Effect of Soil and Foliar Application of Compost Tea on Growth, Yield and Quality of Soybean [*Glycine max* (L.) Merrill]

[kkn Pkk; ds e`nk o i.khZ; fNM+dko dk Lkks;chu [*Xykblhu eSDl* (,y-½ esfjy] dh o`f)] mit ,oa xq.koÙkk ij izHkko

PRIYA SIDANA

Thesis

Master of Science in Agriculture

(Agronomy)

2021

DEPARTMENT OF AGRONOMY
RAJASTHAN COLLEGE OF AGRICULTURE
MAHARANA PRATAP UNIVERSITY OF AGRICULTURE & TECHNOLOGY
UDAIPUR – 313001 (RAJASTHAN)

Effect of Soil and Foliar Application of Compost Tea on Growth, Yield and Quality of Soybean [*Glycine max* (L.) Merrill]

[kkn Pkk; ds e`nk o i.khZ; fNM+dko dk Lkks;chu [*Xykblhu eSDl* (,y-½ esfjy] dh o`f)] mit ,oa xq.koÙkk ij izHkko

Thesis

Submitted to the

Maharana Pratap University of Agriculture and Technology, Udaipur

In Partial Fulfilment of the Requirement for the Degree of

Master of Science in Agriculture

(Agronomy)

By

PRIYA SIDANA

2021

RAJASTHAN COLLEGE OF AGRICULTURE
MAHARANA PRATAP UNIVERSITY OF AGRICULTURE & TECHNOLOGY, UDAIPUR

<u>CERTIFICATE-I</u>

CERTIFICATE OF ORIGINALITY

The research work embodied in the thesis titled **“Effect of Soil and Foliar Application of Compost Tea on Growth, Yield and Quality of Soybean [*Glycine max* (L.) Merrill”** submitted for the award of degree of **Master of Science in Agriculture** in the subject of **Agronomy** to Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan), is original and bonafide record of research work carried out by me under the supervision of **Dr. M. K. Kaushik**, Professor, Department of Agronomy, Rajasthan College of Agriculture, Udaipur. The contents of the thesis, either partially or fully, have not been submitted or will not be submitted to any other institute or university for the award of any degree or diploma.

The work embodied in the thesis represents my ideas in my own words and where others ideas or words have been included. I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the university and can also evoke panel action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

The manuscript has been subjected to plagiarism check by software- Urkund.

It is certified that as per the check, the similarity index of the content is 8% and is within permissible limit as per the MPUAT guidelines on checking plagiarism.

Date: / /2020 Priya Sidana

RAJASTHAN COLLEGE OF AGRICULTURE
MAHARANA PRATAP UNIVERSITY OF AGRICULTURE & TECHNOLOGY, UDAIPUR

CERTIFICATE-II

Date: /   /2020

This is to certify that the thesis entitled **"Effect of Soil and Foliar Application of Compost Tea on Growth, Yield and Quality of Soybean [*Glycine max* (L.) Merrill]"** submitted for the degree of Master of Science in Agriculture in the subject of Agronomy, embodies bonafide research work carried out by **Ms. Priya Sidana** under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation have been fully acknowledged. The draft of this thesis was also approved by the advisory committee on / /2020.

(Dr. M.K. Kaushik)
Professor & Head
Department of Agronomy
RCA, Udaipur

(Dr. M.K. Kaushik)
Major Advisor
Professor, Agronomy
RCA, Udaipur

(Dr. Dilip Singh)
Dean
Rajasthan College of Agriculture,
MPUAT, Udaipur 313 001 (Rajasthan)

RAJASTHAN COLLEGE OF AGRICULTURE
MAHARANA PRATAP UNIVERSITY OF AGRICULTURE & TECHNOLOGY, UDAIPUR

CERTIFICATE-III

Date: / / 2021

This is to certify that the thesis entitled **"Effect of Soil and Foliar Application of Compost Tea on Growth, Yield and Quality of Soybean [*Glycine max* (L.) Merrill]** submitted by **Ms. Priya Sidana** to the Maharana Pratap University of Agriculture & Technology, Udaipur in partial fulfilment of the requirement for the degree of **Master of Science in Agriculture** in the subject of **Agronomy** after recommendation by the external examiner was defended by the candidate before the following members of the examination committee. The performance of the candidate in the oral examination held on / /2021 was found satisfactory, we therefore, recommend that the thesis be approved.

(Dr. M. K. Kaushik)
Major Advisor

(Dr. Roshan Choudhary)
Advisor

(Dr. Gajanand Jat)
Advisor

(Dr. N. S. Dodiya)
DRI Nominee

(Dr. M. K. Kaushik)
Professor & Head
Department of Agronomy

(Dr. Dilip Singh)
Dean
Rajasthan College of Agriculture
Udaipur (Raj.)

Approved

(Dr. S. R. Bhakar)
DIRECTOR RESIDENT INSTRUCTIONS
MPUAT, UDAIPUR

RAJASTHAN COLLEGE OF AGRICULTURE
MAHARANA PRATAP UNIVERSITY OF AGRICULTURE & TECHNOLOGY, UDAIPUR

<u>CERTIFICATE-IV</u>

Date: / / 2021

This is to certify that **Ms. Priya Sidana,** student of M.Sc. (Ag.) **Department of Agronomy** has made all the corrections/modifications in the thesis **"Effect of Soil and Foliar Application of Compost Tea on Growth, Yield and Quality of Soybean [*Glycine max* (L.) Merrill]"** which were suggested by the external examiner and the advisory committee in the oral examination held on --/--/2021. The final copies of the thesis duly bound and corrected were submitted on /--/2021.

(Dr. M. K. Kaushik)
Professor & Head
Department of Agronomy
RCA, Udaipur

(Dr. M. K. Kaushik)
Major Advisor
Department of Agronomy
RCA, Udaipur

ACKNOWLEDGEMENT

I feel proud privilege in expressing my intense sense of gratitude and indebtedness to my learned major advisor **Dr. M. K. Kaushik**, Professor and Head, (Agronomy), Rajasthan College of Agriculture, Udaipur for his valuable guidance and constructive suggestions during the entire period of investigation, as well as critically going through the manuscript.

I am gratified to acknowledge my thanks to the members of advisory committee; **Dr. Roshan Choudhary**, Assistant Professor, (Agronomy), **Dr. Gajanand Jat**, Assistant Professor, (Soil Science and Agricultural Chemistry) and DRI Nominee **Dr. N. S. Dodiya**, Professor & Head, (Plant Breeding and Genetics), Rajasthan College of Agriculture, Udaipur for their generous gestures and valuable suggestion in planning and execution of this study.

I am grateful to express my gratitude to **Dr. S. K. Sharma**, Professor (Agronomy) & Director Research, MPUAT, Udaipur for his help and support for the initiation of this investigation.

I am deeply indebted to **Dr. Dilip Singh**, Dean, Rajasthan College of Agriculture, Udaipur for his due attention and encouragement during the study period and also providing me the necessary facilities during the period of research.

Words can hardly register the sincere and heartfelt feeling which I have for my teachers and staff members **Dr. S.L. Mundra**, **Dr. N.S. Solanki**, **Dr. Arvind Verma, Dr. J. Choudhary**, **Dr. L.N. Dashora** and **Dr. Roshan Choudhary**, **Dr. R.S. Choudhary, Dr. H.K. Sumeriya** and other staff memebers for their kind cooperation and help as and when needed.

