram was significantly higher in pots treated with vermicompost 50 %.

Samadhiya *et al.* (2013) studied the “Effect of vermiwash of an epigenic earthworm species (*Eudrilus euginae*) on the growth and development of leaves and stem of tomato plants”. Results after four weeks showed that, shoot length and number of leaves were maximum when treated with soil+ vermicompost (S+VC) (21.65 cm and 66.80) respectively, followed by soil + vermiwash (S+VW) (19.72 cm) with respect to shoot length and the number of leaves in S+VC+VW treated plants compared to the control (soil + cow dung), shoot length (17.92 cm) and the number of leaves (63.95) in tomato.

Fathima and Malathy (2014) studied on “Growth promoting effects of Vermiwash on the germination of vegetable crops” and concluded that, vermiwash along with gibberellic acid was used to bring about seed germination and seedling growth in *Hibiscus sabdariffa* and *Phaseolus vulgaris*.

Jadhav *et al.* (2014) conducted an experiment on “Effect of different levels of vermiwash spray on growth and yield of radish *cv.* local variety”, revealed that, 100 % RDF as fertigation and two sprays of vermiwash (1:4) at 15 and 30 days after sowing

recorded significantly higher yield than all other treatments besides growth and yield attributes such as root diameter (10.41 cm), length (23.79 cm), weight (85.21 g), yield plot⁻¹ (17.04 kg), yield ha⁻¹ (56.80 tons ha⁻¹) and marketable yield (49.25 tons ha⁻¹) of radish cv. local variety. Vermiwash was obtained by culturing earthworms on organic substrates such as 65 per cent pre-composted crop wastes and 35 per cent animal manure. Thus, it can be concluded that foliar spray of vermiwash (1:4) is effective than control.

Sundararasu and Jeyasankar (2014) conducted an experiment on “Effect of vermiwash on growth and yield of brinjal *Solanum melongena* (eggplant)”. Assessed the effect of vermiwash spray which is prepared from vermicomposting of cow dung on the growth and yield of brinjal. Significantly higher plant height was observed in vermiwash at 50 per cent (50.8 cm) and followed by 25 per cent (50.1 cm) when compared with control (49.84 cm) at 90 days. Higher number of leaves were registered with vermiwash at 50 per cent (65.7) and followed by 25 per cent (64.1) compared to control on 90 days. More number of flowers and fruits were recorded with the vermiwash at 50 per cent (37.4, 31.6) and followed by 25 per cent (36.6, 27.2) at 90 days.

Varghese and Prabha (2014) did an investigation on “Biochemical characterization of vermiwash and its effect on growth of *Capsicum frutescens*” revealed that treatment with vermiwash in *Capsicum frutescens* at 30 DAP showed increased root and shoot length as well as number of leaves than the vermiwash untreated plant. The present study suggests that the quality liquid manure vermiwash obtained from the degradation of jackfruit waste by *Eudrilus eugeniae* is a 10 effective biofertilizer that would facilitate the increased use of the nutrients by the plants, resulting in higher growth and yield.

Anoop and Garg (2015) reported the “Influence of vermi-fortification on chickpea (*Cicer arietinum* L.) growth and photosynthetic pigments”. The results indicate that the vermicompost the application has increased plant height, plant shoot biomass, seed pods, and photosynthetic pigments. Substitution of soil with 10 and 20 per cent vermicompost significantly increased growth in chickpea plants progressively with the increase in vermicompost substitution compared with those grown in soil (control).

Chauhan and Singh (2015) did an investigation “Potency of vermiwash with neem plant parts on the infestation of *Earias vitella* and productivity of okra

(*Abelmoschus esculentus* L)”. reported that effect of vermiwash with neem plant parts on germination, growth, productivity of okra and its pest infestation. The significant higher germination of okra seed recorded in vermiwash with aqueous extract of neem bark than other combinations. Early germination as well as highest growth and yield of okra was also observed with this treatment.

Maya and Satish (2015) did an investigation on “Influence of vermiwash on gemination and growth parameters of seedlings of green gram (*Vigna radiata* L.) and black gram (*Vigna mungo*)”. found that seeds of green gram treated with 30 per cent vermiwash showed higher germination percentage than that of GA3, control treatment and there was also increase in hypocotyl and radical length of seedling.

Bhardwaj and Sharma (2016) carried out an experiment at Kurukshetra district of Haryana to assess the “Effect of different fertilizers on the growth and yield of moong dal”. Finding that Leaf litter of *Mangifera indica*. L and cow dung in 1:1 ratio was same as an organic waste for preparation of vermicompost. The maximum number of seeds pod⁻¹ were found in vermicompost (15 tons ha⁻¹) followed by vermiwash (500 ml ha⁻¹) prepared by washing the earth worms (from culturing unit) in warm water for 5 minutes, whereas the average weight of seeds per pod was found to be higher in vermiwash treatment.

Nath and Singh (2016) conducted an experiment on “Utilization of vermiwash potential on certain summer vegetable crops” reported that the effect of vermiwash of different vermicompost of animal and kitchen wastes observed on the growth, flowering periods and productivity of wheat, chickpea, pea and mustard. In case of wheat, after 30 days of sowing the vermiwash from combination of goat dung with wheat residue and goat dung with vegetable wastes shows a higher growth of 26.20 ± 0.97 cm and 26.54 ± 0.53 cm respectively, whereas the maximum growth 65.00 ± 0.88 cm at 50 DAS was observed in concentration of 30 mg m^{-2} of buffalo dung combination with rice bran. The significant productivity of wheat was observed in combination of buffalo dung with rice bran i.e. $0.496 \pm 0.01 \text{ kg m}^{-2}$, followed by the treatment of 10 mg m^{-2} buffalo dung with rice bran. The highest significant productivity recorded in goat dung with wheat bran i.e. $0.621 \pm 0.06 \text{ kg m}^{-2}$ concentration in 30 mg m^{-2} .

Tiwari and Singh (2016) conducted an experiment on “Combined effect of liquid biofertilizer with biopesticide on yield of tomato (*Solanum lycopersicum* L.) and infestation of *Helicoverpa armigera*” reported higher growth, early flowering and yield as well as minimum pest infestation of tomato crop due to foliar the applications of vermiwash with neem oil, aqueous extract of leaf, bark then vermiwash alone.

Verma *et al.* (2017) did an investigation on “Bio-efficacy of organic formulations on crop production” concluded that, the application of vermiwash @100 % ha⁻¹ was recorded significantly the highest plant height, number of primary branches, number of secondary branches, leaf area index and dry matter accumulation as compare to other Treatments.

Senthilmurugan *et al.* (2018) did an investigation on “Evaluation of different concentration of vermiwash on seed germination and biochemical response in okra (*Abelmoschus esculentus* L.)” evaluated okra plant with different concentrations of vermiwash for germination percentage and growth parameters. Vermiwash by *Esinea foetida* species was prepared and seeds were treated with vermiwash at different concentrations i.e. T₁ (0.25 %), T₂ (0.5 %), T₃ (0.75 %), T₄ (1 %) and control (no treatment). Results demonstrated that, maximum shoot and root length were recorded in T₁ (2.9 cm) and T₃ (2.1 cm) respectively. 100% seed germinated in all vermiwash treated group and maximum chlorophyll content was recorded in T₂ (4.91 mg g⁻² dry wt.) as compared to control.

Verma *et al.* (2018) did an investigation on “Significance of vermiwash on crop production” resulted that, vermiwash is a rich source of vitamins, hormones, enzymes, macronutrients and micronutrients when applied to plants help in efficient growth. The comparative study was done on the effect of vermiwash on crop production capacities of soil by improve the physiochemical property of soil and reduced the insect pest infestation which would have facilitated increased uptake of the nutrients by the plants resulting in higher growth and yield. It also helps in sustainable crop production.

Behera and Bhoi (2021) carried out an experiment “Cost and return analysis of inorganic and organic agriculture” concluded that, in organic farming costs are relatively lower than that of the cost of inorganic farming and organic farms have secured relatively higher net returns than inorganic farms.

2.3 Effect of Panchagavya on Growth, Yield and Quality of Chickpea.

Vivekanandan (1999) published a section in *Agri news* stated that the spray of panchagavya resulted in doubling the stick yield apart from pest and disease resistance in moringa. The increased yields were also observed in crops like Chili by Balasubramanian *et al.* (2001); in Moringa by Beulah *et al.* (2002); in green gram by Somasundaram *et al.* (2003) and in French bean by Selvaraj, (2003) with the use of panchagavya.

Balasubramanian *et al.* (2001) reported that, the enhanced growth and yield were observed in seedlings dipped in panchagavya before transplanting in rice.

Vasumathi (2001) and Sanjutha *et al.* (2008) conducted an experiment on “Influence of organic manures, biofertilizers and plant density on growth, yield and alkaloid content of Bhumyamalaki (*Phyllanthus amarus*)” at Tamil Nadu Agricultural University, Coimbatore, concluded that, the growth enzymes present in panchagavya might have favored rapid cell division and multiplication for higher growth characters and increased height in *Phyllanthus amarus* and *Andrographis paniculata*, respectively.

Beulah (2002) conducted experiment on “Growth and development of moringa (*Moringa oleifera* Lam.)” under organic and inorganic systems of culture, concluded that the beneficial microorganisms from panchagavya and their presence in the rhizospheres environment of the root zone influence the plant growth and crop yield.

Natarajan (2002) concluded that, panchagavya enhanced the growth, vigour and resistance to pests and diseases and further in the enhancement of keeping quality of vegetables and fruits in various crops like turmeric, paddy, onion, gingelly, sugarcane, banana, vegetables and curry leaf.

Kanimozhi, (2003) investigated on the topic “Organic production package of *Coleus forskohili*” at TNAU, observed that spraying of 4 per cent panchagavya was found to give superior yield with respect to root yield i.e. 2.5 times, when compared to control in *Coleus forskohili*.

Somasundaram *et al.* (2003) investigated on the topic “Response of green gram to varied levels of panchagavya (organic nutrition) foliar spray” observed that, there was significantly higher number of seeds per pod (12.9) and seed yield (17.87 q ha⁻¹) recorded with panchagavya 3 per cent as compared to other treatments in green gram.

Subramanian (2005) investigated on “Integrated Nutrient Management in *Andrographis paniculate*” concluded that the use of traditional panchagavya as manure resulted in the increase of nodule formation by almost 18 to 62 per cent.

Velmurugan (2005) experimented on “Studies on organic farming practices on growth, yield and quality of radish (*Raphanus sativus* L.) cv. Pusa chetki”. Observed that seed treatment + foliar the application of panchagavya 3 per cent produced the tallest plant height (26.75 cm), higher number of leaves (14.0) as compared to other treatments in Radish.

Yadav and Lourduraj (2006) conducted a field experiment for estimation of “Effect of organic manures and Panchagavya spray (consisting of cow dung, cow urine, cow milk, cow curd and ghee) on yield attributes of rice”. The findings revealed that the the application organic manures and foliar spray of 3 per cent Panchagavya significantly increased the yield attributes and seed yield.

Birendra and Christopher (2007) investigated on the topic “Use of panchagavya as a growth stimulant and biopesticide in agriculture” noted that, the foliar the application of 3 per cent panchagavya resulted in significant increase in yield attributes.

Somasundaram and Amanullah (2007) investigated on the topic “Panchagavya on growth and productivity of crops”, reviewed that, panchagavya shows positive effect on growth and productivity of crops.

Swaminathan *et al.* (2007) investigated on the topic “Panchagavya - Boon to organic Farming” concluded that, foliar the application of 3 per cent panchagavya at 15, 25 and 40 DAS recorded the highest seed yield (1195 kg ha⁻¹) in black gram.

Mohanalakshmi and Vadivel (2008) experimented on “Influence of organic manure and bioregulators on growth and yield of aswagandha” showed that, the application of poultry manure (5 t ha⁻¹) + panchagavya (3 %) resulted in the highest root yield of 1354.5 kg ha⁻¹ and produced higher leaf number plant⁻¹ in aswagandha.

Sanjutha *et al.* (2008) investigated on the topic “Integrated Nutrient Management in *Andrographis paniculata*”, concluded that, the the application of FYM @ 15 t ha⁻¹ + NPK @ 75 : 75 : 50 kg ha⁻¹ + panchagavya @ 3 per cent foliar spray recorded the highest plant height (54.10 cm), number of branches (27.40), number of

leaves (105.67) and highest Leaf Area Index (LAI) (1.03) when compared to other treatments in Kalmegh.

Vennila and Jayanthi (2008) investigated on the topic “Response of Okra to integrated nutrient management” concluded that spraying of 2 per cent panchagavya + 100 per cent recommended dose of fertilizer resulted in enhanced plant height (131.7 cm) and production of dry matter (5.9 g plant⁻¹) in okra.

Kumavat *et al.* (2009) conducted experiment on “Growth and development of groundnut under foliar the application of panchagavya and leaf extracts of endemic plants” concluded that when panchagavya + neem leaf extract applied as foliar spray increased chlorophyll content, nutrient content and nitrate reductase activity in groundnut.

Mudigora *et al.* (2009) investigated on the topic “Evaluation of plant products in combination with cow urine and panchagavya against sorghum shoot fly, *Atherigona soccata Rondani*” concluded that among different treatments, panchagavya + NSKE (5 %) recorded highest yield of 14.16 q ha⁻¹ followed by NSKE + cow urine (5 %) (12.59 q ha⁻¹), panchagavya + V. negundo (12.45) and V. negundo + cow urine (12.04 q ha⁻¹) and panchagavya + P. glabra @ 5 % (12.40 q ha⁻¹).

Choudhary *et al.* (2010) conducted experiment on “Effect of foliar the application of panchagavya and leaf extracts of endemic plants on groundnut (*Arachis hypogaea* L.)”. The present study was aimed to improve the growth and yield of groundnut (*Arachis hypogaea* L.) under foliar spray of panchagavya and leaf extracts as organic source of nutrient. The experiment was conducted during *kharif*. The results revealed that foliar the application of panchagavya + leaf extract of neem recorded significantly higher number of nodules, number of pods plant⁻¹, pod weight plant⁻¹, pod yield, haulm yield and harvest index as compared to other treatments. Panchagavya + leaf extracts of neem recorded significantly higher 100 kernels weight, shelling (%), nutrient uptake of N and P, oil content over other sources.

Kumawat *et al.* (2010) investigated on the topic “Comparative performance of groundnut-cumin and cluster bean-cumin cropping systems under foliar the application of panchagavya in western Rajasthan” concluded that the foliar the application of neem + panchagavya increased yield in cluster bean and cumin. In

comparison to cluster bean - cumin system, higher cumin equivalent yield was recorded under groundnut – cumin system with neem + panchagavya (1259 kg ha⁻¹) followed by tumbo + panchagavya (1068 kg ha⁻¹).

Krishnapriya and Padamadevi (2011) investigated on the topic “Effect of panchagavya on the growth and biochemical contents of *Oryza sativa* var. Ponni”. designed experiment to improve the yield and biochemical contents of rice for which panchagavya (an organic fertilizer) was applied. Panchagavya was prepared and applied through flow irrigation on the 15th, 30th, 45th and 60th day. Shoot length, height of the plant, number of seeds, 1000 seeds weight, number of spikelets, seeds protein and carbohydrates were studied. The results showed that in all the parameters studied panchagavya had a positive influence over the control.

Ravi *et al.* (2011) investigated on the topic “Effect of integrated organic sources of nutrients on quality and economics of groundnut (*Arachis hypogaea* L.)” concluded that the treatment RDF + panchagavya spray 3 per cent at 30, 60 and 75 days after sowing showed higher oil percentage (40.7), protein percentage (22.4), oil yield (685.1 kg ha⁻¹) and protein yield (377.7 kg ha⁻¹) as compared to other treatments in ground nut.

Saranraj (2011) investigated on the topic “Growth and development of black gram (*Vigna mungo*) under foliar the application of panchagavya as organic source of nutrient” concluded that the application of 3 % panchagavya foliar spray increase physiological growth, leaf area index, dry matter production, chlorophyll content, N content, protein content, yield, yield attributes and economics of black gram.

Patil *et al.* (2012) conducted field experiment on “Effect of organics on growth and yield of chickpea (*Cicer arietinum* L.) in vertisols”, at Agricultural Research Station, Annigeri, UAS, Dharwad during *Rabi* season, reported that the the application of panchagavya 3 per cent at 15 days after flowering increased plant height (37.01 cm), number of branches per plant (5.22), higher leaf area index (1.31) and root nodules (20.50) in chickpea.

Sunil *et al.* (2012) investigated on the topic “Organic seed production of cumin (*Cuminum cyminum* L.) with foliar the application of panchagavya and plant leaf extracts in arid western Rajasthan” reported that the application of neem + panchagavya

spray at 30, 54 and 80 per cent at 55 and 80 days after sowing recorded higher plant dry matter compared to control in cumin crop.

Vijaykumari *et al.* (2012) conducted field experiment on “Effect of panchagavya, humic acid and micro herbal fertilizer on yield and post-harvest soil of soya bean (*Glycine max* L.)”, concluded that, the seeds soaked in panchagavya (1 %) and humic acid (1 %) for 8 hours gave higher protein content of the harvested seeds (1.25 mg g⁻¹ tissue) and ascorbic acid content of the harvested seeds 0.48 mg g⁻¹ tissue) as compared to other treatments in soybean.

Amalraj *et al.* (2013) investigated on the topic “Microbiological analysis of Panchagavya, vermicompost, and FYM and their effect on plant growth promotion of pigeon pea (*Cajanus cajan* L.) in India”, concluded that, the seed treatment with panchagavya resulted in enhanced root and shoot length of 19.4 cm and 16.9 cm respectively along with dry mass (147 mg), high leaf area (14.57 cm²), chlorophyll content (23 SPAD units) and photosynthetic activity after 15 DAS in pigeon pea.

Naik *et al.* (2013) investigated on the topic “Evaluation of panchagavya as a source of nutrient for Cymbidium orchids” concluded that panchagavya either in foliar or media the application gave better results in growth and spike production in Cymbidium hybrid.

Vimalendran and Wahab (2013) investigated on the topic “Effect of foliar spray of panchagavya on yield attributes, yield and economic of baby corn”, observed that four sprays of panchagavya 3 per cent at 15, 25, 35 and 45 DAS showed higher number of cobs (2.95), cob length (26.66 cm), cob width (4.46 cm), individual cob weight (29.69 g) and yield (7476 kg ha⁻¹) as compared to other treatments in baby corn.

Jain *et al.* (2014) investigated on the topic “Effect of new organic supplement (Panchagavya) on seed germination and soil quality”. Concluded that panchagavya the application increases germination (%), germination index, root and shoot length, fresh and dry weight of the seedlings, plant height and chlorophyll content besides effecting available macro and micro nutrients like Zn, Cu, Mn and microbial activity as compared with FYM and vermicompost.

Sakubai *et al.* (2014) investigated on the topic “Effect of bio-inoculants and bioformulations on growth, yield and quality of buckwheat” recommended that the

organic treatment (VAM + panchagavya + amritpani @ 3 % drench and spray) for enhanced growth and yield of buckwheat.

Shailaja *et al.* (2014) conducted an experiment on “Panchagavya- an eco-friendly insecticide and organic growth promoter of plants” reported that organic manures have high load of beneficial micro-organisms like lactic acid bacteria (*Lactobacillus*), yeast (*Saccharomyces*), actinomyces (*Streptomyces*), photosynthetic bacteria (*Rhodospirillum rubrum*) and certain fungi (*Aspergillus*)

Waghmode *et al.* (2015) investigated on the topic “Differential responses of yield and quality to organic manures in sweet corn (*Zea mays (L.) saccharata*)” found that treatments with cow urine spray 10 per cent and panchagavya spray 3 per cent at grand growth period and tasseling stages gave higher protein content (9.27 and 9.21 %), higher fresh cob yield (5078 and 5262 kg ha⁻¹), fresh seed weight (166.1 and 169.8 g), dry seed weight per plant (69.85 and 70.66 g), cob girth (13.89 and 13.71 cm) and cob length (13.29 and 12.88 cm) compared to other treatments in sweet corn.