I wish to accord my cordial thanks to my senior **Dr. S.K. Yadav, Dr. R.K. Jain**, **Deepak Kumar, Karan, Somdutt, Abhishek, Piyush, Sonika** and my friends **Nitin**, **Pooja, Nilesh** and my junior **Akshita** for sharing their knowledge, encouragement and help in different ways during the completion of this valuable task.

Words will never be enough to express reverence to my beloved parents **Sh. Pradeep Sidana** & **Smt. Seema Sidana**, uncle & aunt (**Sh. Ashok Baghla** & **Smt. Rajni Baghla**), grandmother **Smt. Sunita Chugh and Smt. Raj Rani**, my elder brother **Rahul**, younger brother **Prateek**, **Pulkit**, **Rishabh** and younger sister **Prachi** for their inevitable affection, inspiration, incessant encouragement and blessings for which I have got success in every situation in my life.

Last but not the least, I pray obeisance to **"GOD"** with whose grace and blessing, I could be able to accomplish this task.

Date:

Place: Udaipur **Ms. Priya Sidana**

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACRONYMS & ABBREVIATIONS

%	: Per cent	K	: Potassium
$^{-1}$	: Per	K_2O	: Potassium oxide
@	: At the rate of	LAI	: Leaf area index
a.i.	: Active ingredient	m	: Metre
et al.	: (et alibi) and elsewhere	m^2	: Square metre
Max	: Maximum	Min	: Minimum
B C ratio	: Benefit-cost ratio	mg	: Milligram
^oC	: Degree Celsius	Mg	: Mega gram
CD	: Critical difference	M ha	: Million hectare
CV	: Coefficient of variation	mm	: Millimetre
CFU	: Colony forming unit	cm	: Centimetre
MSS	: Mean sum of squares	Mt	: Million tonne
DAS	: Days after sowing	DM	: Dry matter
DMA	: Dry matter accumulation	N	: Nitrogen
NS	: Non-significant	df	: Degrees of freedom
Sl. No.	: Serial Number	TPF	: Tri phenyl formazan
ppm	: Parts per million	P	: Phosphorus
dSm^{-1}	: Deci simon per metre	^oE	: Degree east
P_2O_5	: Phosphorus penta-oxide	EC	: Electrical conductivity
pH	: Negative logarithm of hydrogen ion activity	&	: and
q	: Quintals	Fig.	: Figure
r	: Correlation coefficient	₹	: Rupees
g m^{-2}	: Gram per metre square	ha	: Hectare
RDF	: Recommended dose of fertilizer	g	: Gram
RH	: Relative humidity	HI	: Harvest index
Organic C	: Organic carbon	kg	: Kilogram
SEm ±	: Standard error of mean	HW	: Hand weeding
kg ha^{-1}	: Kilogram per hectare	hrs.	: Hours
Temp.	: Temperature	var	: Variety
viz.	: (*Videlicet*) Namely	*i.e.*	: That is

1. INTRODUCTION

The Green Revolution of 1960's had a phenomenal impact on food production in India. It catapulted our country into league of the world's leading grain producer. However, the effects of the Green Revolution in India have plateaued since then. Though, India is now self-sufficient in aspects of food production, it still relies on imports for crops such as pulses and oilseeds, where production has not kept pace with demand from a burgeoning population. Secondly, high input agriculture generated many problems in front of us like degradation of resources *i.e.* soil and water, beneficial micro flora and fauna, biodiversity, toxicity residues of agro-chemicals which affects human and animal health. Hence, the need of the hour is to infuse fresh energy to drive the next phase of growth in agriculture. Organic agriculture can be a solution to the foregoing problems.

Organic farming is an alternative agricultural production method that relies on ecological processes, biodiversity and cycles adapted to local conditions with the aim of sustaining the health of soils, ecosystems and people (IFOAM, 2008). In world, almost 181 countries till now are involved in organic farming practices. The total world's organically cultivated area is 69.8 million hectares million hectares and the total market of organic produce reaches to 97 billion euros (FiBL and IFOAM, 2020). In India, the organic area is about 5.2 million hectares including certified forest area. India has the highest number of registered organic producers (5.85 million) among all organic producing countries at an annual growth rate of 12-15 per cent. India has a great potential to be a major base for production and export of organic products.

In India, total annual oilseed crops are cultivated over 26.67 million hectares and a production of 30.06 million tonnes (NMOOP, 2018). Despite being 5th largest producer of oilseeds among all the oilseed growing countries, India still depends on other countries for its pulses and edible oils demand. Soybean (*Glycine max* (L.) is one among the crops that grow extensively in India. It can be grown as oilseed and protein crop. The total production of soybean in India in 2019-20 was 13.50 million tonnes (ICAR, IISR 2019-20). Major states that grow soybean are Madhya Pradesh, Rajasthan, Karnataka, Maharashtra, Uttar Pradesh, Andhra Pradesh and Gujarat. In comparison with the annual production of decade 1990-2000, an increasing trend observed during the period of 2001-2013. The reason behind this increased production was area increment and higher productivity led by technological advancement. Still, we are far behind from average global world's productivity (2310 kg ha^{-1}) and our national soybean productivity (1353 kg ha^{-1}) (Directorate of Economics and Statistics, 2017). So, to fulfil the increasing demand of population for oilseeds and its by-products like edible oil etc. we should adopt new strategies to meet out the demands and to accelerate the exports.

Almost 70 per cent of the cultivated area of oilseeds comes under rainfed condition. Rajasthan has a great contribution in oilseed production of the country. In terms of oilseed area and production, this state contributes 10.8 per cent and 14.5 per cent, respectively (GOI, 2013). Important *Kharif* crops grown in Rajasthan are groundnut and soybean while, rapeseed-mustard and taramira are important *rabi* crops grown in majorly districts of Rajasthan. Among total oilseed producing states of India, this state ranked first position in production of rapeseed-mustard and third position in sesame and soybean production with a share of 48.6, 13.8 and 8.1 per cent, respectively (MoA, GOI, 2013).

Soybean seed contains protein (36 %), carbohydrates (35 %), oil (19 %), minerals (5 %) vitamins and several other components like vitamins etc (Liu *et al.*, 1997). Soybean protein is a cheapest available source of dietary protein for vegetarian population (Derbyshire *et al.* 1974). It is also considered as a great substitute for animal protein, as it is quite similar to that of animal protein that comprises most of the essential amino acids and also sulphur containing amino acids like cysteine and methionine (Sacks *et al.*, 2006). Various by-products can be prepared from soybean like soy vegetable oil (contains 15.6 % saturated fatty acids, 23 % monosaturated fatty acids and 57.5 % polyunsaturated fatty acids, sprouts, soy protein flour, soy milk, tofu etc. (Wolke *et al.*, 2007). Soybean can be also used for making soybean meal for domestic animals like pig, horses, cattle, fish feed etc. That's why it plays a crucial role in human and animal health. But over use of chemical fertilizers to enhance its production causes serious health issues and high cost input makes it less attracted to farmers for its sowing.

Organic crops have dual advantages less input intensive and rich in nutrition with no chemical residues. Now-a-days various fermented products are being used in organic agriculture namely compost tea, panchagavya, jeevamrut etc. which helps in plant growth enhancement and can be easily made from farm waste products and readily available products at farm. They contain huge number of useful microorganisms that helps in enhancing the plant growth, better vegetative growth, yield and product quality.

Compost tea is an emerging tool used in organic agriculture for numerous reasons. It contains beneficial microorganisms which minimises the occurrence of various soilborne and foliar diseases. Secondly, it comprises nutrients that are extracted from compost in a very readily available form, that rapidly taken up by plants for their growth. It can be easily amalgamated in to existing fertility and disease minimising programmes due to easy application via existing spray implement or irrigation channels or as drenching of soil or foliar spray. Unlike other bulky organic sources like compost, compost tea does not require large transportation cost to long distant areas because compost teas generally prepared on farm or concentrate compost tea liquid is purchased and being diluted before its application.

"Compost tea" or "Compost leachate" can be defined as a liquid extract made from composted that may contain organic and inorganic soluble nutrients, large number of organisms including bacteria, fungi, actinomycetes, protozoa and nematodes (ROU, 2003). Aerobic and anaerobic brewing techniques are being used for making compost tea which extracts beneficial microorganisms (Ingham, 2005; Scheurelll, 2003). Historically, non-aerated compost tea was prepared by hanging a bag full of compost in a vessel contains water for about 14 days for nutrients extraction and boosting microbial population growth. Now-a-days, compost tea is being prepared by mechanized systems in short period and augmented with microbial starters, oxygen and various nutrients to enhance the properties of compost tea.

Regarding these facts and problems, field experiment has been performed entitled "**Effect of Soil and Foliar Application of Compost Tea on Growth, Yield and Quality of Soybean [*Glycine max* (L.) Merrill]**" during *Kharif* season 2019-20 at Instructional Organic Farm Unit, RCA, Udaipur with the below-mentioned objectives:

1. To find out the effect of compost tea on growth and the yield of soybean.
2. To find out the effect of compost tea on quality of soybean and soil health.
3. To work out the economics of treatments.

2. REVIEW OF LITRATURE

A concise review pertaining to the research work performed on topic **"Effect of Soil and Foliar Application of Compost Tea on Growth, Yield and Quality of Soybean [*Glycine max* (L.) Merrill]"** in *Kharif* season 2019-20 is presented in this chapter.

Now-a-days under organic farming, various research works have been documented in which the use of organic liquid formulations *viz.* compost tea, jeevamrut, beejamrut, etc has shown. Since the investigated work on use of soil and foliar application of compost tea in soybean and other field crops is very scanty and hence, work done on crops including horticultural crops under organic production or organic versus conventional production system in India & abroad has been included to explain the points related to study.

2.1 GROWTH CHARACTERS

Akanbi *et al.* (2007) carried out a trial at Research Farm, Akintola University of Technology, Nigeria for the evaluation of compost tea used as foliar spray which act as nutrient source as well as botanical insecticide in *Telfaria occidentalis* (fluted pumpkin) and prepared compost tea by using Cassava peel and Tithonia plant composts in similar quantity and was immersed in water in the ratio of 1:1, 1:2 and 1:3 to make extract of various nutrient strengths; data revealed that maximum number of secondary vines plant^{-1} (14), number of leaves plant^{-1} (486), leaf area plant^{-1} (10845 cm^{-2}), dry matter (672.7 g plant^{-1}) and shoot yield (20.9 t ha^{-1}) could be observed in treatment i.e. Tithonia compost extract ratio 1:2 over other treatments and control.

El-Din *et al.* (2008) performed an experiment at Ismailia Experimental Farm for investigating effects from application of seaweed extracts on growth parameters and yielding characters of faba bean (*Vicia faba*) for which algal extract was applied in three doses i.e. 15 days - 250 ml of extract plot^{-1}, 45 days - 500ml of extract plot^{-1} and 75 days - 750 ml of extract^{-1} using five concentrations. Their data revealed that mean roots fresh and dry weight and length of roots at various stages had improved by seaweed extract spray, while at the concentration of 0.8 per cent, the best number of nodules for all growth stages were obtained. Tillering was positively influenced by the foliar spray in all concentrations while the number of pods (6.39) were positively influenced only by 0.6 per cent concentration.

Gharib *et al.* (2008) performed a pot experiment in Ciaro, Egypt investigating the sound effects of compost tea and biofertilizers on growth characters of marjoram (*Majorana hortensis*) plant. They transplanted 45 days old seedlings in soil treated with aqueous extracts of compost and/or biofertilizers in addition to the recommended NPK doses as control. There was an increase in plant height (45.7 cm), stem diameter (2.17 cm) and herb fresh (47.13 g) and dry weight (17.94 g) as compared to control which has plant height (40.5 cm), stem diameter (1.13 cm), fresh weight (41.19 g) and dry weight (13.97 g), respectively.

Hegazi and Algharib (2014) accomplished a test at Horticulture Research Station, Kaha, Egypt to study the utilization of compost tea taken as nutrient source in an open field cowpea production using seven treatments using compost tea and water in 1:2 (v/v) proportions and treated plants with two doses at one month and two months after sowing. Their results revealed that application of compost tea used as soil drenching characteristically increased plant height (62.67cm), number of leaves plant^{-1} (58.07), leaf area plant^{-1} (3331cm^{2}) respectively, found highest in treatment *i.e.* 25 % NPK + 75 % compost tea soil drench.

Kim *et al.* (2015) studied the influence of compost tea on the promotion of growth of lettuce, sweet corn and soybean under organic farming practices using four kinds of ACT made from vermicompost, rice straw compost, herb compost and mixture of these three composts to study the effect caused by five concentrations 0.1, 0.2, 0.3, 0.4 and 0.8 per cent mixture of the three composts. Tea applied as foliar spray @ 50 ml plant^{-1} compost tea in 1:1 (v/v) ratio by early morning every week, up to 4 weeks starting 3 days DAT in greenhouse. Data revealed that 0.4 per cent mixture of the three composts had most significant effect on growth parameters in leafy part while 0.8 per cent mixture of the three composts pointedly enhanced the root growth and shoot growth of both sweet corn and soybean plants. Soybean plants treated with more concentration mixtures of the three composts gave 7.25 times more root nodule formation than in other lower mixtures of the three composts.

Sugandhi and Jayananda (2015) studied the impact of compost tea on the growth of *Vigna radiata* (L.) by using 40 seeds of it, out of 40, 20 were soaked in water and 20 were soaked in compost tea and then after 24 hrs, sprouted seeds were further placed in field. The results bring to light that the compost tea showed a maximum germination percentage (100%) compared to control (58.33%), highest shoot yield (15.6 cm) if compared with the control (12.5 cm), higher length of roots (15 cm) as compared to control (8 cm) with highest number of leaves plant^{-1} (10) in comparison to control (7).

Morale-Corts *et al.* (2017) performed an experiment in University of Salamanca, Spain to study the effect of compost teas made from garden waste compost in tomato for growth and disease suppression of soil borne diseases. They have taken compost tea and vermicompost tea prepared from garden waste and were applied *in vitro* and *in vivo* using three concentrations of teas: non diluted tea, tea: water (1:2) (v/v) and tea: water (1:4) (v/v). Results revealed that the maximum total dry weight (50.3 mg) is observed under non diluted tea treatment followed by 1 tea:2 water treatment, 1 tea:4 water and control which were (45.1 mg), (34.8 mg) and (30 mg), respectively.

Hafez and Geries (2018) carried out study in Nashert village, Egypt for two successive seasons for the evaluation of nitrogen fertilization and bio-stimulative compounds effect on onion growth and yield. The outcomes from the study discovered that with foliar application of compost tea, a positive impact was seen on plant's height (75.77 cm), number of leaves plant^{-1} (9.21), and diameter of bulb (6.33 cm) in comparison to control in both the seasons.