Pagar *et al.* (2016) investigated on the topic “Influence of panchagavya on growth and yield of wheat”, reported that the application of panchagavya influenced the plant height, dry matter accumulation, total and effective tillers significantly in wheat.

Ananda and Murthy (2017) investigated on the topic “Response of finger millet under organic nutrient management in groundnut (*Arachis hypogaea* L.) – Finger millet (*Eleusine coracana* L.) cropping system” found that, the treatment with enriched bio digester at 25 kg N equivalent per hectare + panchagavya at 3 per cent gave higher leaf area index (3.20) at 60 DAS when compared to other treatments in groundnut and finger millet.

Choudhary *et al.* (2017) investigated on the topic “Effect of Panchagavya on Growth and Yield of Organic Black gram [*Vigna mungo* (L.) Hepper]” reported that, the application of panchagavya gave the maximum plant height, higher dry matter accumulation, maximum leaf area index at branching and flowering stages, number of pods, number of seeds, seed yield, haulm yield and biological yield in black gram.

Panchal *et al.* (2017) conducted experiment on “Effect of Panchagavya on growth, yield and economics of chickpea (*Cicer arietinum* L.)” during *Rabi*, at Agronomy Instructional Farm, CP College of Agriculture, Sardarkrushinagar. The result

reported that, among different treatments, foliar spray of panchagavya@ 4% at branching and flowering stage showed its superiority by producing the highest plant height (54.9 cm), number of nodules plant⁻¹ (15.67), fresh (157.57 mg) and dry (52.67 mg) weight of nodules plant⁻¹, seed (2054 kg ha⁻¹) and stover (2483 kg ha⁻¹) yield of chickpea along with maximum net return of ₹ 50008 and B: C ratio of 3.05.

Suchitra *et al.* (2017) investigated on the topic “Effect of Panchagavya on Growth and Yield of *Abelmoschus esculentus* cv. Arka Anamika” observed that 3 % panchagavya spray resulted in the highest number of fruits (19) and fruit weight (30.67 mg fruit⁻¹) when compared with other treatments in *Abelmoschus esculentus*. By the above data, the crops treated with panchagavya resulted in the attainment of better and higher yields. The yield also showed better yield quality parameters like higher dry matter content, protein content, fresh and dry weights, root yield, number of fruits, fruit weight, seed and seed weight, cob- length and girth, oil content, and protein content. Thus, Panchagavya plays an important role in the yield and yield attributes of a wide variety of crops.

Prem Kumar *et al.* (2021) conducted field experiment on “Influence of spacing and organic nutrients spray on growth and yield of chickpea (*Cicer arietinum* L.)” during *Rabi*, (2020) at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (UP). The experimental results revealed that significantly highest plant height (69.91 cm), number of nodules (4.63 plant⁻¹), dry weight (20.31 g plant⁻¹), pods plant⁻¹ (49.47), seeds pod⁻¹ (1.87), test weight (232.66), seed yield (2553.02 kg ha⁻¹), stover yield (3142.53 kg ha⁻¹) and harvest index (37.25 %) were recorded with 30 cm x 10 cm+ panchagavya (4 %). Maximum gross returns (Rs. 157593ha⁻¹), net returns (Rs. 125383ha⁻¹) and benefit: cost ratio (2.89) was obtained highest in the treatment combination of 30 cm x 10 cm + panchagavya (4 %).

2.4 Effect of Waste Decomposer on Growth, Yield and Quality of Chickpea

Gokul Kannan (2020) conducted experiment on “Waste decomposer – A multifunctional microbial consortium”. Waste Decomposer has an immense potential to undergo effective organic waste management, crop production, and soil health revival

due to its beneficial multifunction. It is an eco-friendly, cost-effective, and beneficial product that could work as a great component for Clean India Movement (Swachh Bharat Mission) by converting bio-waste into organic manure. Hence, it could also give some additional revenue through the marketing of compost produced by the addition of the Waste Decomposer.

2.5 Effect of Jeevamruth on Growth, Yield and Quality of Chickpea

Boraiah (2013) investigated on the topic “Effect of panchagavya, jeevamrutha and cow urine on beneficial microorganisms and yield of capsicum (*Capsicum annuum* L. var. *grossum*)” that, the application of jeevamrut resulted in 7.98 to 26.20 per cent increase in fruit yield of chili as compared to no jeevamrut the application. Higher yield of capsicum was documented with the application of jeevamrut @ 500-liter ha⁻¹ (32.26, 39.55, 51.63, 121.20, 100.280, 86.40, 50.05 q ha⁻¹ at 60, 70, 80, 90, 100, 110 and 120 DAT respectively). The 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 plant⁻¹ (126.12 to 125.67 g) could be due to the application of jeevamrut.

Kesarwani (2007) investigated on the topic “Effect of organic nutrient management practices on the stalk yield and juice quality of sweet sorghum (*Sorghum bicolor* L. Monech) for ethanol production” mentioned that the application of jeevamrut as soil the application + haulm mulch to sweet sorghum improved the ear head weight per plant, 100 seed weight and total biomass production which were at par with 100 % RDF.

Kasbe *et al.* (2009) investigated on the topic “Characterization of farmers jeevamurtha formulations with respect to aerobic rice”. The study advocates that jeevamruta is an efficient bio-resource and could be a component of INM for aerobic rice.

Manjunatha *et al.* (2009) investigated on the topic “Effect of farm yard manure treated with jeevamrut on yield attributes, yield and economics of sunflower (*Helianthus annuus* L.)” examined the comparative effect of farm yard manure and jeevamrut on yield attributes, yield and economics of sunflower. the application of FYM @ 7.5 t ha⁻¹ + 100 % RDF, significantly increased the test weight (49.26 g), seed yield

(1774 kg ha⁻¹) and stalk yield (4.21 t ha⁻¹) compared to control (36.62 g, 851 kg ha⁻¹, 2.83 t ha⁻¹, respectively). And, this treatment was found at par with FYM @ 7.5 t ha⁻¹ + jeevamrut 500 l ha⁻¹.

Sreenivasa *et al.* (2009) investigated on the topic “Beneficial traits of microbial isolates of organic liquid manures” at ANGRAU, Hyderabad, reported that organic liquid manures viz., panchagavya, beejamrut and jeevamrut prepared by using cow products are known to contain beneficial microflora like Azospirillum, Azotobacter, phosphobacteria, Pseudomonas, lactic acid bacteria and Methylotrrophs in abundant numbers and also contain some useful fungi and *actinomyces*.

Nileema and Sreenivasa (2009) investigated on the topic “Influence of liquid organic manures on growth, nutrient content and yield of tomato (*Lycopersicon esculentum* Mill.)” at Department of Agricultural Microbiology, University of Agricultural Sciences, Dharwad, India, to study the influence of liquid organic manures viz., panchagavya, jeevamruth and beejamruth on the growth, nutrient content, yield and quality of tomato in the sterilized soil during *Kharif*. In the present study, significantly highest plant growth and root length was recorded with the the application of RDF+ beejamruth + jeevamruth + panchagavya and it was found to be significantly superior over other treatments. The the application of beejamruth + jeevamruth + panchagavya was next best treatment and resulted in significantly highest yield as compared to RDF alone. The N, P and K concentration of plants was significantly highest in the treatment given RDF + beejamruth + jeevamruth + panchagavya.

Manjunath *et al.* (2009) investigated on the topic “Effect of farm yard manure treated with jeevamrut on yield attributes, yield and economics of sunflower (*Helianthus annuus* L.)” studied the effect of farm yard manure treated with jeevamrut on soil properties and yield of sunflower. They also found that the the application of jeevamrut increased the activity of microbes by solubilization and nutrient uptake was enhanced.

Aulakh *et al.* (2013) investigated on the topic “Evaluation of microbial culture (jeevamruth) preparation and its effect on productivity of field crops” reported that pH of jeevamrut prepared from dung and urine of buffalo, Indian cow and hybrid cow decreased progressively with time from 8.32, 7.89 and 7.71 at the beginning to 3.86,

3.65 and 3.56, respectively after 5 days of incubation and this is ascribed to the increased activity of acid producing microorganisms. The jeevamrut solutions from the excreta of buffalo, Indian cow and hybrid cow contained 0.22, 0.04 and 0.60g nitrogen, 0.11, 0.04 and 0.06 g phosphorus, 1.09, 0.28 and 0.75 g potassium and 0.46, 0.43 and 0.39 g sulphur litre⁻¹, respectively. Also, the jeevamrut the application resulted in significantly higher counts of bacteria and fungi in soil under all the crops grown under experiment.

Goveanthan *et al.* (2016) studies on “Biochemical evaluation of organic inputs (Jeevamruth and Beejamruth) and their efficacy on Greens” was carried out. Results of plant height, root length and single plant weight are high in the treatment T₃ (Jeevamruth 5 % spray). From the results, the the application of Jeevamruth and Beejamruth as a 5 % spray was observed as a viable organic approach to improve soil and eco-friendly fenugreek production.

Hameedi *et al.* (2018) investigated on the topic “Effect of organic nutrient sources on growth, yield and quality of bell pepper (*Capsicum annuum* L.)” under mid hill condition of Himachal Pradesh reported that the application of vermicompost @ 7 t ha⁻¹ along with jeevamrut significantly influenced growth and yield attributes of bell pepper and recorded 82.4 per cent increase in yield over control along with less incidence of insect-pest and diseases.

Spehia *et al.* (2018) investigated on the topic “Lettuce growth and yield in Hoagland Solution with an organic concoction” observed the effect of hoagland nutrient solution (HNS) and jeevamrut on growth, yield and quality of lettuce using nutrient film technique compared to grow bags. Treatment with hoagland nutrient solution + 5 per cent the application of jeevamrut in nutrient film technique reported an increase in numbers of leaves, root length, leaf area and yield by 40, 34, 24 and 24 per cent, respectively, over the control (fertigation with hoagland nutrient solution in grow bags). The water used for hydroponics was 22 times less compared to grow bags. Growing lettuce in hydroponics fertilized with hoagland nutrient solution + 5 per cent the application of jeevamrut using the nutrient film technique produced good quality lettuce with higher yield.

Reshma *et al.* (2019) investigated on the topic “Growth and yield of Cowpea [*Vigna unguiculata* (L.) Walp] as influenced by jeevamrutha and panchagavya the application” reported that interaction effect of jeevamrutha and panchagavya was

significant in enhancing the seed yield of cowpea besides improvement in yield attributes like number of pods per plant, length of pods, pod weight, number of seeds per pod, seed weight per plant and 100 seed weight. Nodule characteristics – total and effective number of nodules as well fresh and dry weight of nodules was also significantly influenced by jeevamrutha and panchagavya the application at different levels and also due to their interaction. Liquid organic formulations–jeevamrutha and panchagavya are effective in producing higher seed yield in cowpea.

Nitin and Purohit (2021) conducted experiment on “Effect of different Jeevamrut based liquid organic formulations on biochemical properties of soil and on plant growth of black gram [*Vigna mungo* (L.)” under pot culture conditions. The research shows the combined the application of organic fertilizers yield high in terms of plant height, dry matter accumulation, number of pods plant⁻¹, number of seeds pod⁻¹, test weight (g), seed yield plant⁻¹, haulm yield plant⁻¹, biological yield plant⁻¹, bacterial count(cfu ml⁻¹), fungal count (cfu ml⁻¹), actinomycetes (cfu ml⁻¹), nitrogen content (%) phosphorus content (%) and potassium content (%)

Robin *et al.* (2021) investigated on the topic “Effect of bio-manures on growth and development of tomato (*solanum Lycopersicon* L.)” proofed that the application of either organic input has potential for the sustainable crop production system, that assist to boost in food production and provides nutritional security for human as well as save the soil health and environment. However, combine the application of both liquid manures will give enhance results for both crops and soil.

2.6 Effect of Organic Formulation Combinations on Growth, Yield and Quality of Chickpea

Jadhav *et al.* (1997) conducted an experiment on “Influence of the conjunctive use of FYM; vermicompost and urine on growth and nutrient uptake in rice” reported that effect on growth attributes was well pronounced with the application of 10 t ha⁻¹ vermicompost and urine. Increase in plant height, number of tillers and dry matter production due to vermicompost the application.

Chandrakala (2008) investigated on the topic “Effect of FYM and fermented liquid manures on yield and quality of chilli. Biology and Fertility of Soils” reported that dehydrogenase activity was significantly influenced by the the application

of organic manures and liquid organic manures at both 120 DAT and 160 DAT. Among liquid organic manures, the treatment given beejamruth + jeevamrut + panchagavya realized significantly higher dehydrogenase activity of 26.69 and 22.24 $\mu\text{g TPF g}^{-1} \text{ soil day}^{-1}$ at 120 DAT and at 160 DAT respectively as compared to panchagavya and control, but it was on par with beejamrut + jeevamrut at 120 DAT. The interaction effects of manures and liquid manures did not show any significant difference.

Shwetha and Babalad (2008) investigated on the topic “Effect of nutrient management through the organics in soybean-wheat cropping system in medium deep black clay loam soil”. They observed a significant improvement in plant height, accumulation of dry matter, number of branches, leaf area index (LAI) and seed yield. With the the application of organic manures in combination with fermented organics such as beejamrut, jeevamrut and panchagavya over organics alone the application, the yield parameters like number of pods plant⁻¹ were significantly higher.

Sreenivasa *et al.* (2009) investigated on the topic “Beneficial traits of microbial isolates of organic liquid manures” reported that organic liquid manures viz., panchagavya, beejamrut and jeevamrut prepared by using cow products are known to contain beneficial microflora like *Azospirillum*, *Azotobacter*, phosphobacteria, *Pseudomonas*, lactic acid bacteria and Methylotrrophs in abundant numbers and also contain some useful fungi and *actinomycete*, and even reported the amount of total nitrogen, total phosphorous and potassium content of liquid organic manures, at ANGRAU, Hyderabad.

Venkataramana *et al.* (2009) studied on “Efficacy of foliar spray of vermiwash and cow urine on biochemical and yield and yield attributes of mulberry (*Morus alba* L.)”. concluded that influence of foliar sprays of vermiwash and cow urine on leaf yield and yield attributing parameters in comparison to control in Mulberry. It was found that the leaf yield (72600 kg ha⁻¹ year⁻¹) and yield attributing parameters such as height plant (199.50 cm). length of shoot plant⁻¹ (189 cm), number of branches plant⁻¹ (13.00), number of leaves plant (155), weight of leaves plant (1.2 kg). leaf moisture content (73 %) and leaf moisture retention capacity (85 %) were significantly higher in 200 ppm vermiwash, followed by 200 ppm cow dung wash, 150 and 100 ppm vermiwash and 150 and 100 ppm cow dung wash treatment in a descending order.

Patil *et al.* (2012) investigated on the topic conducted field experiment on “Effect of organics on growth and yield of chickpea (*Cicer arietinum* L.) in vertisols”, at Agricultural Research Station, Annigeri, UAS, Dharwad during *Rabi* season. The soil the application of organic manures (panchagavya @ 3 %, Cow Urine @ 10 %, Vermiwash @ 10 %) and foliar spray of liquid organic manures at flower initiation and 15 days after flowering significantly enhanced the growth and yield parameters of chickpea viz., plant height, number of branches, Leaf Area Index, Total Dry Matter, number of root nodule and dry weight of nodules, number of pods plant⁻¹, 100-seed weight, seed yield, haulm and biological yield. B:C ratio of (2.34) was recorded in combined spray.

Pawar *et al.* (2013) investigated on the topic “Effect of different organic inputs on yield, economics and microbial count of sweet corn (*Zea mays* var. *Saccharata*)”. Studied that the application of vermicompost 2.5 t ha⁻¹ + jeevamrut + farmyard manure @ 5 t ha⁻¹ at 30 and 45 DAS to *kharif* sweet corn recorded significantly higher cob and green fodder yield. Microbial count of bacteria, fungi was also increased significantly in this treatment over control. However, the effect of this treatment was found to be at par with the application of vermicompost @ 2.5 t ha⁻¹ + FYM @ 5 t ha⁻¹.

Dwivedi *et al.* (2014) investigated on the topic “Integrated nutrient management in cape gooseberry (*Physalis peruviana*)” and studied the effect of organic amendments like amritpani, jeevamrut + vermicompost and FYM and noted positive impacts on physico-chemical properties of soil.

Kaswala (2014) conducted field experiment to study the “Effect of organic growth promoters on yield and quality of Chickpea (*Cicer arietinum* L.) grown on organic farm”, at certified organic farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari. Recorded significantly higher values of plant height, plant spread, number branches per plant, number of pods per plant at 60 DAS and at harvest as well as other ancillary growth and yield attributing parameters. Significantly higher seed (952.30 kg ha⁻¹) and stover (1870.55 kg ha⁻¹) yield of chickpea were observed under the treatment of the application of vermicompost + Cow urine (2 %) (T₃) which was at par with treatment T₄ and T₅ in case of seed yield and with T₄, T₅ and T₂ in case of stover yield.

Amareswari and Sujathamma (2015) investigated on the topic conducted experiment on “Effect of vermicompost, jeevamrutha, panchagavya and mulching on the cost-benefit ratio in French bean”.

Yogananda *et al.* (2015) investigated on the topic “Growth and yield of cowpea as influenced by different sources of organic manures - National Symposium on Organic Agriculture for Sustainable Food Security” Reported that the application of 100 percent N equivalent compost along with recommended dose of FYM @ 10 t ha⁻¹, Jeevamrut @ 500 liter ha⁻¹ and beejamrut @ 200 liter ha⁻¹ significantly increased the plant height (70.13 cm), number of leaves (63.53), number of branches (8.47), seed yield (1740 kg ha⁻¹) and stover yield (1864 kg ha⁻¹) of cowpea.

Patil and Udmale (2016) investigated on the topic “Response of different organic inputs on growth and yield of soybean on inceptisol” at Rahuri, Maharashtra reported that the application of FYM + vermicompost (50 %) + jeevamrut 2 times (30 and 45 DAS) to soybean recorded significantly higher values for growth, yield attributes and yield of soybean. The the application of FYM + vermicompost (50 % each) + jeevamrut 2 times at 30 and 45 DAS showed higher protein and oil content in soybean seed in comparison to other treatments used.

Samir (2016) conducted experiment on “Effect of plant growth regulators, vermiwash and cow urine on vegetative growth, flowering, corm production and vase life of gladiolus var. candyman”. Ascertained that GA3 at 200 ppm + cow urine @ 10 % + vermiwash @ 10 % produces higher in plant height, number of shoots, days to 50 % flowering, number of florets spike⁻¹ weight of corms plant⁻¹, number of cormels plant⁻¹ and number of corms ha⁻¹.