2.2 YIELD ATTRIBUTES AND YIELD

Khan *et al.* (2011) performed an experiment on laboratory scale at Department of Environmental Sciences, University of Peshawar, Pakistan for a comparative study to evaluate the effect of compost tea (aerated and non- aerated) of agro-waste on the germination and yield of maize, cauliflower and mung bean using distilled water. Aerated and non-aerated compost teas that was prepared using compost and water in a ratio 1:4 (w/w) and compost tea was applied @ 10 ml on seeds of maize and mung bean to check their germination and foliar application of compost tea as 250 ml day^{-1} on cauliflower. Their results revealed that highest germination per cent (85%) and biomass yield (6.02 g plant^{-1}) in maize, (90%) and (3.0 g plant^{-1}) in mung bean were obtained by using aerated compost tea while, in cauliflower, using foliar spray of aerated compost tea gave highest germination (96%), biomass yield (31.0 g plant^{-1}) in comparison with other treatments.

Islam *et al.* (2014) conducted a field trial at Bangladesh Agriculture University for the evaluation of compost tea used as soil drenching in which compost tea was prepared from mixing and compost and water at a proportion of 1:5 (w/v) that was followed by fermentation process for almost seven days and finally used compost tea in 1:1 ratio for soil drenching. The results unveiled that using compost tea as soil drenching harness maximum fruits number plant^{-1} (162.50) and fruit yield per ha^{-1} (26 tonnes ha^{-1}) was achieved with treatment T_2 (compos tea as soil drench) which was followed by other treatments and control.

Naidu *et al.* (2013) conducted a trial at Putra University Malaysia, Serdang, Malaysia to know the impacts of foliar application of compost tea enriched with microbes on growth characters, yields and quality of muskmelon with fertigation and compost tea which was prepared from 3 months old compost, immersed in water in the ratio of 1 compost : 5 water (w/v) for at least 3 days and further applied it as foliar application after 2 weeks of transplanting in muskmelon as fertigation. Their data revealed that treatment (full strength + microbial enriched compost tea) gave highest mean flower formation plant^{-1} as 4.1, 9.1 and 10.8 at 4, 5 and 6 weeks of growth, respectively and mean fruit set plant^{-1} as 2.3 and 9.8 at 5 and 6 weeks of growth, respectively in comparison to other treatments and control.

Shaheen *et al.* (2013) directed a testing at National Research Centre, Ciaro, Egypt to investigate the impact complementarity between compost tea and amino acids for maintaining quality as well as quantity under onion production system. They took two levels of compost tea extract *i.e.* 100 and 200 L/fed as applied with irrigation water and foliar spraying of amino mix compound. Results revealed that the maximum total bulb yield, heaviest fresh weight and leaves dry weight of neck and bulb of onion was recorded when onion plant irrigated with compost tea extract with a rate of 200 L fed^{-1}. which was more than the 100 L fed^{-1} treatment and control.

Hegazi and Algharib (2014) conducted an experiment at Horticulture Research Station, Kaha, Egypt to study the use of compost tea, as nutrient amendment in field conditions on cowpea production system using seven treatments as [100 %

NPK(control), 75 % NPK + 25 % compost tea, 50 % NPK + 50 % compost tea, 25 % NPK+ 75 % compost tea, 75 % NPK + 25 % compost tea soil drench, 50 % NPK+ 50 % compost tea soil drench, 25 % NPK + 75 % compost tea soil drench] using compost tea and water at a proportion of 1:2 (v/v) and treated plants with two doses at one month and two month after sowing. Their results revealed that application of compost tea as soil drench gave better results than control, yielding highest number of pods plant^{-1} (60.50 plant$^{-1)}$, length of pod (18.05 cm), number of seeds pod^{-1} (11.78 pod^{-1}), seed weight plant^{-1} (66.17 g), 100 seed weight (20.57 g), respectively.

Pane *et al.* (2014) studied the effect of compost extract on the productivity of kohlrabi and lettuce under organic management of field, using artichoke, fennel residues and woodchips compost which further be used for making compost extract, In this experiment, compost and water was taken as 1 part compost: 5 part water (v/v) and kept it for 7 days. Their results discovered that compost tea application increased the commercial and total yield of kohlrabi (9.8 kg m^{-2}) and lettuce (5.2 kg m^{-2}) in comparison to the yield of untreated plots of both vegetables which were 5 kg m^{-2} for lettuce and 6.5 kg m^{-2} for kohlrabi, respectively.

Zewail and Ahmed (2015) tested the influence of some biofertilizers (PGPR, biosoal and compost tea) on growth attributes, yield, fibre quality and properties of yarn of Egyptian cotton by the addition of different treatments at 45, 65, 85 and 105 DAS in both seasons. They continued this experiment for two years (2013 and 2014) at Cotton Research Institute, Egypt. The results revealed that the maximum boll weight plant^{-1}, seed cotton yield plant^{-1}, lint weight (g) plant^{-1} and seed yield index was found with the treatment application of combination of PGPR + Biosoal + Compost tea.

Farrag *et al.* (2017) conducted an experiment at Sakha Agriculture Research Station Farm during summer season in 2013-2014 to observe the effect of compost tea, cyanobacteria filtrate and nitrogen fertilizer at different rates on yield, growth of fruits and cantaloupe plant's quality (*Cucumis melo*) in which compost tea prepared from rice straw was used and diluted to 1:5 and used @ 450 L ha^{-1}. Outcomes has displayed that the foliar application of cyanobacteria filtrate with inclusion of compost tea along with N fertilization at increasing rate to 240 Kg N ha^{-1} verified to be best out from other treatments in enhancing growth, yield and its component over the control (water).

Shaheen *et al.* (2018) performed two-year investigation in 2016-2017 at VRD (Vegetable Research Department), Giza, Egypt to see the impacts of tea made off chicken manure and effective microorganism on growth parameters and productivity of common bean plant (*Phaseolus vulgaris*). In this, compost tea applied as soil drenching at different levels of dilution (without, 1:1 and 1:2 v/v) applied singly or with effective microorganism at the rate of 5ml L^{-1} in comparison with application of inorganic fertilizers (NPK) at the rate of (45 N: 60 P_2O_5: 90 K_2O) in soil and observed that in most of the cases *i.e.* number of branches plant^{-1}, number of seeds pod^{-1}, weight of 100 seeds, there was no significant difference realized between treatment application of soil drenched compost tea (1:2 v/v) with effective microorganism as compared to treatment application of inorganic fertilizers.

Zaccardelli *et al.* (2018) test the effect of spraying compost tea on the pepper (*Capsicum annum* L.) yield and using that compost in the ratio of 1:4 (v/v) with distilled water to make aerated compost tea mix, this compost tea mix further diluted 10% by volume and applied weekly through foliar spray. Data revealed that total yield (149.88 t ha^{-1}), harvested fruit (611.81number ha^{-1}), weight (246.6 g), single fruit longitudinal length (14.04 cm) and equatorial length (8.56 cm) were highest in the treatment over control.

2.3 NUTRIENT UPTAKE AND QUALITY

Hangreaves *et al.* (2009) conducted a 2 year study at Canada to know the impact of compost tea taken as a source of nutrient amendment on soil and plant tissue of strawberries and five treatments were taken as compost made by municipal solid waste, compost made by ruminant excreta, municipal solid waste compost tea prepared in non-aerated conditions, non-aerated compost tea made off ruminant compost and inorganic mineral fertilizers. Outcome data revealed that compost tea had increased similar amounts of nutrients *i.e.* P, Mg, Ca, S, Zn, Cu, B and Na in strawberry leaves as equated to municipal solid waste compost, ruminant compost and fertilizer treatments.

Fayed (2010) conducted an experiment at Tanbol region, Egypt on effect of compost tea on leafy constituent, yield and quality of pomegranate fruits using two applications of compost tea (foliar and soil applications each @ 5 litre tree^{-1}) besides control plants with or without three foliar antioxidant treatments (ascorbic acid, citric acid, citric and ascorbic acid). It was found that compost tea application gave higher leaf mineral content *i.e.* leaf nitrogen, phosphorus, potassium, calcium, magnesium and iron, chlorophyll a, chlorophyll b and fruit's physio-chemical properties (total sugars, vitamin C, total anthocyanin and TSS) as compared to control.

Hussein *et al.* (2010) carried out a trial at National Research Centre (NRC), Egypt to analyse response of compost tea on *Coriandrum sativum* L. especially for its essential oil content and plants were sprayed one or two times first at 45 DAS and second at 2 weeks after the first spray. Their data revealed that fruit essential oil had significantly increased by applying compost tea as one-time application @ 0.43 per cent or 0.077 ml plant^{-1} or 5.12 litre feddan^{-1} as well as two times application @ 0.41 per cent or 0.077 ml plant^{-1} or 5.11 litre feddan^{-1} in compared to control.

Gea *et al.* (2012) examined the efficiency of compost tea prepared from mushroom substrate on dry bubble using compost tea made from spent mushroom using two compost tea preparations: one prepared from spent mushroom substrate with mineral soil as casing layer and other with peat. One, two or three drench applications were given and their data revealed that application of compost tea made by using peat as substrate was most effective in controlling the dry bubble disease and best results were obtained when compost teas preparations were applied close to the onset of harvesting.

Naidu *et al.* (2013) performed a research trial at University Putra Malaysia, Serdang, Malaysia to inquire the impacts caused by foliar application of microbes-supplemented compost tea on muskmelon growth, yield and quality of muskmelon with fertigation and compost tea which was prepared from 3 months old compost, steeped in water at a ratio of 1part compost: 5part water (w/v) for 3 days and used as foliar application after 2 weeks of transplanting with fertigation system. Their data revealed that in treatment T_2 (half diluted fertigation + microbes enriched compost tea) mean fresh weight (1.42 kg) of fruits plant^{-1} diameter of fruits (14.46 cm), size of mesocarp (4.01 cm), fruit firmness (5.93 lbf) and total soluble solids (13.62%) which were highest than other treatments and control.

2.4 EFFECT ON SOIL PROPERTIES

Fritz *et al.* (2012) carried out experimentation to evaluate the influence of vermicompost tea in the community analysis of microbes and role of vermicompost tea on cereals (wheat and barley) and vegetables (*Rucola selvatica, Raphanus sativus, Pisum sativum*) growth by applying different vermicompost preparations made from green parts of plant, cattle dung manure and agricultural waste of plants and used compost tea as foliar application (80 ml tea m^{-2}) at different growth stages and showed that there was no significant effect of vermicompost tea application on plant yield as compared to control but activity of microbes in soil after repetitive treatment of vermicompost tea to plant pots had increased microbial biomass and basal respiration over control.

Pant *et al.* (2012) performed two greenhouse experiments at University of Hawaii, USA to study the impacts driven by compost tea application on pak choi related to soil biological and chemical properties using three media i.e oxisols, mollisols and peat perlite media. At one experiment, plants were grown with compost while at the second, plants were grown with chemicals (14-14-14 NPK). Compost tea applied in two ways i.e. soil drenching and foliar spray @ 200 ml pot^{-1} weekly for four weeks starting after 3 days of transplanting by taking five treatments i.e., aerated vermicompost tea (T_1), aerated vermicompost tea with microbial enhancer (T_2), non-aerated vermicompost tea (T_3), mineral nutrient solution (T_4) and control (T_5). Data revealed that vermicompost tea application had significantly increased soil respiration and also EC (594.7 µ cm^{-1}), N (2.6 g kg^{-1}), K (655.2 mg kg^{-1}) content of growth media as compared to control and mineral nutrient solution.

Vela-Cano *et al.* (2014) analysed the effects of heavy metals present in sewage sludge compost tea on the growth of bacteria by using 100 litres distilled water along with 1.5 kg homogenised compost in a 12 litres capacity bioreactor and applied on poor quality soil to know the tolerance power of culturable microbiological entities present in the sewage sludge compost tea to 4 heavy metals i.e. copper, lead, zinc and cadmium and results showed that among microbiota isolated, 8 strains had shown high resistance to heavy metals thereby indicating it to be effective in bioremediation process.

3. MATERIALS AND METHODS

The title of the present investigation is **"Effect of Soil and Foliar Application of Compost Tea on Growth, Yield and Quality of Soybean [*Glycine max* (L.) Merrill]** which was carried out during the *kharif* season 2019. This chapter provides the descriptions of the experiment materials, procedures used for the preparation and execution of the field experiment.

3.1 EXPERIMENTAL SITE AND LOCATION

The experiment was performed at the Organic Farm, Rajasthan College of Agriculture, Udaipur located in South-East Rajasthan at an altitude of 581.13 metre above mean sea level with 24°35′ N latitude and 74°42′ E longitude and this region is located in Rajasthan's agro-climatic zone IVa (Sub-humid Southern Plains and Aravalli Hills).

3.2 CLIMATE AND WEATHER CONDITIONS

This region comprises sub-tropical climate distinguished by cool winters and medium summers in conjunction with high relative humidity in months from July to September. While, the average annual rainfall of Udaipur lies in the range of 620-650 mm.

The mean of weather parameters recorded weekly at Agro-Meteorological observatory, RCA, Udaipur in between crop duration are given in Table 3.1 and Fig. 3.1. Observations taken by observatory conveyed the information regarding minimum and maximum temperatures ranges between 16.1°C to 24.1°C and 27.60°C to 33.60°C, respectively. While, minimum relative humidity and maximum relative humidity sandwiched in a range of 38.1 to 84.4 per cent and 71.60 to 94.30 per cent, respectively during *Kharif,* 2019. The total rainfall that was received during growing period of soybean in 2019 year was 488.8 mm which was higher than the previous year.

3.3 MECHANICAL, PHYSICAL, CHEMICAL AND BIOLOGICAL PROPERTIES OF THE SOIL

Soil of the experimental site was deep black in colour with good drainage. Representative soil samples were collected from each spot. A composite soil sample was prepared and analysed for estimation of its various physical and chemical properties. The relevant results are presented in Table 3.2.

Table 3.2 Mechanical, physical, chemical and biological properties of soil

Features	Content	Analysis Method	References
A. Mechanical composition			
Sand (%)	35.25 %	Hydrometer method	Bouyoucos (1962)
Silt (%)	29.98 %		
Clay (%)	33.37 %		
Textural class	Clay-loam	Triangular diagram	Brady (1983)
B. Physical composition			
Bulk density (Mg m^{-3})	1.39	Core sampler method	Piper (1950)
Particle density (Mg m^{-3})	2.65		Black (1965)
Porosity (%)	47.55		
C. Chemical properties			
Organic C (%)	0.55	Walkley and Black Method	Walkley and Black (1934)
Available N (kg ha^{-1})	241.2	Alkaline $KMnO_4$ method	Subbiah and Asija (1956)
Available P_2O_5 (kg ha^{-1})	20.9	Olsen's method	Olsen *et al.* (1954)
Available K_2O (kg ha^{-1})	351.3	Flame photometer	Jackson (1973)
Available Zn (mg kg^{-1})	2.45	DTPA-extract with AAS	Lindsay and Norvell (1978)
Available S (mg kg^{-1})	4.14		
Electric conductivity (dSm^{-1} at 25 °C)	0.80	Using solubridge	Richards (1968)
pH (soil water suspension of 1:2.0)	8.1	Glass electrode pH meter	Richards (1968)
D. Biological properties			
Bacterial count (cfu g^{-1} soil)	62.05×10^6	Standard serial dilution and plate count method	Scmidt and Colwell (1967)
Fungal count (cfu g^{-1} soil)	21.56×10^4		
Actinomycetes (cfu g^{-1} soil)	32.05×10^5		

The data depicts that the soil of experimental field has clayey-loam texture, slightly alkaline in nature, low in available nitrogen, medium in available phosphorus while high in available potassium.