Atal and Thakur (2017) investigated on the topic “Effect of Organic Nutrient Sources on Bell Pepper (*Capsicum annuum* L.) Production”. Reported that combined the application of vermicompost @ 7 t ha⁻¹ along with jeevamrut (drenching + foliar spray) resulted in significantly maximum plant height (66.00 cm), number of branches plant⁻¹ (3.20), leaf area (85.39 cm²), fruit weight (59.33 g), number of fruits plant⁻¹ (29.13), fruit yield plot⁻¹ (24.73 kg) and fruit yield (366.42 q ha⁻¹) of bell pepper. Vermicompost @ 7 t ha⁻¹ along with jeevamrut recorded 82.4 per cent rise in yield of bell pepper over control along with increase in soil available N P K contents and N P K

uptake. However, FYM @ 10 t ha⁻¹ + vermicompost 3.5 t ha⁻¹ along with jeevamrut documented highest TSS (6.20 °B) and ascorbic acid content (181.33 mg 100 g⁻¹)

Jitendra *et al.* (2016) conducted field experiment during *Rabi* to find out “Effect of different organic manures on growth and yield of chickpea (*Cicer arietinum* L.)”. Results revealed that the application of vermicompost 2 t ha⁻¹ recorded significantly tallest plant (54.70 cm), total number of root nodules (40.73 plant⁻¹), effective root nodules (36.05 plant⁻¹), dry matter accumulation (18.61 g plant⁻¹), pods (50.12 plant⁻¹), seed yield (1916 kg ha⁻¹) and haulm yield (2998 kg ha⁻¹) compared to other organic manure treatments. Among liquid organic manures, the application of panchagavya 3 per cent remained on par with vermiwash 10 per cent also recorded significantly tallest plant (54.48 cm), total number of root nodules (39.78 plant⁻¹), effective root nodules (35.10 plant⁻¹), dry matter accumulation (17.90 g plant⁻¹), pods (49.54 plant⁻¹), seed yield (1888 kg ha⁻¹) and haulm yield (2804 kg ha⁻¹) as compared to cow urine and control, respectively.

Patel *et al.* (2017) conducted experiment on “Impact Evaluation of Cow-Urine and Vermiwash on Insect Pests of Brinjal” ascertained that spray of 25 per cent cow urine + 25 per cent vermiwash decrease the pest population and improves the fruit yield.

Boraiah *et al.* (2018) investigated on the topic “Effect of Panchagavya, Jeevamruta and Cow Urine on Beneficial Microorganisms and Yield of Capsicum (*Capsicum annuum* L. var. *grossum*)”, at AICRP (SM), PC unit, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka, India, The experiment consisting 12 treatment combinations with three factors viz., Jeevamruta (2 levels), Cow urine (2 levels) and Panchagavya (3 levels). Among different organic liquid formulations, the application of jeevamrut recorded significantly higher fruit yield (32.26, 39.55, 51.63, 121.20, 100.28, 86.40, 50.05 q ha⁻¹ at 60, 70, 80, 90, 100, 110 and 120 DAT, respectively.

Mahmad *et al.* (2018) investigated on the topic “Evaluation of Some Cow-based Bio-enhancers and Botanicals for Organic Cultivation of Summer Groundnut” in *summer* season at Junagadh (Gujarat) to evaluate some cow-based bio-enhancers (Panchagavya, Beejamrut, Jeevamrut, Amrutpani, Sanjivak and cow urine) and botanicals

(Seaweed extract and Banana pseudo stem sap) for organic cultivation of summer groundnut. The results revealed that the application of FYM @ 5 t ha⁻¹ produced significantly higher pod (1653 kg ha⁻¹) and haulm (3387 kg ha⁻¹) yields, followed by panchagavya as foliar spray @ 3 % at 30, 45 and 60 DAS (1397 and 2954 kg ha⁻¹), and seaweed extract as foliar spray @ 3.5 % at 30, 45 and 60 DAS (1200 and 2623 kg ha⁻¹). While significantly the lowest pod (504 kg ha⁻¹) and haulm (2108 kg ha⁻¹) yields were recorded under the control.

Safiullah *et al.* (2018) investigated on the topic “Effect of solid and liquid organic manures on growth, yield and economics of sweet corn (*Zea mays* L. Var. *Saccharata*)” observed significant higher plant height, cob weight plant⁻¹, green cob (16145 kg ha⁻¹) and fodder (20068 kg ha⁻¹) yield; cob length and cob and stem girth of sweet corn was noted with the application of jeevamrut, panchagavya and sanjeevak @ 600 l ha⁻¹, respectively. The higher total reducing (3.19 %) and non-reducing sugar (19.57 %) content was recorded under the the application of treatments panchagavya and jeevamrut, receiving panchagavya and jeevamrut @ 600-liter ha⁻¹).

Suchit *et al.* (2018) conducted experiment on “Effect of organic priming on seed germination behaviour and vigour of chickpea (*Cicer arietinum* L.)” during *Rabi* season of 2018, to study the effect of organic priming on seed germination behaviour and vigour of chickpea (*Cicer arietinum* L.) of Gaurav variety, with 4 replication and 9 treatments comprised of Control, Distilled water, vermiwash (2 % solution), vermiwash (6 % solution), cow urine (2 % solution), cow urine (6 % solution), curry leaf extract (2 % solution) and curry leaf extract (6 % solution) found that all the organic priming methods showed significance difference with the control and the highest germination (%), seedling length, fresh weight of seedling (g), dry weight of seedling (g), seedling vigour index length and seedling vigour index mass were observed in (T₃) for vermiwash at 6 per cent and followed by (T₅) cow urine 6 per cent.

Bishal and Indrajit (2019) “Quality Analysis and Characterization of Panchagavya, Jeevumrutha and Sasyamrutha” ascertained those liquid organic formulations have high content of total nitrogen, total phosphorus and total potassium and higher microbial load of bacteria, fungi, actinomycetes, *E.coli*, *Azospirillum*, *Azotobacter*, P solubilizers, K solubilizers, *Pseudomonas* and *Rhizobium*. Ravina Kumari

et al. (2019) conducted an experiment entitled “Studies on Effect of organic nutrient sources on nutrient uptake and different soil properties in onion (*Allium cepa* L.)” and the results revealed that treatment T₈ [vermicompost @ 8 t ha⁻¹ + jeevamruta (drenching, 5 %)] recorded maximum N, P, K content in soil (336.16, 62.24 and 362.644 kg ha⁻¹) and N, P, K uptake by plant (141.93, 24.86 and 47.19 kg ha⁻¹).

Vora *et al.* (2019) conducted experiment on “Effect of Foliar the application of Organic and Inorganic Substances on the Yield of Chick Pea under Limited Water Supply” ascertained that organic fertilization improves plant height, number of branches, plant spread, number of mature pods, harvest index, seed index, seed weight pod yield, seed yield, haulm yield, biological yield, harvest index, gross income, cost of cultivation, net income and B:C ratio of chick pea.

Dhananjay *et al.* (2020) conducted experiment on “Growth and Yield of a Chickpea (*Cicer arietinum*) and Mustard (*Brassica juncea*) as Influenced by Row Ratio and Liquid Manures” advocated that chickpea + mustard 3:1 row ratio intercropping system along with liquid organic fertilizers had higher plant height (cm), number of nodules plant⁻¹, dry weight plant⁻¹, days to flowering, days to maturity, seed index, protein content and excellent seed yield of chick pea.

Manoj *et al.* (2020) conducted experiment on “significance of liquid organic manures in sustainable crop production” at Department of Agronomy, UAS, GKVK, Bengaluru, Karnataka, India. Reported that foliar spray of 5 % jeevamrut at 20, 40 and 60 DAS recorded significantly higher plant height (202.57 cm), leaf area index (8.09), cob length (22.38 cm), cob girth (14.07 cm), number of seeds per cob (438.73), seed yield (5863 kg ha⁻¹) and stover yield of maize (8119 kg ha⁻¹) but it was found on par with 5 % beejamrutha the application at 20, 40 and 60 DAS. Combined the application of recommended dose of fertilizers and 4 sprays of 3 % panchagavya at 15, 25, 35 and 45 DAS resulted in higher plant height (199 cm), leaf area index (5.77), green cob yield (7476 kg ha⁻¹) and fodder yield (33.37 t ha⁻¹) of baby corn when compared to sole the application of recommended dose of fertilizers as soil the application resulted in maximum number of Rhizobium, Azospirillum and Azotobacter population in experimental soil 13 per cent over control. Combined the application of beejamrutha + jeevamrut + panchagavya recorded significantly higher uptake of N, P and K (102.74,

11.99 and 98.65 kg ha⁻¹, respectively) as compared to beejamrutha + jeevamruta the application (60.61, 12.98 and 58.47 kg ha⁻¹, respectively).

Maksudan (2021) demonstrated a concept on “studies on effect of organic and inorganic fertilizers on growth, yield and quality of pomegranate under precision farming” ascertained that the application of 80 % RDF + vermiwash + cow urine through drip improves plant height, no of shoot plant⁻¹, plant spread, number of fruits plant⁻¹ and fruit weight and volume plant⁻¹.

Shakil (2021) conducted experiment on “Effect of cow urine and vermiwash the application on growth and yield of organic chickpea” ascertained that the application of cow urine 10 ml litre⁻¹ + vermiwash 10 ml litre⁻¹ at flowering and pod formation stage recorded significantly higher growth yield and quality parameters.

3. MATERIAL AND METHODS

The details of various material used and experimental methods adopted for conducting the present investigation entitled “Effect of liquid organic formulations on growth, yield and quality of chickpea (*Cicer arietinum*)” are described in this chapter under suitable heads and subheads.

3.1 Details of Experimental Material

3.1.1 Experimental site

The present experiment was conducted at Organic Farming Research and Training Centre, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra (MH), India.

3.1.2 Soils

The soils of experimental area are grouped under inceptisol order and clay loam in texture with more than 90 cm depth having the topography of experimental field as uniform and levelled. The representative initial soil samples were collected for assessing the initial soil fertility status. These soil samples were thoroughly mixed and the composite soil sample was prepared and analysed for physical and chemical properties of soil. The experimental soil was clay loam in texture, saline in reaction (pH 7.7), moderate in organic carbon (0.58 %) with electrical conductivity (0.35 dSm^{-1}). The soil was low in available nitrogen ($171.43 \text{ kg ha}^{-1}$), medium in available phosphorus (16.13 kg ha^{-1}) and very high in available potassium ($384.53 \text{ kg ha}^{-1}$) respectively. The total count of soil microbes like bacteria ($14 \times 10^7 \text{ g}^{-1}$ of soil), fungi ($11.6 \times 10^5 \text{ g}^{-1}$ of soil) and *actinomycetes* ($8.3 \times 10^4 \text{ g}^{-1}$ of soil), were observed at optimum level before starting of experiment. In nutshell, soil was suitable for chickpea cultivation. The physical and chemical properties are given in Table 3.1.

3.1.3 Climate and weather during the experimental period

The present experiment entitled the “Effect of liquid organic formulations on growth, yield and quality of chickpea” was conducted at Organic Farming Research and Training Centre, MPKV, Rahuri, during *Rabi* season of 2021-22, geographically situated at $19^{\circ} 32' \text{ N}$ latitude and $74^{\circ} 65' \text{ E}$ latitude with altitude 501.0 m above MSL. Climatologically, this area falls in the semi-arid tract with average annual rainfall of 527

mm receives in 15 to 45 rainy days. The climatic parameters, mean maximum temperature (24.7 to 37.8 °C), mean minimum temperature (12.0 to 22.9 °C), relative humidity during morning hour (55.3 to 92.7 %), evening hour (16.0 to 54.4 %), wind velocity (0.4 to 2.1 km hr⁻¹), bright sunshine hours (4.7 to 10.0 Hrs) and open pan evaporation (3.0 to 8.6 mm) was recorded during experimentation. Climate and weather during investigation is given in Table 3.2.

Table 3.1. Initial Physical, chemical and biological properties of experimental site and organic formulations

Sr. No.	Particular	Composition	Method used	Reference/ s
I.	Physical properties of soil			
1.	Particle size distribution		International pipette method	Piper (1966)
i.	Coarse sand (%)	7.12		
ii.	Fine sand (%)	12.72		
iii.	Silt (%)	35.44		
iv.	Clay (%)	44.14		
v.	Soil texture	clay loam		
II.	Chemical properties of soil			
1.	pH (1:2.5 soil: water)	7.70	Potentiometry	Jackson (1973)
2.	EC (dSm ⁻¹)	0.35	Conductometry	Jackson (1973)
3.	Organic carbon (%)	0.58	Wet oxidation	Nelson and Sommer (1982)
4.	Available nitrogen (kg ha ⁻¹)	171.43	Alkaline potassium permanganate	Subbiah and Asija (1956)
5.	Available phosphorus (kg ha ⁻¹)	16.13	0.5M. NaHCO ₃ (pH 8.5)	Watanabe and Olsen <i>et al.</i> (1965)
6.	Available potassium (kg ha ⁻¹)	384.53	Flame photometry NN NH ₄ OAc (pH 7.0)	Jackson (1973)
III.	Biological properties of soil			
1	Bacteria (Cfu x 10 ⁻⁷ g ⁻¹ of soil)	14.00	Serial dilution planting technique	Dhingra and Sinclair (1993)
2	Fungi (Cfu x 10 ⁻⁵ g ⁻¹ of soil)	11.60		
3	<i>Actinomycetes</i> (Cfu x 10 ⁻⁴ g ⁻¹ of soil)	8.30		

Table 3.2. Meteorological data during period December 2021 to March 2022

MW	Date	Temp (⁰ C)		Relative Humidity (%)		Wind Velocity (km. hr ⁻¹)	Rainfall (mm)	Bright sun-shine (hrs.)	Open pan evaporation (mm)
		Max	Min	Morn.	Even.				
December, 2021									
49	03-9	26.2	17.4	92.7	54.4	0.9	6.8	4.7	3.0
50	10-16	28.2	15.9	87.3	46.3	0.6	0.0	5.7	3.8
51	17-23	27.8	12.6	90.6	39.0	0.4	0.0	7.3	4.2
52	24-31	27.6	13.8	91.4	46.4	0.4	0.0	6.3	3.7
January, 2022									
1	01-07	28.3	15.0	91.1	41.6	0.4	0.0	5.7	4.1
2	08-14	25.2	14.6	88.0	54.1	1.5	0.0	5.7	3.1
3	15-21	26.7	14.0	88.7	44.1	0.5	0.0	6.9	3.1
4	22-28	24.7	12.0	82.1	41.9	2.0	0.0	7.5	3.0
5	29-04	28.7	12.1	81.9	24.3	0.8	0.0	10.0	3.8
February, 2022									
6	05-11	27.3	13.2	80.6	33.4	1.5	0.0	9.6	4.3
7	12-18	29.2	14.4	80.1	29.9	0.7	0.0	9.5	4.0
8	19-25	33.0	16.1	73.1	23.3	1.0	0.0	9.7	5.5
9	26-04	33.6	18.6	62.0	21.8	0.7	0.0	8.8	6.0
March, 2022									
10	05-11	32.3	19.7	72.9	29.6	1.4	0.0	7.0	5.6
11	12-18	35.7	21.1	59.4	17.6	2.0	0.0	9.0	6.8
12	19-25	37.6	22.5	55.3	16.0	2.1	0.0	7.1	7.6
13	26-28	37.8	22.9	59.3	16.7	1.5	0.0	8.2	8.6

3.1.4 Cropping history of the experiment field.

The cropping programme followed on the experimental plot for the previous year preceding the present investigation is given in the Table.3.3 which indicates that proper crop rotation was followed.

Table 3.3. Cropping history of the experiment field

Year	Season		
	<i>Kharif</i>	<i>Rabi</i>	<i>Summer</i>
2018-2019	Soybean	Wheat	Fallow
2019-2020	Soybean	Chickpea	Fallow
2020-2021	Soybean	Chickpea	Fallow

3.2 Details of experimental method

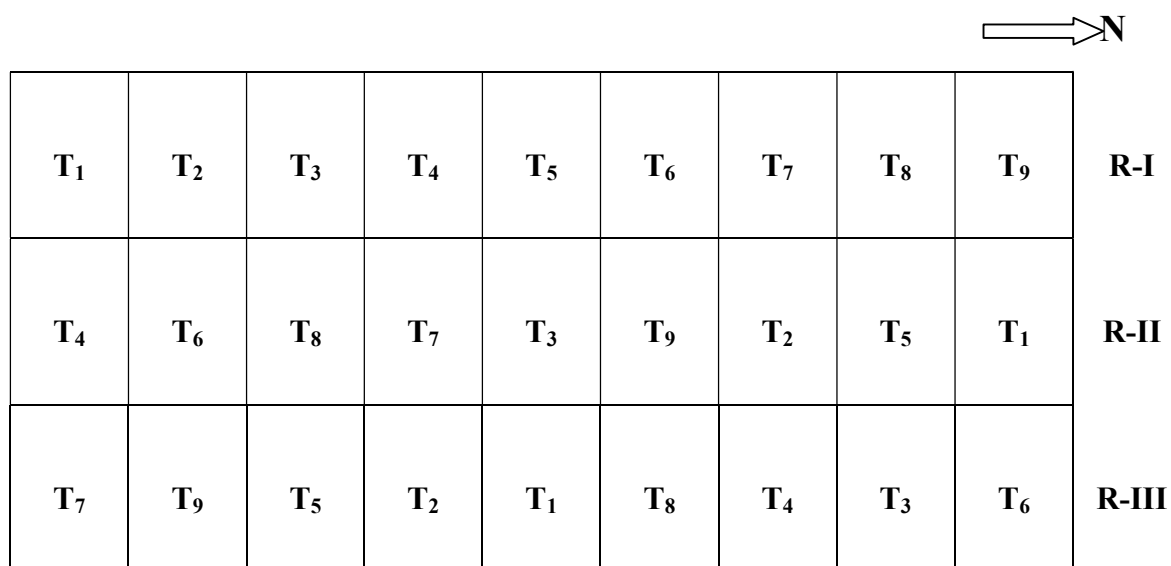
3.2.1 Experimental details

The experiment was laid out in Randomized Block Design with three replications. Nine different treatments were applied through different sources.

3.2.2 Preparation of field layout

The plan of experiment layout is given below and depicted in Fig.1.

Fig. 1. Plan of layout of experiment



T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇	T ₈	T ₉	R-I
T ₄	T ₆	T ₈	T ₇	T ₃	T ₉	T ₂	T ₅	T ₁	R-II
T ₇	T ₉	T ₅	T ₂	T ₁	T ₈	T ₄	T ₃	T ₆	R-III

3.2.3 The details of treatments

Table 3.4 Experimental details

1	Name of crop	Chickpea (<i>Cicer arietinum</i> L.)
2	Variety	Phule Vikram
3	Seed rate	75 kg ha ⁻¹
4	Design	Randomized Block Design (RBD)
5	Plot size	Gross :12 m x 3 m
		Net: 11.4 m x2.4 m
6	Treatments	9
7	Replications	3
8	Spacing	30 cm x 10 cm
9	Number of plots	27
10	Sowing layout	Ridges and Furrow.

11	GRDF	2 ton ha ⁻¹ of vermicompost
12	Time of foliar spray	At branching, At flowering and Pod initiation stage
13	Place of Research	Organic farming Research and Training Centre, MPKV, Rahuri.

3.2.4 Treatments

Table 3.5 Treatment details

Symbol	Treatment
T ₁	Control
T ₂	Foliar spray of cow urine @ 10 %
T ₃	Foliar spray of vermiwash @ 10 %
T ₄	Foliar spray of panchagavya @ 3 %
T ₅	Foliar spray of waste decomposer @ 25 %
T ₆	Foliar spray of jeevamrut @ 10 %
T ₇	Foliar spray of cow urine @ 10 % + vermiwash @ 10 %
T ₈	Foliar spray of cow urine @ 10 % + waste decomposer @ 25 %
T ₉	Foliar spray of vermiwash @ 10 % + waste decomposer @ 25 %

Note : Spraying at branching, flowering and pod initiation stage.

3.3 Cultural operations

Date wise schedule of the cultural operations in the experimental field of chickpea during period of experimentation are given in Table 3.6.

3.3.1 Certification of the field.

Certification of the field was done from Karnataka State Organic Certification Agency (KSOCA) Bengaluru, Karnataka, India.