3.4 CROPPING HISTORY

Table 3.3: Cropping history of the experimental field

Year	Cropping Season	
	Kharif	**Rabi**
2017	Sweet Corn	Gram
2018	Blackgram	Wheat
2019	Soybean*	

3.5 EXPERIMENTAL DETAIL

3.5.1 Treatments

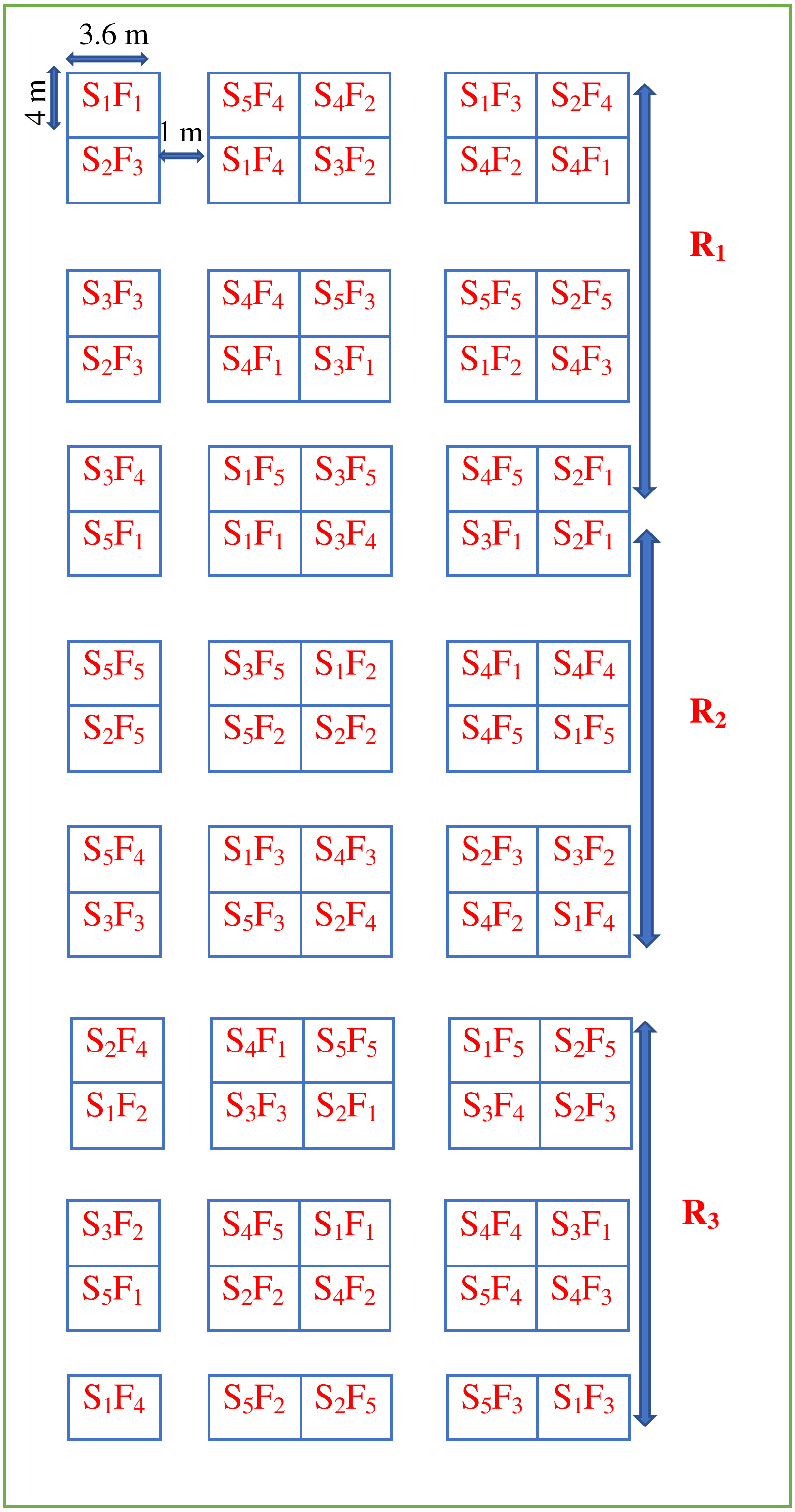
The details of the treatments with their symbols are given in Table 3.4.

Table 3.4: Details of Treatments with their symbols

S.No.	Treatments	Symbols
(A)	**Soil Application**	
	Control (Water spray)	S_1
	Compost Tea 500 lit ha^{-1}	S_2
	Compost Tea 750 lit ha^{-1}	S_3
	Compost Tea 1000 lit ha^{-1}	S_4
	Compost Tea 1250 lit ha^{-1}	S_5
(B)	**Foliar application**	
	Control (Water Spray)	F_1
	Compost Tea 25%	F_2
	Compost Tea 50%	F_3
	Compost Tea 75%	F_4
	Compost Tea 100%	F_5

3.5.2 Experimental design and layout

The design selected for experiment is factorial randomised block design with three replications. The randomisation among treatments has been done with the help of random number table (Fisher, 1950). The layout is given in Fig. 3.2.



Experimental details:
Gross plot size = 4.0 m × 3.6 m = 14.4 m^2
Net plot size = 3.0 m × 3.0 m = 9.0 m^2
Replications = 3
Total treatments = 25
Total number of plots = 75
Design = RBD (Factorial)

Figure 3.2: Plan of Layout

3.5.3 Other experimental details

1.	Season	*Kharif*, 2019
2.	Total number of treatments	25
3.	Number of replications	3
4.	Total number of plots	75
5.	Plot size	
	(a) Gross	4.0 m x 3.6 m = 14.4 m^2
	(b) Net	3.0 m x 3.0 m = 9.0 m^2
6.	Experimental design	RBD (Factorial)
7.	Test crop	Soybean
8.	Variety	RKS-24
9.	Crop geometry	30 cm row to row and 10 cm plant to plant
10.	Seed rate	80 Kg ha^{-1}
11.	Nutrient management and plant protection	Nutrient doses have been given according to organic package of practices through organic products.

3.6 TREATMENT APPLICATION

3.6.1 Method of preparation of compost tea

Compost tea was prepared at the organic farming unit of RCA Farm, Udaipur. Take a small cloth bag filled with 1 kg compost over an earthen pot filled with 20 litre water in a way that the compost remained submerged in water. After 7 days, solution is taken out from earthen pot and was filtered. The prepared compost tea is sprayed on crop with ordinary sprayer with concentrations decided as per treatments.

3.6.2 Spray of compost tea

Different doses of compost tea were applied as soil application and foliar application in experimental plots as per treatment during crop period as per described in Table 3.4.