3.3.2 Preparation of the field

The experimental land was ploughed, followed by Rotovator to remove the weeds and to crush the clods. Soil was finally smoothened to prepare seed bed. The plots were laid out and levelled within each plot and furrows were opened at 30 cm distance with the help of tractor according to layout of the experiment. The field was divided in to 27 plots. The plan of layout depicted in Fig.1

Table 3.6. Schedule of cultural operations carried out during the experimental period (*Rabi*, 2021-22)

Sr. No.	Name of Operation	Frequency	Date
A.	Preparatory tillage		
1.	Site selection	1	7-12-2021
2.	Ploughing	1	9-12-2021
3.	Rotovator	1	10-12-2021
4.	Field layout	1	11-12-2021
5.	the application of Vermicompost	1	28-11-2021
B.	Sowing		
1.	Sowing	1	12-12-2021
C.	Organic formulation preparation		
1.	Panchagavya	1	13-12-2021 to 4-12-2021
2.	Vermiwash	1	16-12-2021
3.	Jeevamruth	1	11-1-2022 to 26-1-2022
4.	Waste decomposer	1	13-2-2022
5	Cow urine collection	1	23-2-2022
D.	Post sowing operations		
1.	Gap filling	1	19-12-2021
2.	Thinning	1	22-12-2021
3.	Hand weeding	1	30-12-2021
D.	Irrigations		
1.	1st	1	12-12-2021
2.	2nd	1	16-1-2022
3.	3rd	1	19-2-2022
E.	Foliar the application		
1.	1 st (Branching stage)	1	14-01-2022
2.	2 nd (Flowering stage)	1	8-02-2022
3.	3 rd (Pod initiation stage)	1	24-02-2022
F.	Plant protection measures		
1.	Flower initiation stage	2	2-02-2022
G.	Harvesting	1	26-3-2022
H.	Threshing	1	28-3-2022

3.3.3 Manure the application

Organic manure *i.e.* vermicompost was applied to all treatments @ 2 t ha⁻¹ 15 days before crop sowing for experimentation.

3.3.4 Seed material

The certified seed of chickpea variety Phule Vikram with crop duration of 105-110 days and seed rate 75 kg ha⁻¹ were obtained from Organic farming Research and Training Centre, MPKV, Rahuri. The information and silent features of variety are given in Table 3.7.

Table 3.7 Information regarding Phule Vikram

Release year	2016
Name of Institute / University	Mahatma Phule Krishi Vidyapeeth, Rahuri
Soil type	Well drained, medium to deep soils having 45 to 60 cm depth.
Climate	Minimum temperature 10-15 ⁰ C, Maximum temperature 25 to 30 ⁰ C, Rainfall 750 to 1000 mm, Humidity 21- 41 %
Sowing Time / Planting period.	Rainfed crop: 20 th Sept to 10 Oct Irrigated crop: 20 th Oct to 10 Nov Late sown: First week of December
Seed Rate (Per acre)	Seed rate: 75 kg ha ⁻¹
Crop duration	105-110 Days
Productivity	Rainfed: Trial Yield: 16-18 q ha ⁻¹ , Average yield: 16.00 q ha ⁻¹ Irrigated: Trial Yield: 40-42 q ha ⁻¹ , Average yield: 22.00 q ha ⁻¹ Late sown: Trial Yield: 22-24 q ha ⁻¹ , Average yield: 21.00 q ha ⁻¹
Characters / features	Tall growth habit hence suitable for mechanical harvesting, medium size yellowish brown seeds, Wilt resistant, suitable for rainfed, irrigated and late sown conditions, Released for Maharashtra.

3.3.5 Liquid organic formulations preparation and the application

Bioinoculants like cow urine, vermiwash, panchagavya, waste decomposer, jeevamruth and their combinations were used to spray in the present investigation. These formulations were sprayed at branching, flowering and pod initiation stage of chickpea.

3.3.5.1 Cow urine

Desi cow urine was diluted at 1:10 (cow urine: water) and sprayed treatment wise at 3 stages of crop. *i.e.* branching, flowering and pod initiation stage of chickpea.

3.3.5.2 Vermiwash

Saturated wash from vermicompost is collected and sprayed by diluting at 1:10 (vermiwash: water) and sprayed treatment wise at 3 stages of crop. *i.e.* branching, flowering and pod initiation stage of chickpea.

3.3.5.3 Panchagavya

Panchagavya was prepared by mixing 7 kg of desi cowdung, 1 kg of cow ghee stirred for three days then added with 10 litres of cow urine and 10 litres of water, stirred for 15 days. The mixture is then added with 3 litres of cow milk, 2 litres of curd, 3 litres of tender coconut water, 3 kg of jaggery and 12 well ripened poovan banana then stir daily up to 30 days thereafter used for spraying at 3 stages of crop. *i.e.* branching, flowering and pod initiation stage of chickpea by diluting at 1:30 (Panchagavya: water) concentration.

3.3.5.4 Waste decomposer

Waste decomposer was prepared by mixing 2 kg of jaggery in 200 litres of water then added with 1 bottle of waste decomposer mixed uniformly and sprayed by diluting at 1:4 (waste decomposer: water) to 3 stages of crop. *i.e.* branching, flowering and pod initiation stage of chickpea.

3.3.5.5 Jeevamruth

Jeevamruth was prepared by mixing 10 kg of desi cow dung, 10 litres of desi cow urine, 2 kg of jaggery, 2 kg of gram flour and hand full of soil collected from farm bund. All these ingredients are mixed with 200 litres of water stirred in clockwise direction and kept in shade by covering with wet jute bag. Then sprayed by diluting at 1:10 (Jeevamruth: water) to 3 stages of crop. *i.e.* branching, flowering and pod initiation stage of chickpea.

3.3.5.6 Microbial analysis

The microbial count was taken by using the method suggested by Dhingra and Sinclair (1993). Microbial population of Fungi, Bacteria and *Actinomyces* in soil

rhizosphere and organic formulations was enumerated by using standard microbiological methods carried out after 5 days of spraying at branching, flowering and pod initiation stage.

3.3.5.7 Soil and organic formulations

Treatment wise representative soil samples were collected from the plots, 5 days after spraying of different organic formulations in replications. And also, different organic formulations used for spray is used to enumerate the microbial load.

3.3.5.8 Culture media

Various culture media were used for estimating the microbial count (bacteria, fungi and *actinomycetes* during the experiment. (a) Nutrient Agar (NA) media for bacteria, (b) Potato Dextrose Agar (PDA) media for fungi and Knight's media for *actinomycetes*.

3.3.5.9 Total bacterial count (TBC) total fungal count (TFC) and *actinomycetes* count

Soil samples were collected from the rhizosphere of the plant for counting microbial load 10 gram of soil is serially diluted up to 10^{-8} by using sterilized distilled water for enumerating bacteria, fungi and *actinomycetes* load in rhizosphere and organic formulations.

Table 3.8. Preparation of culture media.

Sr. No.	Nutrient Agar (NA) media (1 lit.)	
1	Peptone	10.00 g
2	Beef extract	03.00 g
3	Agar-agar	20.00 g
4	Distilled water	800 ml
	Potato Dextrose Agar (PDA) media (1 lit.)	
1	Potato	200 g
2	Dextrose	20.00 g
3	Agar-agar	20.00 g
4	Distilled water	1000 ml
	Knight's media (1 lit.)	
1	Dextrose	1 g
2	Potassium hexametaphosphate	0.1 g
3	Sodium nitrate	0.1 g
4	Potassium chloride	0.1 g
5	Magnesium sulphate	0.1 g
6	Agar-agar	15.0 g
7	Distilled water	1000 ml

3.3.5.10 Procedure for serial dilution plate count technique

The soil collected from root rhizosphere was powdered and 10 gram was mixed in 90 ml sterilized water to give 10^{-1} dilution. Subsequently dilution up to 10^{-8} were made by transferring serially 1 ml of the dilution into 9 ml water blanks. The population of soil bacteria was estimated at 10^{-7} dilution, fungi at 10^{-5} and *actinomycetes* at 10^{-4} dilution. The inoculated plates added with appropriate media were kept for incubation at 30°C for a week and emerged colonies were counted.

3.3.5.11 Initial analysis of organic formulations

3.3.5.11.1 Chemical properties of organic formulations

3.3.5.11.1.1 pH, EC and OC of organic formulations

Organic formulations are taken as it is in beaker, stirred properly and pH is measured by pH meter. Stirred samples are allowed to settle down and from this solution EC of organic formulation is measured with EC meter. OC of organic formulation is analysed by Nelson and Somner, dry ash method.

Table 3.9. pH, EC and OC of organic formulations

Sr. No.	Organic formulations	pH	EC (dSm^{-1})	OC (%)
1	Cow urine	6.89	7.46	1.38
2	Vermiwash	7.16	2.68	0.12
3	Panchagavya	5.46	11.84	0.77
4	Waste decomposer	7.28	0.56	0.17
5	Jeevamruth	5.81	5.32	0.24
6	Cow urine + Vermiwash	7.03	5.08	0.74
7	Cow urine + Waste Decomposer	7.09	4.02	0.78
8	Vermiwash + Waste Decomposer	7.24	1.63	0.15

3.3.5.11.1.2 N, P and K content of organic formulation

Determined quantities of organic formulations were treated with concentrated H_2SO_4 overnight for pre digestion. Then, the pre-digested samples were treated H_2O_2 and digested on sand bath at low temperature till colourless solution was obtained. This was used for further nutrient analysis.

Total N, P and K content in organic formulations were determined by the standard methods like Micro-Kjeldhal, Vandomolybdate yellow colour method in nitric acid system and Flame photometer respectively. Then the total N, P and K content was calculated and expressed in per cent.

Table 3.10. N, P and K of organic formulations

Sr. No.	Organic formulations	N (%)	P (%)	K (%)
1	Cow urine	0.80	0.11	0.55
2	Vermiwash	0.07	0.04	0.06
3	Panchagavya	0.34	0.27	0.03
4	Waste decomposer	0.08	0.13	-
5	Jeevamruth	0.14	0.41	0.08
6	Cow urine + Vermiwash	0.44	0.07	0.31
7	Cow urine + Waste Decomposer	0.42	0.12	0.28
8	Vermiwash + Waste Decomposer	0.08	0.09	0.03

3.3.5.11.2 Biological properties of organic formulations

Table 3.11. Microbial count in organic formulations

Sr. No.	Organic formulations	Bacteria (Cfu x 10^{-7})	Fungi (Cfu x 10^{-5})	<i>Actinomycetes</i> (Cfu x 10^{-4})
1	Cow urine	7.66	8.00	1.66
2	Vermiwash	9.33	8.00	5.33
3	Panchagavya	23.00	14.00	37.00
4	Waste decomposer	7.66	15.00	13.40
5	Jeevamruth	27.00	14.00	11.66
6	Cow urine + Vermiwash	9.42	9.53	4.24
7	Cow urine + Waste Decomposer	7.50	11.00	7.20
8	Vermiwash + Waste Decomposer	8.35	11.43	9.17

3.3.6 Sowing

The seeds were sown by dibbling keeping the inter row spacing of 30 cm and intra-row spacing of 10 cm.

3.3.7 Gap filling and thinning

The gap filling and thinning was carried out at one week after sowing to maintain uniform plant stand and to avoid crop competition by keeping one healthy, vigorous seedling hill⁻¹ respectively.

3.3.8 Hand weeding

One hand weeding was given to keep the plots weed free at 18 days after sowing of chickpea.

3.3.9 Irrigation

Three irrigations were applied first at the time of sowing, second irrigation at pre-flowering stage, third irrigation at pod initiation of chickpea.

3.3.10 Plant protection

The pest and disease incidence were observed during crop growth period hence the plant protection was undertaken. Spraying was carried out at flower initiation and pod filling stage by spraying Neem oil (10000 ppm) i.e. 3 ml litre⁻¹.

3.3.11 Harvesting

At physiological maturity stage, firstly all the border rows from each plot were separately harvested and then remaining plots were harvested as net plot produce. Harvesting of chickpea was done by cutting plants at their base with sickle and kept for sun drying.

3.3.12 Threshing and winnowing

The sun-dried chickpea plants were threshed separately by beating with sticks, winnowed and cleaned. By then seed and stalk yield were weighed separately from net plot. Then plot wise yield obtained were tabulated and interpreted in experimental results.

3.4 Biometric observations

3.4.1 Sampling technique

The various biometric observations were recorded on five randomly selected plants of chickpea from each net plot. Pegs were fixed near respective plots and

tags are tied to randomly selected 5 plants of plot for easy identification. The details of observations recorded during the season are presented in Table 3.1.

Table 3.12. The details of biometric and other observations recorded during experimentation (2021-2022)

Sr. No	Particulars	Frequency	Period (DAS)	Sample Size
A.	Growth studies			
1.	Initial and final plant count	1	15 DAS and at harvest respectively	All plants from each net plot
2.	Plant height (cm)	4	30, 60, 90 DAS and at harvest	5 selected and tagged plants from net plot
3.	Number of branches plant ⁻¹	4	30, 60, 90 DAS and at harvest	5 selected and tagged plants from net plot
4.	Plant spread (cm)	4	30, 60, 90 DAS and at harvest	5 selected and tagged plants from net plot
5.	Dry matter plant ⁻¹ (g m ⁻²)	4	30, 60, 90 DAS and at harvest	1 selected plant from net plot
6.	Nodule count plant ⁻¹	2	30 and 60 DAS	1 selected plant from net plot
7.	Nodule weight plant ⁻¹ (g)	2	30 and 60 DAS	1 selected plant from net plot
8.	Days to 50% flowering	1	At flowering	Net plot
9.	Days to maturity	1	At maturity	Net plot
B.	Yield and Yield attributing characters			
1.	Number of pods plant ⁻¹	1	At harvest	5 plants from net plot
2.	Number of seeds pod ⁻¹	1	At harvest	5 plants from net plot
3.	Weight of pods plant ⁻¹ (g)	1	At harvest	5 plants from net plot
4.	Seed yield plant ⁻¹ (g)	1	At harvest	5 plants from net plot
5.	Test weight (g)	1	At harvest	1000 seed from each net plot
6.	Seed yield (q ha ⁻¹)	1	At harvest	Net plot
7.	Haulm yield (q ha ⁻¹)	1	At harvest	Net plot
8.	Biological yield (q ha ⁻¹)	1	At harvest	Net plot
9.	Harvest Index (%)	1	At harvest	Net plot
C.	Quality parameters			
1.	Protein content (%)	1	At harvest	5 selected and tagged plants from net plot
2.	Total N, P and K (kg ha ⁻¹) content of chickpea samples	1	At harvest	Plant sample from each net plot.
D.	Chemical Analysis of soil			
1	pH	1	At harvest	Net plot
2	EC	1	At harvest	Net plot
3	Organic carbon (%)	1	At harvest	Net plot
4	Soil available N (kg ha ⁻¹)	1	At harvest	Net plot
5	Soil available P (kg ha ⁻¹)	1	At harvest	Net plot
6	Soil available K (kg ha ⁻¹)	1	At harvest	Net plot

Table 3.12 contd.....

Sr. No	Particulars	Frequency	Period (DAS)	Sample Size
E.	Biological studies of soil.			
1	Microbial population after every spray	3	5 days after every spray	Net plot
F.	Economics			
1	Cost of cultivation (₹ ha^{-1})	1	At harvest	Net plot
2	Gross monetary returns (₹ ha^{-1})	1	At harvest	Net plot
3	Net monetary returns (₹ ha^{-1})	1	At harvest	Net plot
4	Benefit: Cost ratio	1	At harvest	Net plot

3.4.2 Growth studies

3.4.2.1 Plant count (%)

The initial and final plant count was recorded by counting all the plants from each net plot at 15 days after sowing, when complete emergence was observed and just before harvest of the crop, respectively and were converted on hectare basis and per cent worked out on the basis of theoretical population.

3.4.2.2 Plant height (cm)

Five selected plants were used for observation of the plant height. The plant height was recorded in cm from the ground level up to the tip of the stem with the help of metric scale. Observations were started from 30, 60, 90 DAS and at harvest of five selected plant and were subsequently recorded at an interval of 30 days up to harvest. The average plant height was worked out and recorded.

3.4.2.3 Branches plant⁻¹

Number of primary and secondary branches was recorded periodically at 30, 60, 90 DAS and at harvest of five selected plant and average number of branches was worked out and recorded.

3.4.2.4 Plant spread (cm)

Plant spread shows the vigour of the plant. Plant spread (cm) was measured by taking two observations of tagged plant by measuring maximum horizontal space occupied by the plant between tips of two extreme leaves on either side of plant at 30, 60, 90 DAS and at harvest of five selected plants. The mean plant spread was reported by averaging plant spread of five observation plants.

3.4.2.5 Dry matter plant⁻¹ (g)

One representative plant from each net plot were selected randomly and uprooted at every growth stage *i.e.* at 30, 60, 90 DAS and at harvest, for dry matter studies. Roots were discarded for dry matter studies. First, plants were air dried and then in hot air oven at $55 \pm 5^{\circ}\text{C}$ until constant weight was obtained. After air cooling, the dry weight plant⁻¹ was recorded.

3.4.2.6 Root nodules count plant⁻¹ and nodule weight

The complete block of observation plant along with root and soil mass was lifted from soil. Then immediately put in water bucket and allow to wash out soil particles attached to plant roots then again roots are washed with water spray 1 plant samples of chickpea from each net plot were uprooted carefully at 60 and 90 DAS and then the numbers of effective root nodules (pink coloured) developed in chickpea counted and computed average number of nodules plant⁻¹ and fresh weight of root nodules were weighted.

3.4.2.7 Days to 50 % flowering

The days to 50 % flowering of chickpea was recorded on the basis of visual observations as the number of days required from the date of sowing to the day when 50 % anthesis of the net plot.

3.4.2.8 Days to maturity

The visual observation of pod and seed characteristics such as changes in colour of seed coat, hilum, cotyledons, pod wall, canopy and first indication of seed shrinkage (visual and volume) in pod chambers were recorded in developing and maturing chickpea. Days to physiological maturity for chickpea was recorded on the basis of visual observations as the number of days required from the date of sowing to the day when seed embryos of the plants in each plot had attained physiological maturity.

3.4.3 Yield and yield attributes

3.4.3.1 Number of pods plant⁻¹

All the pods from five sampled plants were counted separately after harvest and the average number of pods plant⁻¹ was worked out.

3.4.3.2 Number of seeds pod⁻¹

After harvest and threshing number of seeds per pod from five sampled plants were counted separately and the average number of seeds per pod was worked out.

3.4.3.3 Weight of pod plant⁻¹ (g)

The total seeds obtained from 5 observed plant were weighed separately on analytical weighing balance and average value was calculated for obtaining weight of seeds plant⁻¹.

3.4.3.4 Seed yield plant⁻¹

After harvest and threshing number of seeds per plant from five sampled plants were weighed separately and the average number of seed yield plant⁻¹ was worked out.

3.4.3.5 Test weight (g)

After harvesting and threshing of all samples from each treatment, from composite sample of net plot 1000 seeds were counted and weighted on analytical weighing balance and values were recorded and expressed in gram.

3.4.3.6 Seed yield (q ha⁻¹)

The produce was dried in sun for a week. After threshing, the seeds were cleaned of dried leaves, soil and other trash material. The seed yield from net plot⁻¹ was recorded and then converted on hectare basis by multiplying with hectare factor.

3.4.3.7 Haulm yield (q ha⁻¹)

After removing the seed from pods, the stalks along with empty pods were dried in the sun. Upon drying, the weight of the bundle of stalk plot⁻¹ was recorded. The weight plot⁻¹ was converted into q ha⁻¹ basis by utilizing hectare factor.

3.4.3.8 Biological yield (q ha⁻¹)

Biological yield of a crop is the total biomass put by a crop, and is calculated by summing up the seed yield and haulm yield.