Table 3.5: Bio-chemical composition of compost tea

S. No.	Parameters	Values
1.	Ph	6.76
2.	EC (dS m^{-1})	0.905
3.	Total Nitrogen (ppm)	205
4.	Total Phosphorus (ppm)	7.6
5.	Total Potassium (ppm)	205
6.	Total Zinc (ppm)	5.8
7.	Total Iron (ppm)	63
8.	Bacterial count (cfu ml^{-1})	$10x10^8$
9.	Fungal count (cfu ml^{-1})	$8x10^3$
10.	Actinomycetes (cfu ml^{-1})	$4x10^5$

3.7 DETAILS OF CROP RAISING

The schedule of various pre- and post-operations performed in the experiment during *Kharif* 2019 are listed in the Table 3.6

Table 3.6: Schedule of field operations carried out during crop growth period

S.No.	Operation	Date	Particulars
1.	Ploughing and field preparations	07.07.2019	By tractor drawn MB plough and disc harrow
2.	Layout of experimental field and seed bed preparation	08.07.2019	Manually
3.	Organic manure application	08.07.2019	Manually
4.	Sowing by dibbling	09.07.2019	Manually
5.	Soil Application of Compost tea	09.08.2019	By Knapsack Sprayer
6.	Thinning	30.07.2019	Manu
7.	1st Hand weeding	10.08.2019	Hand weeding
8.	2nd Hand weeding	30.08.2019	Hand weeding
9.	Spray of compost tea		
	1st Spray	03.09.2019	By Knapsack Sprayer
	2nd Spray	02.10.2019	By Knapsack Sprayer
10.	Harvesting	04.11.2019	Manually
11.	Threshing	07.11.2019	Manually

3.7.1 Nutrient, pest and disease management

The organic inputs used for nutrient, pest and disease management in soybean are given in details in Table 3.7.

Table 3.7 Organic input used in soybean for nutrient and pest management

NADEP	At the time sowing	5000 kg ha^{-1}	Nutrient management
Neem oil	45 DAS	0.3 %	Diseases and Pest management

3.7.2 Seed inoculation with *Rhizobium* culture

For seed inoculation with *Rhizobium* culture, firstly 500 g jaggery was taken and it was boiled in 1 litre of water, then this solution was kept for cooling. Then, one *Rhizobium* culture packet of 200 g was mixed in jaggery solution and seeds were thoroughly mixed in the solution. Then treated seeds were put for shade drying.

3.7.3 Seed rate and sowing

Seed rate of 80 kg ha^{-1} was used. The seeds were sown manually at a depth of 3-4 cm with row spacing of 30 cm and plant to plant distance of 10 cm and after placing the seed in furrows it was covered with soil.

3.7.4 Thinning

Thinning of soybean seeds was done after 15 DAS during light rainfall to maintain plant to plant distance of 10 cm.

3.7.5 Weeding and hoeing

Weeding was done to reduce the crop weed competition thereby increases the crop yield, so, hand weeding done as per schedule given in Table 3.6.

3.7.6 Irrigation

The crop was sown in peak monsoon period therefore no irrigation was applied.

3.7.7 Harvesting

The crop was harvested from a net plot size (3.0 m x 3.0 m =9.0 m^2) in each plot. The harvested plants were tied in bundles, tagged and kept for sun drying on threshing floor. After complete drying these bundles were weighed to record biological yield.

3.7.8 Threshing and winnowing

Threshing of the harvested produce from individual plot was done manually by labours. Seeds were weighted and straw samples were collected plot wise for further analysis.

3.8 TREATMENT EVALUATION

In order to study of growth, yield and quality attributing characters and yield, nutrient content, their uptake and quality of crop, observations were recorded for each parameter as per method mentioned below.

3.8.1 Growth attributes

3.8.1.1 Plant population

The number of plants were counted from five randomly selected spots in one metre row length in each experimental unit at 30 DAS and at harvest. These were averaged and number of plants ha^{-1} were worked out and expressed in lakh ha^{-1}.

3.8.1.2 Plant height

The height of five randomly tagged plants from each plot was measured at 30, 60 DAS and at harvest from the base of the plant to fully open leaf tip and the average plant height was worked out and expressed in cm**.**

3.8.1.3 Dry matter accumulation

The periodic changes in the dry matter accumulation plant^{-1} were observed at 30 DAS, 60 DAS and at harvest by uprooting five randomly selected plants from each plot. These samples were chopped and placed in perforated paper bags, sundried for two days and finally kept in oven at 70˚C till a constant weight was noted.

3.8.1.4 CGR: Crop growth rate is the gain in dry matter production on a unit land in a unit time. The efficiency parameter CGR between 30-60 DAS and 60 DAS-harvest was computed on the basis of dry matter accumulation plant^{-1} using following formula given by Redford (1967) and expressed in g m^{-2} day^{-1}.

$$\text{CGR= crop growth rate [g m}^{-2}\text{ day}^{-1}\text{]} = \frac{W_2 - W_1}{T_2 - T_1}$$

Where,

W_1 and W_2 are dry matter production at time T_1 and T_2 respectively.

3.8.1.5 RGR:

The RGR expresses the dry weight increase in time interval in relation to its initial weight. RGR was computed between 30-60 DAS and 60-harvest by using following formula which is given below

$$\text{RGR= Relative growth rate [g g}^{-1}\text{ day}^{-1}] = \frac{\log W_2 - \log W_1}{T_2 - T_1}$$

Where,

Log_e = Natural log

W_1 = Total dry matter at time T_1

W_2 = Total dry matter at time T_2

T_1 = Time of first observation

T_2 = Time of second observation

3.8.1.6 Total chlorophyll (mg g^{-1} fresh weight)

The method given by Arnon (1949) was used to determine the content of total chlorophyll at 50 DAS. A pre-weighed (25 mg) quantity of fresh leaf material was grounded into a fine paste. After that, 10 ml of 80% acetone was added into it. The extract was then centrifuged and the green supernatant obtained. The optical density of the extract was read at 645 and 663 wave lengths using spectrophotometer (UV spectrophotometer). From the optical densities, the chlorophyll content was calculated using the formula:

$$\text{Total Chlorophyll (mg g}^{-1}) = \frac{20.2\ (\text{OD } 645) + 8.02\ (\text{OD } 663) \times \text{v}}{1000 \times \text{w}}$$

Where,

OD = Optical density

V = Final vol. of 80% acetone (10ml)

W = Wt. of sample taken (0.025g)

3.8.1.7 Number of effective nodules plant^{-1}

Three plants were uprooted randomly from the outer rows of plant at 50 per cent flowering stage without disturbing the roots and their nodules. After drying plant in shade, nodules were separated from the roots with the help of forceps and their numbers are recorded.

3.8.2 Yield attributes

3.8.2.1 Number of branches plant^{-1}

The number of branches from five randomly selected plants from each plot were recorded at 75 DAS and average was recorded out.

3.8.2.2 Pod plant^{-1}

Fully matured and developed pods from randomly selected five plants from each plot were plucked and counted. The average pods plant^{-1} were worked out.

3.8.2.3 Number of seed pod^{-1}

Pods collected from ten randomly selected plants were threshed, cleaned and total number of seeds were counted and the average number of seed pod^{-1} was estimated by dividing the number of pods.

3.8.2.4 1000 seed weight

Seed samples was drawn after weighing of produce from each net plot yield. From, these 1000 seeds were counted and weighed and expressed in gram.

3.8.3 Yield and harvest index

3.8.3.1 Seed yield

The net plot crop was harvested, threshed, and winnowed. The seeds harvested from each net plot were sun dried for 2-3 days to attain 10 per cent moisture and then the weight of grains net plot^{-1} area was recorded and expressed in kg ha^{-1}.

3.8.3.2 Haulm yield

The straw yield in kg per plot was obtained by subtracting the seed yield from biological yield per plot recorded earlier and expressed in terms of straw yield kg ha^{-1}.