3.4.3.9 Harvest index (%)

Harvest index of chickpea was calculated by using formula.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (q ha}^{-1}\text{)}}{\text{Biological yield (q ha}^{-1}\text{)}} \times 100$$

3.4.4 Quality parameters

3.4.4.1 Protein (%)

The nitrogen content in chickpea seed was multiplied with 6.25 protein conversion factor to calculate the protein content. (A.O.A.C., 2005)

3.4.4.2 Nutrient content of plant

3.4.4.2.1 Preparation of plant sample

The five tagged plants for estimating nutrient uptake from each plot at harvest were thoroughly washed with distilled water and dried in hot air oven at 65°C. Dried samples were powdered in a Willey mill to the considerable fineness before storing them in polythene bags for further analysis.

3.4.4.2.2 Digestion of plant samples

Powdered plant samples were treated with concentrated H₂SO₄ overnight for pre digestion. Then, the pre-digested samples were treated with H₂O₂ and digested on sand bath at low temperature till colourless solution was obtained. This was used for further nutrient analysis. The following analyses were carried out from the di-acid digested samples of powdered plant and seed.

Total N, P and K content (%) in the plant sample and organic formulations were determined by the standard methods like Micro-Kjeldhal (Parkinson and Allen, 1975) Vandomolybdate yellow colour method in nitric acid system and Flame photometer respectively. Then the total N, P and K was computed by multiplying N, P and K content in seed and haulm of plants with treatment wise yield of respective crop as followed,

$$\text{Uptake by seed (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content in the seed (\%)} \times \text{Seed yield (kg ha}^{-1}\text{)}}{100}$$

$$\text{Uptake by haulm (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content in the seed (\%)} \times \text{dry haulm yield (kg ha}^{-1}\text{)}}{100}$$

3.4.5 Soil analysis

3.4.5.1 Collection of soil samples

For identification of soil fertility status in the study area, surface (0-15 cm) soil samples were collected during March 2022. Processed soil samples were analysed for available nutrients by using standard methods

3.4.5.2 Preparation and storing of soil samples

Soil samples collected were dried under shade. The air-dried samples were ground with a wooden pestle and mortar and passed through 2 mm sieve to separate the coarse fragments (>2 mm). The fine earth samples were stored in separate containers and used for analysing pH, electrical conductivity, organic carbon, available nitrogen, phosphorous and potassium content.

3.4.5.3 Soil reaction (pH)

Soil pH was determined in 1:2.5 soil-water suspension after stirring the contents intermittently for half an hour. pH value was recorded by ELICO pH meter by potentiometric method (Jackson, 1973).

3.4.5.4 Electrical conductivity (dSm^{-1})

Soil water suspension used for measuring pH was kept overnight to get a clear supernatant solution. Electrical conductivity of supernatant was determined by ELICO Conductivity Bridge and expressed as dS m^{-1} Jackson (1973).

3.4.5.5 Organic carbon (%)

The organic carbon or easily oxidisable organic carbon content of a finely ground (0.2 mm) soil sample was determined by Walkley and Blacks wet oxidation method. The soil was treated with chromic acid to oxidize organic carbon to CO_2 and untreated $\text{K}_2\text{Cr}_2\text{O}_7$ was back titrated against standard ferrous ammonium sulphate using diphenylamine indicator (Nelson and Sommer, 1982) and expressed in per cent.

3.4.5.6 Soil available nitrogen (kg ha^{-1})

Available nitrogen in the soil was estimated by modified alkaline permanganate method (Subbiah and Asija, 1956). The organic matter present in the soil was oxidized by the nascent oxygen liberated by KMnO_4 in the presence of NaOH . Ammonia released was absorbed in boric acid mixed indicator. The quantity of NH_3

distilled was estimated by titration against a standard H_2SO_4 (expressed as kg ha^{-1} and interpreted as, low, medium and high).

3.4.5.7 Soil available phosphorus (kg ha^{-1})

The available phosphorus in the soil samples was extracted with Olsen's reagent (0.5N NaHCO_3). Phosphorus in the extracts was determined by ascorbic acid reductant method using spectrophotometer at 660 nm (Watanabe and Olsen, 1965) (expressed as kg ha^{-1} and interpreted as, low, medium and high).

3.4.5.8 Soil available potassium (kg ha^{-1})

Available potassium in soil was extracted by neutral normal ammonium acetate and subsequent estimation was done by flame photometer (Jackson, 1973) (Expressed as kg ha^{-1} and interpreted as, low, medium and high).

3.4.6 Economics

The economic evaluation in terms of gross and net monetary returns, cost of cultivation and B : C ratio were computed treatment wise.

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

The gross monetary returns (₹ ha^{-1}) were calculated by multiplying the yield from respective treatment and prevailing market prices commodities. To get gross monetary returns market price obtained by seed and haulm yield of respective treatments was summed up.

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

The cost of cultivation (₹ ha^{-1}) for each treatment was worked out by taking into consideration the cost of all the operations right from the preparatory tillage till the harvesting and threshing and the cost of all inputs involved.

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

The net monetary returns (₹ ha^{-1}) for each treatment was worked out by deducting the cost of cultivation of each treatment from gross monetary returns of respective treatments.

Net monetary returns (₹ ha^{-1}) = Gross monetary returns (₹ ha^{-1}) - Cost of cultivation (₹ ha^{-1})

3.4.6.4 Benefit: cost ratio

Benefit: cost ratio was worked out by taking into consideration the gross monetary returns and total cost of cultivation (₹ ha^{-1}) for each treatment using the formula given below.

$$\text{B: C ratio} = \frac{\text{Gross monetary returns (₹ ha}^{-1}\text{)}}{\text{Cost of cultivation (₹ ha}^{-1}\text{)}}$$

3.4.7 Statistical analysis and interpretation of data

Standard method of "Analysis of variance" was used for analysing the data (Panse and Sukhatme, 1985). Standard error of the means (S. Em) was worked out for each factor and interactions. Wherever the results were significant, the critical difference (C.D.) was worked out at 5 % level of significance. The data were suitably illustrated with graphs and Figures at appropriate places. The data of the *rabi* chickpea were analysed with Randomized Block Design.

4. RESULTS AND DISCUSSION

The present experiment on “**Effect of liquid organic formulations on growth, yield and quality of chickpea (*Cicer arietinum*)**” conducted during *rabi* season 2021-2022 at Organic Farming Research and Training Centre, Mahatma Phule Krishi Vidyapeeth, Rahuri. This chapter analyses, presents and discusses the detailed study results.

This chapter can be broadly divided into the following topics:

- 4.1 Growth studies
- 4.2 Yield attributing characters and Yield
- 4.3 Quality parameters
- 4.4 Chemical parameters
- 4.5 Biological parameters
- 4.6 Economics studies

4.1 Growth studies

Biometric observations were made on the several growth characteristics including plant count, plant height, number of branches plant⁻¹, plant spread, dry matter plant⁻¹, nodule count and nodule weight plant⁻¹, days to 50 % flowering and days to maturity. Research findings on these elements are presented in Table 4.1 to 4.7.

4.1.1 Plant population

Data on initial and final plant counts as influenced by various treatments are represented in the Table 4.1 mean initial plant count and final plant count was 317551 ha⁻¹ and 316322 ha⁻¹ respectively.

4.1.1.1 Initial plant count

Data on the mean initial plant population at 15 DAS was recorded from net plot of different treatments and the percentage of the population under study is calculated. From the data in Table 4.1 it was observed that, mean initial plant population of chickpea was 317551 ha⁻¹ which was 95.27 per cent of theoretical plant population. As a result, it could be concluded that, the plant population was constant and uniform throughout the trial plot.

Since, the foliar the application treatments did not significantly differ in plant population. There was no impact on plant population at 15 DAS.

4.1.1.2 Final plant count

Data of Table 4.1 revealed that mean final population of chickpea at harvest was 316322 ha⁻¹, which was 94.89 per cent. The plant population did not alter considerably due to various treatments. Different foliar treatments had no impact on the chickpea plant population at harvest.

Table 4.1. Effect of liquid organic formulations on plant count of chickpea

Treatment	Initial plant count		Final plant count	
	ha ⁻¹	Per cent	ha ⁻¹	Per cent
T ₁ : Control	317601	95.28	316299	94.89
T ₂ : Cow urine @ 10 %	317477	95.24	316233	94.87
T ₃ : Vermiwash @ 10 %	318659	95.59	316809	95.04
T ₄ : Panchagavya @ 3 %	318555	95.56	316687	95.01
T ₅ : Waste decomposer @ 25 %	316422	94.93	315224	94.57
T ₆ : Jeevamrut @ 10 %	316370	94.91	315153	94.55
T ₇ : Cow urine @ 10 % + Vermiwash @ 10 %	316741	95.02	316698	95.01
T ₈ : Cow urine @ 10 % + waste decomposer @ 25 %	317691	95.31	316515	94.95
T ₉ : Vermiwash @ 10 % + waste decomposer @ 25 %	318445	95.53	317279	95.18
S.Em. ±	651.33	0.19	545.93	0.16
C.D. at 5 %	NS	NS	NS	NS
General mean	317551	95.27	316322	94.89

Note : Spraying of organic formulations at branching, flowering and pod initiation stage.

The various treatments applied to chickpea did not significantly affect the mean initial and final plant population. Due to various treatments of foliar the application on chickpea, the uniform initial and final plant populations were observed.

4.1.2 Plant height

The information regarding plant height as affected periodically by various treatments is presented in the Table 4.2 and graphically through Fig.3 The mean plant

height was 13.84, 40.05, 43.73 and 44.63 cm at 30, 60, 90 DAS and at harvest respectively.

Chickpeas grow continuously, the plant's height gradually increased as time progresses with age. Initially, the plant height was at slower magnitude up to 30 DAS. When it came to plant growth in terms of plant height, it was more active at 60, 90 DAS as well as during harvest. Due to several treatments of foliar the application at the chickpea branching, flowering and pod formation stages, the plant height was considerably altered after 30, 60, 90 DAS and at harvest.

The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited significantly higher plant height of chickpea at 60, 90 DAS and at harvest due to foliar the application at branching, flowering and pod initiation stage. While, Treatment T₄ i.e. the application of Panchagavya @ 3 % was determined to be on par in respect to plant height. The minimum plant height of chickpea was recorded in the treatment T₁ i.e. control where no foliar the application was done.

Table 4.2. Effect of liquid organic formulations on plant height of chickpea

Treatment	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	At harvest
T ₁ : Control	13.82	38.18	40.98	41.06
T ₂ : Cow urine @ 10 %	13.87	39.64	41.65	42.75
T ₃ : Vermiwash @ 10 %	13.81	39.21	43.76	44.47
T ₄ : Panchagavya @ 3 %	13.99	41.73	46.57	47.67
T ₅ : Waste decomposer @ 25 %	13.99	39.78	43.81	44.48
T ₆ : Jeevamrut @ 10 %	13.96	39.90	43.37	44.47
T ₇ : Cow urine @ 10 % + Vermiwash @ 10 %	13.66	44.80	49.05	50.15
T ₈ : Cow urine @ 10 % + waste decomposer @ 25 %	13.73	39.50	43.39	44.49
T ₉ : Vermiwash @ 10 % + waste decomposer @ 25 %	13.70	37.68	41.06	42.16
S.Em. ±	0.68	1.61	1.75	1.80
C.D. at 5 %	NS	4.83	5.24	5.39
General mean	13.84	40.05	43.73	44.63

Note: Spraying of organic formulations at branching, flowering and pod initiation stage.

The increased plant height of chickpea is caused by cow urine, which contains uric acid and ammoniacal nitrogen that plants can readily absorb, also vermiwash, which contains readily available macro and micronutrient sources as well as hormonal action that leads to enhanced growth.

It was clear from the observed data that at harvest mean plant height was varied between 41.06 cm to 50.15 cm due to various treatments. The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % recorded tallest height of plants (50.15 cm), which was noticeably superior over all the treatment. The treatment T₇ recorded 9.09 cm increase in height over T₁- Control.

Similar results were reported by Jitendra *et al.* (2017), Vora *et al.* (2019), Dhananjay *et al.* (2020), Prem Kumar *et al.* (2021), Shakil (2021) in chickpea, observed that the foliar the application of liquid organic manures at branching, flowering and pod initiation stage had a considerable impact on the growth of the chickpea mainly on plant height.

4.1.3 Number of branches

Table 4.3 and Fig. 4 provides data on the number of branches plant⁻¹ of chickpea as influenced by various treatments during the *Rabi* season, 2021–22. The mean number of branches plant⁻¹ 2.72, 11.59, 15.29 and 16.99 at 30, 60, 90 DAS and at harvest, respectively. Due to various treatments of foliar the application at the branching, flowering and pod initiation stages, the data on the number of branches plant⁻¹ were significantly altered after 30, 60, 90 DAS, and at harvest.

The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited significantly good number of branches plant⁻¹ of chickpea at 60, 90 DAS and at harvest due to foliar the application at branching, flowering and pod initiation stage. While, treatment T₄ i.e. the application of Panchagavya @ 3 % was determined to be on par in respect to number of branches plant⁻¹. The minimum number of branches plant⁻¹ of chickpea was recorded in the treatment T₁ i.e. control, where no foliar the application was done. The growth enzymes found in cow urine and vermiwash, which encouraged quick cell division and multiplication, may be the cause of the rise in the number of branches plant⁻¹.

Similar outcome was reported by Vora *et al.* (2019).

Table 4.3. Effect of liquid organic formulations on number of branches of chickpea

Treatment	Number of branches plant ⁻¹			
	30 DAS	60 DAS	90 DAS	At harvest
T ₁ : Control	2.60	10.55	14.27	16.07
T ₂ : Cow urine @ 10 %	2.67	11.52	14.41	16.21
T ₃ : Vermiwash @ 10 %	2.70	11.73	15.22	17.02
T ₄ : Panchagavya @ 3 %	2.80	12.60	16.23	18.03
T ₅ : Waste decomposer @ 25 %	2.86	10.75	14.81	16.08
T ₆ : Jeevamrut @ 10 %	2.84	11.36	15.13	16.93
T ₇ : Cow urine @ 10 % + Vermiwash @ 10 %	2.76	13.50	18.23	20.03
T ₈ : Cow urine @ 10 % + waste decomposer @ 25 %	2.71	11.01	14.70	16.13
T ₉ : Vermiwash @ 10 % + waste decomposer @ 25 %	2.53	11.27	14.68	16.48
S.Em. ±	0.14	0.45	0.81	0.73
C.D. at 5 %	NS	1.36	2.41	2.18
General mean	2.72	11.59	15.29	16.99

Note : Spraying of organic formulations at branching, flowering and pod initiation stage.

4.1.4 Plant spread

Table 4.4 and Fig. 5 provides data on the plant spread of chickpea as influenced by various treatments during the *Rabi* season, 2021-22. The mean plant spread was 10.55, 27.72, 32.73 and 33.17 cm at 30, 60, 90 DAS and at harvest, respectively. Due to various treatments of foliar the application at the branching, flowering and pod initiation stages, the data on the plant spread were significantly varies after 30, 60, 90 DAS and at harvest.

Different nutrient management techniques at all growth stages of chickpea considerably impacted on the data regarding plant spread. The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited significantly higher plant spread of chickpea at 60, 90 DAS and at harvest due to foliar the application at branching, flowering and pod initiation stage. While, Treatment T₄ i.e. the application of Panchagavya @ 3 % was determined to be on par in respect to plant spread. The

minimum plant spread of chickpea was recorded in the treatment T₁ i.e. control where no foliar the application was done.

Spread of the plants is a result of successful crop growth. Due to the positive effects of the foliar spray, the growth characteristic of the chickpea crop has been improved. Higher plant spread in the chickpea crop was a result of its favourable effects on cell elongation and cell division, which boost photosynthetic activity and facilitate the effective transfer of photosynthates from source to sink.

Table 4.4. Effect of liquid organic formulations on plant spread of chickpea

Treatment	Plant spread (cm)			
	30 DAS	60 DAS	90 DAS	At harvest
T ₁ : Control	10.53	26.59	31.06	31.59
T ₂ : Cow urine @ 10 %	10.56	27.18	32.18	32.79
T ₃ : Vermiwash @ 10 %	10.63	27.35	31.95	32.32
T ₄ : Panchagavya @ 3 %	10.46	28.76	34.14	34.41
T ₅ : Waste decomposer @ 25 %	10.78	27.37	32.01	32.46
T ₆ : Jeevamrut @ 10 %	10.95	27.19	33.00	33.27
T ₇ : Cow urine @ 10 % + Vermiwash @ 10 %	10.28	30.86	35.91	36.24
T ₈ : Cow urine @ 10 % + waste decomposer @ 25 %	10.23	26.88	32.15	33.08
T ₉ : Vermiwash @ 10 % + waste decomposer @ 25 %	10.57	27.29	32.10	32.37
S.Em. $\pm$	0.64	1.14	0.98	1.09
C.D. at 5 %	NS	3.43	2.96	3.29
General mean	10.55	27.72	32.72	33.17

Note: Spraying of organic formulations at branching, flowering and pod initiation stage.

Comparable conclusions reported by Vora *et al.* (2019) and Maksudan (2021).

4.1.5 Dry matter plant⁻¹

The use of foliar sprays at various growth stages had a profound influence on the chickpea dry matter plant⁻¹ as depicted in Table 4.5 and Fig. 6. The mean dry matter plant⁻¹ was 1.93, 9.88, 14.93 and 16.19 g at 30, 60, 90 DAS and at harvest, respectively. Due to various treatments of foliar the application at the branching,

flowering and pod initiation stages, the data on the dry matter plant⁻¹ were significantly varied after 30, 60, 90 DAS and at harvest.

Table 4.5. Effect of liquid organic formulations on dry matter of chickpea.

Treatment	Dry matter plant ⁻¹ (g)			
	30 DAS	60 DAS	90 DAS	At harvest
T ₁ : Control	1.98	8.35	13.32	15.33
T ₂ : Cow urine @ 10 %	1.93	9.61	14.61	15.89
T ₃ : Vermiwash @ 10 %	1.99	9.75	14.50	15.69
T ₄ : Panchagavya @ 3 %	1.91	10.91	16.54	17.59
T ₅ : Waste decomposer @ 25 %	1.92	9.53	14.50	15.82
T ₆ : Jeevamrut @ 10 %	1.90	9.65	14.62	15.69
T ₇ : Cow urine @ 10 % + Vermiwash @ 10 %	1.94	11.88	17.22	18.19
T ₈ : Cow urine @ 10 % + waste decomposer @ 25 %	1.98	9.33	14.30	15.92
T ₉ : Vermiwash @ 10 % + waste decomposer @ 25 %	1.84	9.91	14.75	15.67
S.Em. ±	0.13	0.49	0.66	0.62
C.D. at 5 %	NS	1.48	1.97	1.86
General mean	1.93	9.88	14.93	16.19

Note: Spraying of organic formulations at branching, flowering and pod initiation stage.

The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited significantly noticeable dry matter plant⁻¹ of chickpea at 60 DAS (11.88 g), 90 DAS (17.22 g) and at harvest (18.19 g) due to the foliar the application at branching, flowering and pod initiation stage. While, Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par with respect to dry matter plant⁻¹. The minimum accumulation of dry matter plant⁻¹ of chickpea was recorded in the treatment T₁ i.e. control where no foliar the application was done. It's suspected that hormones and micronutrients, which are biologically involved in the formation of photosynthates through enzymatic activities of plants that led to higher dry matter production, are responsible for the increase in dry matter relative to control.

These results are in accordance with Jitendra *et al.* (2017) and Prem Kumar *et al.* (2021).

4.1.6 Nodule growth of chickpea

4.1.6.1 Nodule count plant⁻¹

The use of foliar sprays at various growth stages had a profound influence on the chickpea nodule count plant⁻¹ and was depicted in Table 4.6 and Fig. 7. The mean nodule count plant⁻¹ was 7.31 and 5.56 at 30 and 60 DAS, respectively. Due to various treatments of foliar the application at the branching, flowering and pod initiation stages, the data on the nodule count plant⁻¹ were significantly varied at 60 DAS.

Table 4.6. Effect of liquid organic formulations on nodule growth of chickpea

Treatment	Nodule count plant ⁻¹		Nodule weight plant ⁻¹ (mg)	
	30 DAS	60 DAS	30 DAS	60 DAS
T ₁ : Control	7.38	5.00	28.03	21.05
T ₂ : Cow urine @ 10 %	7.11	5.27	28.99	23.74
T ₃ : Vermiwash @ 10 %	7.13	5.27	29.06	24.18
T ₄ : Panchagavya @ 3 %	7.36	6.47	29.67	26.00
T ₅ : Waste decomposer @ 25 %	7.27	5.47	29.69	24.89
T ₆ : Jeevamrut @ 10 %	7.40	5.20	28.08	22.94
T ₇ : Cow urine @ 10 % + Vermiwash @ 10 %	7.40	6.73	29.61	29.54
T ₈ : Cow urine @ 10 % + waste decomposer @ 25 %	7.40	5.33	27.27	21.90
T ₉ : Vermiwash @ 10 % + waste decomposer @ 25 %	7.40	5.27	27.32	23.35
S.Em. ±	0.48	0.37	1.61	1.47
C.D. at 5 %	NS	1.13	NS	4.39
General mean	7.31	5.56	28.63	24.18

Note : Spraying of organic formulations at branching, flowering and pod initiation stage.

The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited a significantly noticeable nodule count plant⁻¹ of chickpea at 60 DAS (6.73) due to foliar the application at branching, flowering and pod initiation stage. While, Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par with respect to nodule count plant⁻¹. The minimum accumulation of nodule count plant⁻¹ of chickpea was recorded in the treatment T₁ i.e. control where no foliar the application was carried out.

The performance is closely related to Jitendra *et al.* (2017) and Prem Kumar *et al.* (2021).

4.1.6.2 Nodule weight plant⁻¹

Table 4.6 and Fig. 7 provide data on the nodule weight plant⁻¹ of chickpea as influenced by various treatments during the *Rabi* season, 2021–22. The mean nodule weight plant⁻¹ was 28.63 mg and 24.18 mg at 30 and 60 DAS respectively. Due to various treatments of foliar the application at the branching, flowering and pod initiation stages, the data on the nodule weight plant⁻¹ were significantly varied at 60 DAS.

The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited significantly noticeable nodule weight plant⁻¹ of chickpea at 60 DAS (29.54 mg) due to foliar the application at branching, flowering and pod initiation stage. While, Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par in respect to nodule weight plant⁻¹. The minimum accumulation of nodule count plant⁻¹ of chickpea.

It was found that applied cow urine and vermiwash work together synergistically to improve the energy sources available to microorganisms for their growth and development. Increased root food allocation results in increased root volume and, as a result, higher root nodule count plant⁻¹ and nodule weight plant⁻¹.

The similar result scenario with Panchal *et al.* (2017) and Dhananjay *et al.* (2020).

4.1.7 Days to 50 % flowering and Days to maturity

4.1.7.1 Days to 50 % flowering

The use of foliar sprays at various growth stages had a meagre influence on the days to 50% flowering of chickpea and was depicted in Table 4.7 and Fig. 8 The mean days to 50% flowering of chickpea was 55 days.

The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited relatively but not significantly more days to 50 % flowering (59 days) of chickpea due to foliar the application at branching flowering and pod initiation stages. While, Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par in respect to days to 50% flowering (59 days) . The minimum number of days to 50% flowering (49 days) was recorded in control where no fertilization is carried out.

4.1.7.2 Days to maturity

The use of foliar sprays at various growth stages had a limited influence on the days to maturity of chickpea and was depicted in Table 4.7 and Fig. 8.

The mean days to maturity of chickpea were 103 days. The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited relatively but not significantly more days to maturity (105 days) of chickpea due to the application at branching, flowering and pod initiation stage. While, Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par in respect to days to maturity (104 days) . The minimum number of days to maturity (98 days) was recorded in control where no fertilization is carried out.

Table 4.7. Effect of liquid organic formulations on days to 50% flowering and days to maturity

Treatment	Days to 50% flowering	Days to maturity
T ₁ : Control	49	98
T ₂ : Cow urine @ 10 %	54	102
T ₃ : Vermiwash @ 10 %	56	104
T ₄ : Panchagavya @ 3 %	59	104
T ₅ : Waste decomposer @ 25 %	51	102
T ₆ : Jeevamrut @ 10 %	55	103
T ₇ : Cow urine @ 10 % + Vermiwash @ 10 %	59	105
T ₈ : Cow urine @ 10 % + waste decomposer @ 25 %	53	103
T ₉ : Vermiwash @ 10 % + waste decomposer @ 25 %	55	104
S.Em. $\pm$	2.27	2.70
C.D. at 5 %	NS	NS
General mean	55	103

Note : Spraying of organic formulations at branching, flowering and pod initiation stage.

In control chickpea vegetative and reproductive phases are shortened by lack of foliar fertilisation, which results in early "days to 50 % flowering and days to maturity", which are brought on by insufficient fertility. As in treatments T₇ and T₄ which took more days to 50 % flowering and days to maturity, yields more proportionately.

Comparable conclusions reported by Samir (2016) and Dhananjay *et al.* (2020).

4.2 Yield attributing characters and Yield

4.2.1 Number of pods plant⁻¹

The use of foliar sprays at various growth stages had a profound influence on the number of pods plant⁻¹ of chickpea and was depicted in the Table 4.8 and Fig. 9. The mean number of pods plant⁻¹ was 36.44 at harvest.

The yield characteristics serve as a sign of vigorous crop growth. The number of pods plant⁻¹ was significantly influenced by foliar the application of different organic formulations at branching, flowering and pod initiation stages. The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited better results (44.63) compared to other treatments at harvest. Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par in respect to number of pods plant⁻¹ (42.00) at harvest. The minimum number of pods plant⁻¹ (31.91) was observed in control. Foliar fertilization upgrades the number of primary and secondary branches plant⁻¹. Mixture of cow urine and vermiwash includes combination of hormones, enzymes, minerals, and other growth promoting substances that boosted flower retention and increased the number of pods plant⁻¹ in the chickpea crop.

Similar results were published by Mahto and Yadav (2005), Patil *et al.* (2012), Jitendra *et al.* (2017) and Prem Kumar *et al.* (2021).

4.2.2 Number of seeds pod⁻¹

The use of foliar sprays at various growth stages had a meagre influence on the number of seeds pod⁻¹ of chickpea and was depicted in Table 4.8 and the mean number of seeds pod⁻¹ of chickpea was 1.11 at harvest. The number of seeds pod⁻¹ ranges between 1.07 to 1.27. Different foliar the application treatments seemed to have no noticeable impact on number of seeds pod⁻¹.

4.2.3 Weight of pods plant⁻¹

The use of foliar sprays at various growth stages had a substantial impact on the weight of pods plant⁻¹ of chickpea and was depicted in the Table 4.8 and Fig. 9. The mean weight of pods plant⁻¹ was 10.39 g at harvest. Due to various treatments of foliar the application at the branching, flowering and pod initiation stages, the data on weight of pods plant⁻¹ were significantly varied.

Table 4.8. Effect of liquid organic formulations on Yield attributing characters of chickpea

Treatment	Number of pods plant ⁻¹	Number of seeds pod ⁻¹	Weight of pods plant ⁻¹ (g)	Seed yield plant ⁻¹ (g)	Test weight (g)
T ₁ : Control	31.91	1.07	10.04	7.16	169.77
T ₂ : Cow urine @ 10 %	35.02	1.07	10.24	7.35	170.60
T ₃ : Vermiwash @ 10 %	33.75	1.13	10.19	7.26	172.88
T ₄ : Panchagavya @ 3 %	42.00	1.07	10.75	8.16	174.89
T ₅ : Waste decomposer @ 25 %	35.09	1.13	10.12	7.30	173.25
T ₆ : Jeevamrut @ 10 %	35.47	1.13	10.17	7.28	175.48
T ₇ : Cow urine @ 10 % + Vermiwash @ 10 %	44.63	1.27	11.75	8.44	178.84
T ₈ : Cow urine @ 10 % + waste decomposer @ 25 %	34.85	1.07	10.10	7.32	174.27
T ₉ : Vermiwash @ 10 % + waste decomposer @ 25 %	35.19	1.07	10.22	7.32	173.42
S.Em. $\pm$	2.13	0.07	0.49	0.32	6.49
C.D. at 5 %	6.38	NS	1.47	0.96	NS
General mean	36.44	1.11	10.39	7.51	173.71

Note : Spraying of organic formulations at branching, flowering and pod initiation stage

The attributes of the yield serve as an indicator of healthy and active crop growth. The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited better results (11.75 g) compared to other treatments at harvest. Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par in respect to weight of pods plant⁻¹ (10.75 g) at harvest. The minimum weight of pods plant⁻¹ (10.04 g) was observed in control. Increased metabolite diversion to the fruiting portions, which results in increased pod production, may be the factor behind the increase in the number of pods plant⁻¹ and weight of pods plant⁻¹

The similar scenario with Jadhav *et al.* (2014).

4.2.4 Seed yield plant⁻¹

Table 4.8 and Fig. 9 provide data on the seed yield plant⁻¹ of chickpea as influenced by various treatments during the *Rabi* season, 2021–22. The mean seed yield plant⁻¹ was 7.51 g at harvest. Due to various treatments of foliar the application at the branching, flowering and pod initiation stages, the data on the seed yield plant⁻¹ were varied significantly.

The treatment T₇ i.e. the application of cow urine @ 10 % + Vermiwash @ 10 % exhibited better results (8.44 g) compared to other treatments at harvest.

Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par in respect to weight of pods plant⁻¹ (8.16 g) at harvest. The minimum weight of pods plant⁻¹ (7.16 g) was observed in control. Chlorophyll generation, photosynthesis, and protein synthesis in leaves are all significantly influenced by hormones, enzymes, and minerals present in mixture of cow urine and vermiwash which is evident in the luxuriant seed yield.

The performance is closely related to Jadhav *et al.* (2014) and Nitin and Purohit (2021).

4.2.5 Test weight (g)

The use of foliar sprays at various growth stages had a meagre influence on the test weight of chickpea and was depicted in Table 4.8 and Fig. 11. The mean test weight of chickpea was 173.71 g at harvest. The test weight of chickpea ranges between 169.77 g to 178.84 g. Different foliar the application treatments seemed to have no significant impact on test weight.

Similar results were published by Vora *et al.* (2019), Dhananjay *et al.* (2020) and Prem Kumar *et al.* (2021).

4.2.6 Seed yield (q ha⁻¹)

Table 4.9 and Fig. 10 provide data on the seed yield ha⁻¹ of chickpea as influenced by various treatments during the *Rabi* season, 2021–22. The mean seed yield ha⁻¹ was 21.86 q ha⁻¹ at harvest.

The seed yield ha⁻¹ was significantly influenced by foliar the application of different organic formulations at branching, flowering and pod initiation stages. The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited better results (24.81 q ha⁻¹) compared to other treatments at harvest also % increase in seed yield was highest with 19.66 per cent compared to control. Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par in respect to seed yield ha⁻¹ (23.94 q ha⁻¹) at harvest. The minimum seed yield ha⁻¹ (20.74 q ha⁻¹) was observed in control. The cumulative effect of yield-related traits, improved photosynthetic efficiency, and improvement in the ability of the reproductive sinks to absorb the incoming

assimilates as a result of the foliar the application of cow urine and vermiwash, these all together contributed to an increase in chickpea crop seed yield.

The results are in accordance with Jitendra *et al.* (2017) and Vora *et al.* (2019).

Table 4.9. Effect of liquid organic formulations on yield parameters of chickpea

Treatment	Seed yield (q ha ⁻¹)	% Increase in Seed yield	Haulm yield (q ha ⁻¹)	% Increase in Haulm yield	Biological yield (q ha ⁻¹)	Harvest Index (%)
T ₁ : Control	20.74	-	24.84	-	45.58	45.47
T ₂ : Cow urine @ 10 %	21.36	3.00	25.99	4.62	47.35	45.13
T ₃ : Vermiwash @ 10 %	21.09	1.70	25.71	3.49	46.79	45.03
T ₄ : Panchagavya @ 3 %	23.94	15.44	28.86	16.21	52.80	45.33
T ₅ : Waste decomposer @ 25 %	21.12	1.86	25.83	4.00	46.96	44.95
T ₆ : Jeevamrut @ 10 %	21.07	1.61	25.45	2.47	46.52	45.32
T ₇ : Cow urine @ 10 % + Vermiwash @ 10 %	24.81	19.66	29.87	20.25	54.68	45.39
T ₈ : Cow urine @ 10 % + waste decomposer @ 25 %	21.29	2.66	26.19	5.43	47.47	44.87
T ₉ : Vermiwash @ 10 % + waste decomposer @ 25 %	21.31	2.78	25.50	2.66	46.81	45.46
S.Em. $\pm$	0.99	-	1.02	-	1.94	-
C.D. at 5 %	2.99	-	3.09	-	5.82	-
General mean	21.86	5.42	26.47	6.57	48.33	45.22

Note: Spraying of organic formulations at branching, flowering and pod initiation stage.

4.2.7 Haulm yield (q ha⁻¹)

Table 4.9 and Fig. 10 provide data on the haulm yield ha⁻¹ of chickpea as influenced by various treatments during the *Rabi* season, 2021–22. The mean haulm yield ha⁻¹ was 26.47 q ha⁻¹ at harvest. Due to various treatments of foliar the application at the branching, flowering and pod initiation stages, the data on the seed yield were significantly varied.

The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited better results (29.87 q ha⁻¹) compared to other treatments at harvest also per cent increase in haulm yield was highest with 20.25 per cent compared to control Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par in

respect to haulm yield ha^{-1} (28.86 q ha^{-1}) at harvest. The minimum haulm yield ha^{-1} (24.84 q ha^{-1}) was observed in control. The chickpea haulm yield depends on luxuriant crop growth, the accumulation of dry matter, yield characteristics, and physiological traits.

The performance is closely related to Jitendra *et al.* (2017) and Prem Kumar *et al.* (2021).

4.2.8 Biological yield (q ha^{-1})

The use of foliar sprays at various growth stages had a substantial impact on the biological yield ha^{-1} of chickpea and was depicted in the Table 4.9 and Fig. 10. The mean biological yield ha^{-1} was 48.33 q ha^{-1} at harvest. The chickpea's biological yield depends on its seed and haulm yield. The biological yield ha^{-1} was significantly influenced by foliar the application of different organic formulations at branching, flowering and pod initiation stages.

The treatment T_7 i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited better results (54.68 q ha^{-1}) compared to other treatments at harvest. Treatment T_4 i.e. the application of Panchagavya @ 3 % was found to be on par in respect to biological yield ha^{-1} (52.80 q ha^{-1}) at harvest. The minimum biological yield ha^{-1} (45.58 q ha^{-1}) was observed in control. Potent biological yield due to the healthy crop growth, which resulted in a higher harvest of seed and haulm.

The similar scenario with Patil *et al.* (2012) and Vora *et al.* (2019).

4.2.9 Harvest Index (%)

The use of foliar sprays at various growth stages had a mere influence on the harvest index of chickpea and was depicted in Table 4.9 and Fig. 10. The mean harvest index of chickpea was 45.22 per cent at harvest. The harvest index of chickpea ranges between 44.87 to 45.47 per cent. Different foliar the application treatments seemed to have no consequential impact on harvest index of chickpea.

The results are in accordance with Vora *et al.* (2019) and Prem Kumar *et al.* (2021).

4.3 Quality parameters

4.3.1 Protein content (%)

The use of organic foliar sprays at various growth stages had a substantial impact on the protein content of chickpea and was depicted in the Table 4.10 and Fig. 12. The mean protein content was 19.93 per cent at harvest.

Table 4.11. Effect of liquid organic formulations on protein content of chickpea

Treatment	Protein content (%)
T ₁ : Control	19.40
T ₂ : Cow urine @ 10 %	19.32
T ₃ : Vermiwash @ 10 %	20.07
T ₄ : Panchagavya @ 3 %	20.66
T ₅ : Waste decomposer @ 25 %	19.56
T ₆ : Jeevamrut @ 10 %	19.87
T ₇ : Cow urine @ 10 % + Vermiwash @ 10 %	20.92
T ₈ : Cow urine @ 10 % + waste decomposer @ 25 %	19.93
T ₉ : Vermiwash @ 10 % + waste decomposer @ 25 %	19.66
S.Em. $\pm$	0.36
C.D. at 5 %	NS
General mean	19.93

Note: Spraying of organic formulations at branching, flowering and pod initiation stage

The chickpea's protein content depends on nitrogen content of seeds. Due to various treatments of foliar the application at the branching, flowering and pod initiation stages, the data on protein content of chickpea was varied but not significantly. The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited better results (20.92 %) compared to other treatments at harvest. Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par in respect to protein content (20.66 %) at harvest. The minimum protein content (19.40 %) was observed in control. Certain enzymes are stimulated by organic formulations to produce protein. Different foliar the application treatments seemed to have no noticeable impact on protein content.

Comparable conclusions reported by Ravi *et al.* (2011) and Shakil (2021).

4.3.2 Nutrient content of chickpea

4.3.2.1 Nitrogen content of chickpea

The use of organic foliar sprays at various growth stages had a substantial impact on the nitrogen content of chickpea. The nitrogen content of seed and haulm was analysed separately and was depicted in the Table 4.11. The mean nitrogen content of seed and haulm was 3.21 and 1.95 per cent at harvest respectively.

Due to various treatments of foliar the application at the branching, flowering and pod initiation stages, the data on nitrogen content of chickpea was significantly varied. The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited better nitrogen content of seed and haulm (3.44 and 2.29 %) respectively, compared to other treatments at harvest. Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par in respect to nitrogen content of seed and haulm (3.39 and 2.28 %) respectively, at harvest. The minimum nitrogen content of seed and haulm (3.10 and 1.41 %) respectively, was observed in control.

The similar scenario with Choudhary *et al.* (2010) Ravina Kumari *et al.* (2019) and Nitin and Purohit (2021).

4.3.2.2 Phosphorus content of chickpea

The use of organic foliar sprays at various growth stages had a substantial impact on the phosphorus content of chickpea. The phosphorus content of seed and haulm was analysed separately and was depicted in the Table 4.11. The mean phosphorus content of seed and haulm was 0.53 and 0.31 per cent at harvest respectively.

Due to various treatments of foliar the application at the branching, flowering and pod initiation stages, the data on phosphorus content was significantly varied. The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited better phosphorus content of seed and haulm (0.58 and 0.35 %) respectively, compared to other treatments at harvest. Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par in respect to phosphorus content of seed and haulm (0.56 and 0.34 %) respectively, at harvest. The minimum phosphorus content of seed and haulm (0.50 and 0.29 %) respectively, was observed in control.

The results are in accordance with Pradhan *et al.* (2018) and Ravina Kumari *et al.* (2019).

Table 4.11. Effect of liquid organic formulations on nutrient content of chickpea

Treatment	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	Seed	Haulm	Seed	Haulm	Seed	Haulm
T ₁ : Control	3.10	1.41	0.50	0.29	0.71	0.82
T ₂ : Cow urine @ 10 %	3.09	1.85	0.53	0.31	0.71	0.91
T ₃ : Vermiwash @ 10 %	3.21	2.05	0.54	0.31	0.72	0.91
T ₄ : Panchagavya @ 3 %	3.39	2.28	0.56	0.34	0.75	0.95
T ₅ : Waste decomposer @ 25 %	3.13	1.77	0.52	0.30	0.71	0.91
T ₆ : Jeevamrut @ 10 %	3.18	2.01	0.54	0.31	0.71	0.91
T ₇ : Cow urine @ 10 % + Vermiwash @ 10 %	3.44	2.29	0.58	0.35	0.76	0.98
T ₈ : Cow urine @ 10 % + waste decomposer @ 25 %	3.19	1.89	0.54	0.31	0.72	0.90
T ₉ : Vermiwash @ 10 % + waste decomposer @ 25 %	3.15	1.98	0.54	0.31	0.71	0.91
S.Em. $\pm$	0.05	0.04	0.01	0.01	0.01	0.02
C.D. at 5 %	0.17	0.12	0.03	0.03	0.03	0.06
General mean	3.21	1.95	0.53	0.31	0.72	0.91

Note: Spraying of organic formulations at branching, flowering and pod initiation stage.

4.3.2.3 Potassium content of chickpea

The use of organic foliar sprays at various growth stages had a substantial impact on the potassium content of chickpea. The potassium content of seed and haulm was analysed separately and was depicted in the Table 4.11. The mean potassium content of seed and haulm was 0.72 and 0.91 per cent at harvest respectively. Due to various treatments of foliar the application at the branching, flowering and pod initiation stages, the data on potassium content was significantly varied. The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited better content of seed and haulm (0.76 and 0.98 %) respectively, compared to other treatments at harvest.

Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par in respect to potassium content of seed and haulm (0.75 and 0.95 %) respectively, at harvest. The minimum potassium content of seed and haulm (0.71 and 0.82 %) respectively, was observed in control.

The results are in accordance with and Ravina Kumari *et al.* (2019) and Nitin and Purohit (2021).

4.3.3 Total Nutrients Uptake (kg ha⁻¹)

4.3.3.1 Nitrogen uptake by chickpea (kg ha⁻¹)

Total nitrogen uptake by the crop was calculated by estimating the nitrogen uptake by seed and haulm independently in and was expressed in kg ha⁻¹, reported in the Table 4.12 and Fig. 13. The mean nitrogen uptake by chickpea was 122.14 kg ha⁻¹ at harvest.

Due to various treatments of foliar the application at the branching, flowering and pod initiation stages, the data on nitrogen uptake was significantly varied. The treatment T₇ i.e. the application of cow urine @ 10 % + Vermiwash @ 10 % exhibited better nitrogen uptake by the chickpea (153.96 kg ha⁻¹) compared to other treatments at harvest. Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par in respect to nitrogen uptake by chickpea (147.04 kg ha⁻¹) at harvest. Minimum nitrogen uptake by chickpea (99.25 kg ha⁻¹) was observed in control.

Table 4.12. Effect of liquid organic formulations on total nutrient uptake by chickpea

Treatment	Total Nutrients Uptake (kg ha ⁻¹)		
	N	P	K
T ₁ : Control	99.25	17.76	35.24
T ₂ : Cow urine @ 10 %	113.94	19.35	38.69
T ₃ : Vermiwash @ 10 %	120.58	19.29	38.61
T ₄ : Panchagavya @ 3 %	147.04	22.86	45.35
T ₅ : Waste decomposer @ 25 %	111.81	18.75	38.56
T ₆ : Jeevamrut @ 10 %	118.41	19.30	38.34
T ₇ : Cow urine @ 10 % + Vermiwash @ 10 %	153.96	24.78	47.76
T ₈ : Cow urine @ 10 % + waste decomposer @ 25 %	116.91	19.62	39.12
T ₉ : Vermiwash @ 10 % + waste decomposer @ 25 %	117.33	19.30	38.33
S.Em. ±	2.53	0.43	0.77
C.D. at 5 %	7.58	1.27	2.30
General mean	122.14	20.11	40.00

Note: Spraying of organic formulations at branching, flowering and pod initiation stage

Similar outcome was reported by Ravina Kumari *et al.* (2019)

4.3.3.2 Phosphorus uptake by chickpea (kg ha⁻¹)

Separate calculations of the phosphorus intake by seeds and haulm were made, and the total phosphorus uptake by the chickpea crop was calculated in kg ha⁻¹ and reported in the Table 4.12 and Fig. 13. The mean phosphorus uptake by chickpea was 20.11 kg ha⁻¹ at harvest.

Due to various treatments of foliar the application at the branching, flowering and pod initiation stages, the data on phosphorus uptake was significantly varied. The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited better phosphorus uptake by the chickpea (24.78 kg ha⁻¹) compared to other treatments at harvest. Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par in respect to phosphorus uptake by chickpea (22.86 kg ha⁻¹) at harvest. The minimum phosphorus uptake by chickpea (17.76 kg ha⁻¹) was observed in control.

The results are in accordance with Pradhan *et al.* (2018) and Ravina Kumari *et al.* (2019).

4.3.3.3 Potassium uptake by chickpea (kg ha⁻¹)

Separate calculations of the potassium intake by seeds and haulm were done, and the total potassium uptake by the chickpea crop was calculated in kg ha⁻¹ and reported in the Table 4.12 and Fig. 13. The mean potassium uptake by chickpea was 40.00 kg ha⁻¹ at harvest. Due to various treatments of foliar the application at the branching, flowering and pod initiation stages, the data on potassium uptake was significantly varied. The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited better potassium uptake by the chickpea (47.76 kg ha⁻¹) compared to other treatments at harvest.

Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par in respect to potassium uptake by chickpea (45.35 kg ha⁻¹) at harvest. The minimum potassium uptake by chickpea (35.24 kg ha⁻¹) was observed in control.

The results are in accordance with Pradhan *et al.* (2018) and Ravina Kumari *et al.* (2019).

4.4 Chemical parameters

4.4.1 Initial and final pH, EC, OC, and N, P, K in soil.

4.4.1.1 Initial and final available pH

Soil pH data shows that the mean initial available active pH of soil was 7.70 and pH of soil decreases gradually. At harvest the mean pH of soil is 7.51 the effect of foliar sprays on soil available pH was not significant. The initial and at harvest status of available soil pH presented in Table 4.13 and Fig. 14.

4.4.1.2 Initial and at harvest available EC

Soil EC data shows that the mean initial EC of soil was 0.35 and EC of soil not differs significantly. At harvest the mean EC of soil is 0.35 dSm⁻¹. The initial and at harvest status of available soil EC was presented in Table 4.13 and Fig. 14.

Table 4.13. Effect of liquid organic formulations on pH, EC, OC of soil

Treatment	Soil available nutrients		
	pH	EC (dSm ⁻¹)	OC (%)
T ₁ : Control	7.47	0.38	0.60
T ₂ : Cow urine @ 10 %	7.58	0.34	0.57
T ₃ : Vermiwash @ 10 %	7.41	0.37	0.57
T ₄ : Panchagavya @ 3 %	7.18	0.33	0.59
T ₅ : Waste decomposer @ 25 %	7.57	0.37	0.56
T ₆ : Jeevamrut @ 10 %	7.36	0.35	0.57
T ₇ : Cow urine @ 10 % + Vermiwash @ 10 %	7.60	0.36	0.53
T ₈ : Cow urine @ 10 % + waste decomposer @ 25 %	7.73	0.37	0.54
T ₉ : Vermiwash @ 10 % + waste decomposer @ 25 %	7.66	0.35	0.57
S.Em. ±	0.10	0.01	0.01
C.D. at 5 %	NS	NS	NS
General mean	7.51	0.35	0.56
Initial status	7.70	0.35	0.58

Note : Spraying of organic formulations at branching, flowering and pod initiation stage

4.4.1.4 Initial and at harvest soil available nitrogen

The data regarding soil available nitrogen shows that the initial soil available nitrogen was $165.43 \text{ kg ha}^{-1}$. At harvesting the soil available nitrogen was increased. At harvest the mean soil available nitrogen is $181.45 \text{ kg ha}^{-1}$. The effect of foliar sprays on soil available nitrogen differs significantly. The maximum value of soil available nitrogen is found in plot sprayed with treatment T_7 i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited ($188.59 \text{ kg ha}^{-1}$) compared to other treatments at harvest. Treatment T_4 i.e. the application of Panchagavya @ 3 % was found to be on par in respect to soil available nitrogen ($185.67 \text{ kg ha}^{-1}$) at harvest. The minimum soil available nitrogen ($176.82 \text{ kg ha}^{-1}$) was observed in control.

The higher value of soil available nitrogen in soil due to spray of cow urine and vermiwash at branching, flowering and pod initiation stage. From analysis we found that vermiwash contains nitrogen fixing bacteria (Zambare *et al.*) also increased nodulation is seen in the chickpea plants applied with cow urine which helps to fix atmospheric nitrogen (Rahate *et al.*) which altogether increases soil available nitrogen. The initial and at harvest status of soil available nitrogen presented in Table 4.14 and Fig. 15.

Similar results were reported by Ravina Kumari *et al.* (2019).

4.4.1.5 Initial and at harvest soil available phosphorus

The data regarding soil available phosphorus shows that the initial soil available phosphorus was 12.13 kg ha^{-1} . At harvesting the soil available phosphorus was increased. At harvest the mean soil available phosphorus is 17.26 kg ha^{-1} . The effect of foliar sprays on soil available phosphorus differs significantly. The maximum value of soil available phosphorus is found in plot sprayed with treatment T_7 i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited (18.59 kg ha^{-1}) compared to other treatments at harvest. Treatment T_4 i.e. the application of Panchagavya @ 3 % was found to be on par in respect to soil available phosphorus (17.82 kg ha^{-1}) at harvest. The minimum soil available phosphorus (15.86 kg ha^{-1}) was observed in control.

The higher value of soil available Phosphorus in soil due to spray of cow urine and vermiwash at branching, flowering and pod initiation stage. From analysis we found that cow urine and vermiwash contains good number of Phosphorus solubilizing

and Phosphorus mobilizing bacteria's which improves soil available Phosphorus. The initial and at harvest status of soil available phosphorus presented in Table 4.14 and Fig. 15.

The similar result scenario with Atal and Thakur (2017) and Ravina Kumari *et al.* (2019).

Table 4.14. Effect of liquid organic formulations on available nitrogen, phosphorus and potassium content of soil

Treatment	Soil available nutrients (kg ha ⁻¹)		
	N	P	K
T ₁ : Control	176.82	15.86	387.17
T ₂ : Cow urine @ 10 %	178.89	17.12	389.83
T ₃ : Vermiwash @ 10 %	181.30	17.10	391.90
T ₄ : Panchagavya @ 3 %	185.67	17.82	395.49
T ₅ : Waste decomposer @ 25 %	180.52	17.15	387.68
T ₆ : Jeevamrut @ 10 %	180.35	17.49	391.22
T ₇ : Cow urine @ 10 % + Vermiwash @ 10 %	188.59	18.59	399.28
T ₈ : Cow urine @ 10 % + waste decomposer @ 25 %	181.76	17.18	388.89
T ₉ : Vermiwash @ 10 % + waste decomposer @ 25 %	179.16	17.03	390.88
S.Em. ±	1.76	0.28	1.67
C.D. at 5 %	5.26	0.84	5.02
General mean	181.45	17.26	391.37
Initial status	165.43	12.13	384.53

Note : Spraying of organic formulations at branching, flowering and pod initiation stage.

4.4.1.6 Initial and at harvest soil available potassium

The data regarding soil available potassium shows that the initial soil available potassium was 384.53 kg ha⁻¹. At harvesting the soil available potassium was increased. At harvest the mean soil available potassium is 391.37 kg ha⁻¹. The effect of foliar sprays on soil available potassium differs significantly. The maximum value of soil available potassium is found in plot sprayed with treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited (399.28 kg ha⁻¹) compared to other treatments at harvest. Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par in respect to soil available potassium (395.49 kg ha⁻¹) at harvest. The minimum soil available potassium (387.17kg ha⁻¹) was observed in control.

The higher value of soil available potassium in soil due to spray of cow urine and vermiwash at branching, flowering and pod initiation stage. From analysis we found that cow urine and vermiwash contains good number of potassium solubilizing and mobilizing bacteria's which improves soil available potassium. The initial and at harvest status of soil available potassium presented in Table 4.14 and Fig. 15.

The results are in accordance with Atal and Thakur (2017) and Ravina Kumari *et al.* (2019).

4.5 Soil microbial population.

Soil microbial population was calculated initially at 38, 68 and 79 DAS i.e. 5 days after every spray. The microbial population of bacteria, fungi and actinomycetes were influenced by foliar spray of organic formulations.

4.5.1 Bacteria population (cfu x 10⁻⁷)

Bacterial population was significantly influenced by the application of different foliar treatments depicted in the Table 4.15 and Fig. 16 The mean bacterial population was 19.32, 21.23 and 24.12 cfu x 10⁻⁷ at 38, 63 and 79 DAS respectively, and it is increased from 38 to 79 DAS.

Table 4.15. Effect of liquid organic formulations on bacterial population of chickpea-grown soil

Treatment	Bacterial population (cfu x 10 ⁻⁷)		
	38 DAS	63 DAS	79 DAS
T ₁ : Control	14.55	15.61	16.87
T ₂ : Cow urine @ 10 %	20.31	22.33	25.43
T ₃ : Vermiwash @ 10 %	19.56	21.58	24.67
T ₄ : Panchagavya @ 3 %	21.85	23.87	26.96
T ₅ : Waste decomposer @ 25 %	18.79	20.82	23.92
T ₆ : Jeevamrut @ 10 %	16.55	18.57	21.66
T ₇ : Cow urine @ 10 % + Vermiwash @ 10 %	22.95	24.97	28.06
T ₈ : Cow urine @ 10 % + waste decomposer @ 25 %	18.76	20.79	23.88
T ₉ : Vermiwash @ 10 % + waste decomposer @ 25 %	20.58	22.60	25.69
S.Em. ±	0.39	0.39	0.39
C.D. at 5 %	1.19	1.19	1.19
C.V.	3.89	3.55	3.09
General mean	19.32	21.23	24.12
Initial status	14.00		

Note : Spraying of organic formulations at branching, flowering and pod initiation stage

The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited significantly higher number of bacteria due to foliar the application at branching, flowering and pod initiation stage. While, Treatment T₄ i.e. the application of Panchagavya @ 3 % was determined to be on par in respect to bacterial population. The minimum bacterial population was recorded in the treatment T₁ i.e. control.

4.5.2 Fungal colony (cfu x 10⁻⁵)

Fungal colony was significantly influenced by the application of different foliar treatments depicted in the Table 4.16 and Fig. 17 The mean fungal colony was 14.72, 17.72 and 21.73 cfu x 10⁻⁵ at 38, 63 and 79 DAS respectively, and it is increased from 38 to 79 DAS.

Table 4.16. Effect of liquid organic formulations on the fungal colony of chickpea-grown soil

Treatment	Fungal colony (cfu x 10 ⁻⁵)		
	38 DAS	63 DAS	79 DAS
T ₁ : Control	12.25	13.15	15.64
T ₂ : Cow urine @ 10 %	13.72	16.99	21.18
T ₃ : Vermiwash @ 10 %	15.71	18.97	23.16
T ₄ : Panchagavya @ 3 %	16.34	19.61	23.80
T ₅ : Waste decomposer @ 25 %	14.56	17.82	22.01
T ₆ : Jeevamrut @ 10 %	13.93	17.20	21.39
T ₇ : Cow urine @ 10 % + Vermiwash @ 10 %	16.63	19.89	24.08
T ₈ : Cow urine @ 10 % + waste decomposer @ 25 %	14.47	17.74	21.93
T ₉ : Vermiwash @ 10 % + waste decomposer @ 25 %	14.87	18.14	22.33
S.Em. $\pm$	0.22	0.21	0.31
C.D. at 5 %	0.66	0.64	0.94
C.V.	2.88	2.28	2.71
General mean	14.72	17.72	21.73
Initial status	11.60		

Note : Spraying of organic formulations at branching, flowering and pod initiation stage

The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited significantly higher number of fungi due to foliar the application at branching, flowering and pod initiation stage. While, treatment T₄ i.e. the application of

Panchagavya @ 3 % was determined to be on par in respect to fungal colony. The minimum fungal colony was recorded in the treatment T₁ i.e. control.

4.5.3 Actinomycetes count (cfu x 10⁻⁴)

Actinomycetes count was significantly influenced by the application of different foliar treatments depicted in the Table 4.17 and Fig. 18. The mean actinomycetes count was 10.76, 20.40 and 24.83 cfu x 10⁻⁴ at 38, 63 and 79 DAS respectively, and it is increased from 38 to 79 DAS.

Table 4.17. Effect of liquid organic formulations on actinomycetes count of chickpea-grown soil

Treatment	Actinomycetes count (cfu x 10 ⁻⁴)		
	38 DAS	63 DAS	79 DAS
T ₁ : Control	8.56	10.06	11.34
T ₂ : Cow urine @ 10 %	9.86	20.61	25.04
T ₃ : Vermiwash @ 10 %	10.33	21.03	25.85
T ₄ : Panchagavya @ 3 %	12.03	23.53	28.05
T ₅ : Waste decomposer @ 25 %	10.06	19.40	25.22
T ₆ : Jeevamrut @ 10 %	11.70	22.70	27.04
T ₇ : Cow urine @ 10 % + Vermiwash @ 10 %	12.56	24.23	28.90
T ₈ : Cow urine @ 10 % + waste decomposer @ 25 %	11.00	20.76	26.03
T ₉ : Vermiwash @ 10 % + waste decomposer @ 25 %	10.70	21.30	25.96
S.Em. $\pm$	0.21	0.29	0.34
C.D. at 5 %	0.64	0.88	1.01
C.V.	3.77	2.64	2.49
General mean	10.76	20.40	24.83
Initial status	8.30		

Note : Spraying of organic formulations at branching, flowering and pod initiation stage

The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited significantly higher number of Actinomycetes due to foliar the application at branching, flowering and pod initiation stage. While, Treatment T₄ i.e. the application of Panchagavya @ 3 % was determined to be on par in respect to Actinomycetes count. The minimum Actinomycetes count was recorded in the treatment T₁ i.e. control.

4.6 Economics

The economic assessment of chickpea was evaluated in terms of gross monetary returns, cost of cultivation, net monetary returns and benefit cost ratio during *rabi* 2021-2022 are presented in Table 4.18.

Table 4.18. Effect of liquid organic formulations on economics of chickpea

Treatment	Gross monetary returns (₹/ha ⁻¹)	Cost of cultivation (₹/ha ⁻¹)	Net monetary returns (₹/ha ⁻¹)	% Increase in net returns	B:C ratio
T ₁ : Control	116528	60797	55731	-	1.91
T ₂ : Cow urine @ 10 %	120073	61497	58576	5.10	1.95
T ₃ : Vermiwash @ 10 %	118556	61672	56884	2.07	1.92
T ₄ : Panchagavya @ 3 %	134538	63797	70741	26.93	2.11
T ₅ : Waste decomposer @ 25 %	118750	62797	55953	0.39	1.89
T ₆ : Jeevamrut @ 10 %	119699	63797	55902	0.31	1.87
T ₇ : Cow urine @ 10 % + Vermiwash @ 10 %	139458	61584	77874	39.73	2.26
T ₈ : Cow urine @ 10 % + waste decomposer @ 25 %	119701	62147	57554	3.27	1.92
T ₉ : Vermiwash @ 10 % + waste decomposer @ 25 %	119768	62234	57534	3.23	1.92
S.Em. ±	5429.55	196.37	2687.20	-	0.09
C.D. at 5 %	16277.78	NS	8056.23	-	0.27
C.V.	8.54	0.61	8.53	-	8.40
General mean	123008	62258	60750	9.01	1.98

Note: Spraying of organic formulations at branching, flowering and pod initiation stage.

4.6.1 Gross monetary returns

Mean gross monetary returns of chickpea obtained during *rabi* 2021-2022 were 123008 ₹ ha⁻¹. Different foliar the application methods have a significant impact on the gross monetary returns of chickpea crop. The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited significantly maximum gross monetary returns of 139458 ₹ ha⁻¹. While, Treatment T₄ i.e. the application of Panchagavya @ 3 % was determined to be on par 134538 ₹ ha⁻¹. Treatment T₁ i.e. control produced significantly lower values of gross monetary returns 116528 ₹ ha⁻¹.

The chickpea crop sprayed with treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited maximum seed and hulm yield because of luxuriant crop growth and yield attributes. This was proved in obtaining highest gross monetary returns.

Results are in close association with Behera and Bhoi (2021) and Vora *et al.* (2019).

4.6.2 Cost of cultivation

The mean cost of cultivation of chickpea was 62258 ₹ ha⁻¹. Cost of cultivation of different treatments of chickpea was not significantly different.

4.6.3 Net monetary returns

The mean net monetary returns of chickpea were 60750 ₹ ha⁻¹. The various foliar application treatments had a considerable impact on the net monetary returns. The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited significantly higher net monetary returns of 77874 ₹ ha⁻¹ and also % Increase in net returns was highest in T₇ i.e. 39.73 % compared to control. While, Treatment T₄ i.e. the application of Panchagavya @ 3 % was seen to be on par which produce net monetary returns of 70741 ₹ ha⁻¹. The chickpea crop with control treatment obtained significantly minimum net monetary returns 55731 ₹ ha⁻¹ than rest of foliar application treatments.

Results are in close association with Behera and Bhoi (2021) and Vora *et al.* (2019).

4.6.4 Benefit: cost ratio

The mean benefit cost ratio of chickpea was 1.98 under experimentation. The various foliar application treatments had a considerable impact on the benefit cost ratio. The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited significantly higher benefit cost ratio 2.26. While, Treatment T₄ i.e. the application of Panchagavya @ 3 % was seen to be on par which produce benefit cost ratio of 2.11. The chickpea crop with control treatment obtained significantly minimum benefit cost ratio of 1.91 than rest of foliar application treatments.

The function of gross monetary returns and cost of cultivation is benefit cost ratio. The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10

% exhibited significantly higher gross monetary returns which was proved in achieving maximum benefit cost ratio.

Results are in close association with Behera and Bhoi (2021), Vora *et al.* (2019) and Patil *et al.* (2012).

5. SUMMARY AND CONCLUSION

5.1 Summary

The field experiment entitled, “**Effect of liquid organic formulations on growth, yield and quality of chickpea**” conducted during *rabi* season 2021-2022 at Organic farming Research and Training Centre, Mahatma Phule Krishi Vidyapeeth, Rahuri.

The soil of experimental field, have saline pH (7.70), moderate in organic carbon (0.58 %) and electrical conductivity (0.35 dSm^{-1}). The soil was low in available nitrogen ($171.43 \text{ kg ha}^{-1}$), medium in available phosphorus (16.13 kg ha^{-1}) and very high in available potassium ($384.53 \text{ kg ha}^{-1}$). Microbial load of soil comprises of bacteria ($14.00 \times 10^{-7} \text{ cfu g}^{-1}$ of soil), fungi ($11.60 \times 10^{-5} \text{ cfu g}^{-1}$ of soil) and actinomycetes ($8.30 \times 10^{-4} \text{ cfu g}^{-1}$ of soil).

The field experiment was laid out in a randomized block design with three replications. There were 9 treatments viz., T₁- Control, T₂ - Foliar spray of cow urine @ 10 %, T₃ - Foliar spray of vermiwash @ 10 %, T₄ - Foliar spray of panchagavya @ 3 %, T₅ - Foliar spray of waste decomposer @ 25 %, T₆ - Foliar spray of jeevamrut @ 10 %, T₇ - Foliar spray of cow urine @ 10 %+ vermiwash @ 10 %, T₈ - Foliar spray of cow urine @ 10 % + waste decomposer @ 25 % and T₉ - Foliar spray of vermiwash @ 10 % + waste decomposer @ 25 %. Foliar the application of these treatments carried out at branching, flowering and pod initiation stage.

The gross and net plot size were 12.00 m x 3.00 m and 11.40 m x 2.40 m, respectively. The spacing adopted was of 30 cm x 10 cm by using 75 kg seed ha^{-1} . The recommended dose of fertilizer i.e. 25: 50: 30 kg N: P₂O₅: K₂O kg ha^{-1} was applied uniformly through 2 t ha^{-1} of vermicompost to all the treatments.

The sowing of chickpea done by dibbling. Three irrigations were applied, first immediately after sowing to ensure good germination, second irrigation at pre-flowering stage and third at pod initiation stage of chickpea. All throughout research, the same chickpea plant population was seen in all treatment plots. To reduce the prevalence of pests and soil-borne infections, plant protection measures were implemented by spraying neem oil.

The rainfall (6.8 mm) was received during the period of crop growth (December 2021- March 2022). The climatic parameters, mean maximum temperature (24.7 to 37.8⁰C), mean minimum temperature (12.0 to 22.9⁰C), relative humidity during morning hour (55.3 to 92.7 %), evening hour (16.0 to 54.4 %), wind velocity (0.4 to 2.1 km hr⁻¹), bright sunshine hours (4.7 to 10.0 Hrs) and open pan evaporation (3.0 to 8.6 mm) was recorded during experimentation. The environment was favourable for the luxuriant growth of chickpeas. The key findings of the field experiment are summarized below.

5.1.1 Growth attributes

The various foliar the application treatments seemed to have a noticeable influence on the chickpea growth parameters, yield and yield characteristics. The chickpea crop treated with treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited significantly higher plant height (50.15 cm), number of branches plant⁻¹ (20.03), plant spread (36.24 cm), dry matter plant⁻¹ (18.19 g) at harvest, nodule count plant⁻¹ (6.73) and nodule weight plant⁻¹ (29.54 mg) at 60 DAS, days to 50 % flowering (59 days) at flowering and days to maturity (105 days) at harvest contrasted with other foliar the applications during *rabi* 2021-22. Treatment T₄ i.e. the application of Panchagavya @ 3 % is at par with plant height (47.67 cm), number of branches plant⁻¹ (18.03), plant spread (34.41cm), dry matter plant⁻¹ (17.59 g) at harvest, nodule count plant⁻¹ (6.47) and nodule weight plant⁻¹ (26.00 mg) at 60 DAS, days to 50% flowering (59 days) at flowering and days to maturity (104 days) at harvest. Chickpea crop with no foliar the application recorded remarkable minimum plant height (41.06 cm), number of branches plant⁻¹ (16.07), plant spread (31.59 cm), dry matter plant⁻¹ (15.33 g) at harvest, nodule count plant⁻¹ (5.00) and nodule weight plant⁻¹ (21.05 mg) at 60 DAS, days to 50% flowering (49 days) at flowering and days to maturity (98 days) at harvest as compared to remaining foliar the application treatments.

5.1.2 Yield attributes

The chickpea crop treated with treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited remarkably elevated yield attributing characters viz., number of pods plant⁻¹ (44.63), number of seeds pod⁻¹ (1.27), weight of pods plant⁻¹ (11.75 g), seed yield plant⁻¹ (8.44 g) and test weight (178.84 g) at harvest as

compared to remaining foliar the application treatments during research. Treatment T₄ i.e. the application of Panchagavya @ 3 % is at par with number of pods plant⁻¹ (42.00), number of seeds pod⁻¹ (1.07), weight of pods plant⁻¹ (10.75 g), seed yield plant⁻¹ (8.16 g) and test weight (174.89 g) at harvest. Chickpea crop with control recorded remarkably reduced values of yield attributes viz., number of pods plant⁻¹ (31.91), number of seeds pod⁻¹ (1.07), weight of pods plant⁻¹ (10.04 g), seed yield plant⁻¹ (7.16 g) and test weight (169.77 g) at harvest as compared to remaining foliar the application treatments.

5.1.3 Seed and Haulm Yield

The chickpea crop applied with treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited remarkably elevated seed yield (24.81 q ha⁻¹), haulm yield (29.87 q ha⁻¹), biological yield (54.68 q ha⁻¹) and harvest index (45.39 %) as compared to remaining foliar the application treatments under experiment . Similarly, treatment T₄ i.e. the application of Panchagavya @ 3 % is at par with seed yield (23.94 q ha⁻¹), haulm yield (28.86 q ha⁻¹), biological yield (52.80 q ha⁻¹) and harvest index (45.33 %). Chickpea crop with control recorded significantly reduced seed yield (20.74 q ha⁻¹), haulm yield (24.84 q ha⁻¹), biological yield (45.58 q ha⁻¹) and harvest index (45.47 %) as compared to remaining foliar the application treatments under investigation.

5.1.4 Quality studies

The average protein content of chickpea was 19.93 % during investigation. The data in respect protein content in chickpea meagrely influenced due to different nutrient treatments. Protein content of chickpea seeds ranges between 19.40% to 20.92 %.

The highest value of nitrogen uptake is analysed in plot applied with treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % (153.96 kg ha⁻¹), treatment T₄ i.e. the application of Panchagavya @ 3 % (147.04 kg ha⁻¹) is at par and minimum in control (99.25 kg ha⁻¹). In case of phosphorus, uptake is higher in the plot applied with treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % (24.78 kg ha⁻¹), treatment T₄ i.e. the application of Panchagavya @ 3 % (22.86 kg ha⁻¹) is at par and minimum in control (17.76 kg ha⁻¹). Coming to the case of potassium, uptake is higher in the plot applied with treatment T₇ i.e. the application of Cow urine @

10 % + Vermiwash @ 10 % (47.76 kg ha⁻¹) which is at par with treatment T₄ i.e. the application of Panchagavya @ 3 % (45.35 kg ha⁻¹) and minimum in control (35.24 kg ha⁻¹).

5.1.5 Chemical parameters

Experimental data showed that the pH, EC and OC of soil after harvest were all statistically identical. The pH, EC and OC content were not influenced noticeably. The available nitrogen, available phosphorus and available potassium in the soil were influenced significantly due to different treatments of foliar the application. The mean pH, EC and OC content in soil after harvest of chickpea were 7.51, 0.35 dSm⁻¹ and 0.56%, respectively. The mean available nitrogen, phosphorus and potassium content in soil after harvest of chickpea crop were 181.45, 17.26 and 391.37 kg ha⁻¹, respectively.

The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited higher available nitrogen, available phosphorus and available potassium (188.59, 18.59, 399.28 kg ha⁻¹) respectively, compared to other treatments at harvest. Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par in respect to available nitrogen, available phosphorus and available potassium (185.67, 17.82 and 395.49 kg ha⁻¹) respectively at harvest. The minimum available nitrogen, available phosphorus and available potassium (176.82, 15.86 and 387.17 kg ha⁻¹) respectively, was observed in control.

5.1.7 Biological parameters

With various organic foliar treatments, the microbial population proliferated more significantly. The treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited higher population of bacteria (28.06 x 10⁻⁷ cfu g⁻¹ of soil), fungi (24.08 x 10⁻⁵ cfu g⁻¹ of soil) and actinomycetes (28.90 x 10⁻⁴ cfu g⁻¹ of soil) at harvest. Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par in respect to bacteria (26.96 x 10⁻⁷ cfu g⁻¹ of soil), fungi (23.80 x 10⁻⁵ cfu g⁻¹ of soil) and actinomycetes (28.05x 10⁻⁴ cfu g⁻¹ of soil) at harvest. The reduced microbial population like bacteria (16.87x 10⁻⁷ cfu g⁻¹ of soil), fungi (15.64 x 10⁻⁵ cfu g⁻¹ of soil) and actinomycetes (11.34 x10⁻⁴ cfu g⁻¹ of soil) at harvest was observed in control.

5.1.6 Economics

The chickpea crop applied with treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % exhibited remarkably raised gross monetary returns (139458.10 ₹ ha⁻¹), net monetary returns (77874.14 ₹ ha⁻¹) and benefit cost ratio (2.26) than other foliar the applications during study. Treatment T₄ i.e. the application of Panchagavya @ 3 % was found to be on par in respect to gross monetary returns (134537.80 ₹ ha⁻¹), net monetary returns (70740.79 ₹ ha⁻¹) and benefit cost ratio (2.11). The chickpea crop with control obtained remarkably minimum gross monetary returns (116527.90 ₹ ha⁻¹), net monetary returns (55730.86 ₹ ha⁻¹) and benefit cost ratio (1.91) as compared to remaining foliar the application during experiment.

5.2 Conclusions

1. The chickpea crop treated with treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % at the branching, flowering and pod initiation stage exhibited remarkably higher values of growth, yield and quality parameters at 60, 90 DAS and at harvest. The value of growth, yield and quality parameters at harvest viz., plant height (50.15 cm), number of branches plant⁻¹ (20.03), plant spread (36.24 cm), dry matter plant⁻¹ (18.19 g) at harvest, nodule count plant⁻¹ (6.73) and nodule weight plant⁻¹ (29.54 mg) at 60 DAS, days to 50% flowering (59 days) at flowering and days to maturity (105 days), number of pods plant⁻¹ (44.63), number of seeds pod⁻¹ (1.27), weight of pods plant⁻¹ (11.75 g), seed yield plant⁻¹ (8.44 g), test weight (178.84 g), seed yield (24.81 q ha⁻¹), haulm yield (29.87 q ha⁻¹), biological yield (54.68 q ha⁻¹), harvest index (45.39 %), total uptake of nitrogen (153.96 kg ha⁻¹), phosphorus (24.78 kg ha⁻¹) and potassium (47.76 kg ha⁻¹) at harvest. These values are higher as compared to remaining foliar the applications and Treatment T₄ i.e. the application of Panchagavya @ 3 % is at par. Control plot T₁ recorded significantly minimum plant height (41.06 cm), number of branches plant⁻¹ (16.07), plant spread (31.59 cm), dry matter plant⁻¹ (15.33 g) at harvest, nodule count plant⁻¹ (5.00) and nodule weight plant⁻¹ (21.05 mg) at 60 DAS, days to 50% flowering (49 days) at flowering and days to maturity (98 days), number of pods plant⁻¹ (31.91), number of seeds pod⁻¹ (1.07), weight of pods plant⁻¹ (10.04 g), seed yield plant⁻¹ (7.16 g), test weight (169.77 g), seed yield (20.74 q ha⁻¹), haulm yield (24.84 q ha⁻¹), biological yield (45.58 q

ha⁻¹), harvest index (45.47 %), total uptake of nitrogen (99.25 kg ha⁻¹), phosphorus (17.76 kg ha⁻¹) and potassium (3.24 kg ha⁻¹) at harvest as compared to remaining foliar the application treatments.

2. The chickpea crop treated with treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % at the branching, flowering and pod initiation stage exhibited remarkably higher values of available nitrogen (188.59 kg ha⁻¹), phosphorus (18.59 kg ha⁻¹), potassium (399.28 kg ha⁻¹), bacteria (28.06 cfu x 10⁻⁷), fungi (24.08 cfu x 10⁻⁵) and actinomycetes (28.90 cfu x 10⁻⁴) in soil at harvest of chickpea. Treatment T₄ i.e. the application of Panchagavya @ 3 % is at par. Treatment T₁ i.e. control have significantly lower concentration of available nitrogen (176.82 kg ha⁻¹), phosphorus (15.86 kg ha⁻¹), potassium (387.17 kg ha⁻¹), bacteria (16.87 cfu x 10⁻⁷), fungi (15.64 cfu x 10⁻⁵) and actinomycetes (11.34 cfu x 10⁻⁴) at harvest as compared to remaining foliar the application treatments.
3. In terms of economics treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % at the branching, flowering and pod initiation stage exhibited remarkably higher gross monetary returns (139458.10 ₹ ha⁻¹), net monetary returns (77874.14 ₹ ha⁻¹) and benefit cost ratio (2.26). Treatment T₄ i.e. the application of Panchagavya @ 3 % is at par. Treatment T₁ i.e. control earns significantly minimum returns investment⁻¹ i.e. gross monetary returns (116527.90 ₹ ha⁻¹), net monetary returns (55730.36 ₹ ha⁻¹) and benefit cost ratio (1.91) as compared to remaining foliar the application treatments.

Conclusion

On the basis of one season trial data, foliar spray of treatment T₇ i.e. the application of Cow urine @ 10 % + Vermiwash @ 10 % at the branching, flowering and pod initiation stage determined to be effective for maximising chickpea growth attributes, yield characteristics, nutritional uptake, protein content, and financial returns.

However, the above-mentioned result is based on one crop season examination. The investigation must be repeated to confirm the findings.

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7. APPENDICES

Appendix-I : Price of inputs and output per unit

Sr. No.	Particulars	Quantity /frequency	Unit Price (₹)
1.	Hired human labour (Unit ⁻¹)		
	Male	60	331.00
	Female	-	331.00
2.	Land preparation		
i	Ploughing (Tractor)(ha ⁻¹)	1	3750 .00
ii	Rotovator (Tractor)(ha ⁻¹)	1	2500 .00
3.	Fertilizers		
i	Vermicompost (Ton ⁻¹)	2	8000.00
ii	Seed (kg ⁻¹)	75	75.00
4.	Inter cultivation operation		
i	Gap filling (unit ⁻¹)	1	331.00
ii	Thinning (unit ⁻¹)	1	331.00
iii	Weeding	1	331.00
5.	Spraying		
i	Cow urine (litre ⁻¹)	20	35.00
ii	Vermiwash (litre ⁻¹)	35	25.00
iii	Panchagavya (litre ⁻¹)	20	150.00
iv	Waste decomposer (litre ⁻¹)	25	80.00
v	Jeevamrut (litre ⁻¹)	25	120.00
vi	Neem oil (litre ⁻¹)	5	350.00
6.	Irrigation (unit ⁻¹)	3	331.00
7.	Output		
i	Harvesting and threshing (day ⁻¹ head ⁻¹)	1	331 .00
ii	Seed (q ⁻¹)	-	5500.00
iii	Haulm (q ⁻¹)	-	100.00

Appendix II. Details of cost of cultivation in different treatment (₹ ha⁻¹)

Sr. No	Particulars	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇	T ₈	T ₉
1	Total labour required	19860	19860	19860	19860	19860	19860	19860	19860	19860
2	Land preparation									
I	Ploughing	3750	3750	3750	3750	3750	3750	3750	3750	3750
ii	Rotovator	2500	2500	2500	2500	2500	2500	2500	2500	2500
iii	Sowing	2500	2500	2500	2500	2500	2500	2500	2500	2500
3	Fertilizer									
i	Vermicompost (ton)	16000	16000	16000	16000	16000	16000	16000	16000	16000
4	Seed (kg)	5625	5625	5625	5625	5625	5625	5625	5625	5625
5	Spray solution									
i	Cow urine (litre)		700					350	350	
ii	Vermiwash (litre)			875				437		437
iii	Panchagavya(litre)				3000					
iv	Waste Decomposer(litre)					2000			1000	1000
v	Jeevamrut(litre)						3000			
vi	Neem oil(litre)	1750	1750	1750	1750	1750	1750	1750	1750	1750
6	Cost of spraying	1800	1800	1800	1800	1800	1800	1800	1800	1800
7	Irrigation	1782	1782	1782	1782	1782	1782	1782	1782	1782
8	Threshing ₹ (250 q ⁻¹)	4730	5233	5163	5910	5140	5023	6153	5213	4983
9	Incidental charges	500	500	500	500	500	500	500	500	500
	Total cost of cultivation	60797	61497	61672	63797	62797	63797	61584	62147	62234

8. VITAE

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