3.8.3.3 Biological yield

The harvested material from net area of each plot was thoroughly sun dried. After drying, the produce of individual net plot was weighed with the help of spring balance and weight was recorded in kg per plot. Later, biological yield per plot was converted into kg per hectare.

3.8.3.4 Harvest index

The harvest index was obtained by dividing the economic yield (seed yield) by total biological yield (seed + haulm yield) obtained from net plot and multiplied by 100 to express it in percent (Donald and Hamblin, 1974).

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

3.8.4 Quality Analysis

3.8.4.1 Protein content in seed (%)

Protein content was determined by multiplying the nitrogen percentage with factor 6.25 as described by AOAC (1975).

Protein (%) = Nitrogen content (%) × 6.25

3.8.4.2 Oil content in seed (%)

Oil content in seeds from each net plot sample was determined by Soxhlet ether extraction method (AOAC, 1965) and expressed as per oil content in seed.

3.8.5 Chemical analysis

3.8.5.1 Plant nutrient analysis

Soybean plant samples were collected at harvest (seed and haulm) from each plot. These plant samples were dried at 65°C in hot air oven. The dried samples were finely ground and used for determination of N, P, K content as per methods furnished in Table 3.8.

Table 3.8 Methods used for chemical analysis of crop plant at harvest

S. No.	Parameters	Method	Reference
1.	Nitrogen	Colorimetric method using spectronic 20 after development of colour with Nesseler's reagent	Snell and Snell (1949)
2.	Phosphorus	Ammonium vanado-molybdate yellow colour method	Richards (1968)
3.	Potassium	Flame Photometer method	Jackson (1973)

3.8.5.2 Nutrient uptake

The uptake of N, P, K content at harvest in seed and straw was estimated by using the following formula:

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content in } \frac{\text{seed}}{\text{haulm}} (\%) \text{ x } \frac{\text{seed}}{\text{haulm}} \text{yield (kg ha}^{-1}\text{)}}{100}$$

Total nutrient uptake by the crop was computed by summing up the uptake by both grain and straw.

3.9 Economics

The economics of different treatments were worked out in terms of net return (₹ ha^{-1}) and B-C ratio, on the basis of prevailing market prices for inputs and outputs.

3.9.1 Net return

To find out the more profitable treatment, economics of different treatments were worked out in terms of net return (₹ ha^{-1}) on the basis of the prevailing market rate so that the most remunerative treatment could be recommended.

3.9.2 Benefit-Cost ratio

Treatment wise benefit-cost (B:C) ratio was also calculated to ascertain economic viability of the treatments by using the following formula:

$$\text{Benefit-Cost ratio} = \frac{\text{Net return (₹ ha}^{-1}\text{)}}{\text{Total cost (Cost of cultivation+Cost of treatment) (₹ ha}^{-1}\text{)}}$$

3.10 Statistical analysis

In order to test the significance of variation in experimental data, the critical differences were calculated to assess the significance of treatment mean, whenever the F-test was found significant at 5 per cent level. To estimate interrelation between various characters, correlation coefficient was computed. All these estimates were computed by standard statistical procedure (Panse and Sukhatme, 1985).

4. EXPERIMENTAL RESULTS

The present investigation was undertaken to study the "**Effect of Soil and Foliar Application of Compost Tea on Growth, Yield and Quality of Soybean [*Glycine max* (L.) Merill]**". A field experiment was conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur during *Kharif,* 2019 with soybean crop variety RKS-24. The data related to effects of different doses of compost tea on soybean was statistically analysed for the test of significance, interpret and presented accordingly. The analysis of variance tables is adjoined at the end in order of results described.

4.1 EFFECT OF COMPOST TEA ON GROWTH PARAMETERS

Growth parameters *viz.* plant population, plant height, dry matter accumulation plant^{-1}, crop growth rate, relative growth rate, number of effective nodules plant^{-1} and chlorophyll content plant^{-1} were recorded during the course of field experiment and the obtained results are described here.

4.1.1 Plant population: The perusal of data presented in Table 4.1 show that the recorded population of soybean at 30 DAS and at harvest stage was not significantly affected by soil application and foliar application of compost tea.

4.1.2 Plant height

Soil application: The perusal of data in Table 4.2 reveal that increasing dose of compost tea in soil up to 1250 lit ha^{-1} (S_5) significantly increased the plant height at 30 DAS, 60 DAS and at harvest stage of crop, which was significantly higher over control, 500 lit ha^{-1} compost tea, 750 lit ha^{-1} and 1000 lit ha^{-1} compost tea application in soil. However, maximum plant height at 30 DAS (33.27 cm), 60 DAS (46.80 cm) and at harvest stage (68.77 cm) was recorded with application of 1250 lit ha^{-1} (S_5) compost tea in soil. The plant height is increased by 2.3, 6.0, 11.55 and 16.30 per cent over control by application of 500 lit ha^{-1}, 700 lit ha^{-1}, 1000 lit ha^{-1} and 1250 lit ha^{-1} compost tea at harvest stage respectively.

Foliar application: Data presented in Table 4.2 reveal that the plant height of soybean at 30 DAS was not significantly influenced by application of different concentrations of compost tea as foliar spray. But, increasing concentrations of compost tea as foliar spray significantly increased plant height at 60 DAS and at harvest stage. However, maximum plant height at 60 DAS (44.35 cm) and at harvest (65.70 cm) was recorded with the application of 100 % compost tea (F_5) which was found at par with 75 % compost tea (F_4) as foliar application. The plant height is increased by 7.19, 10.27, 12.38 and 12.55 per cent over control by application of 25% compost tea, 50% compost tea, 75% compost tea and 100% compost tea as foliar application respectively.

4.1.3 Dry matter accumulation

Soil application: The data given in Table 4.3 indicate that increasing the dose of compost tea application in soil significantly increases the dry matter accumulation at 30 DAS, 60 DAS and at harvest. Significantly maximum dry matter accumulation of 3.09, 15.17 and 26.67 g plant^{-1} was recorded with application of 1250 lit ha^{-1} (S_5) compost tea in soil at 30 DAS, 60 DAS and at harvest, respectively. Data further indicated that dry matter accumulation is increased by 7.98, 12.77, 24.83 and 37.40 per cent over control by application of 500 lit ha^{-1} (S_2), 700 lit ha^{-1} (S_3),1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest stage, respectively.

Foliar application: Data presented in Table 4.3 reveal that the dry matter accumulation in soybean at 30 DAS was not significantly influenced by application of different concentrations of compost tea as foliar spray. But, increasing concentrations of compost tea as foliar spray significantly increased the dry matter accumulation at 60 DAS and at harvest stage. However, maximum dry matter accumulation at 60 DAS (13.73 g plant^{-1}) and at harvest (23.92 g plant^{-1}) was recorded with the application of 100 % compost tea (F_5) which was found at par with 75 % compost tea (F_4) as foliar application. The dry matter accumulation is increased by 5.90, 9.69, 12.77 and 14.83 per cent over control by application of 25% compost tea (F_2), 50% compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application respectively.

4.1.4 Crop growth rate

Soil application: The perusal of data presented in Table 4.4 show that increasing dose of compost tea in soil up to 1250 lit ha^{-1} (S_5) significantly increased the crop growth rate in soybean between 30-60 DAS interval and 60 DAS-harvest time intervals over control and other treatments. Highest crop growth rate (8.56 g m^{-2} day^{-1}) between 30-60 DAS and (8.59 g m^{-2} day^{-1}) and between 60 DAS-harvest was recorded with application of 1250 lit ha^{-1} (S_5) compost tea in soil. The CGR is increased by 4.36, 10.09, 12.96 and 17.18 per cent over control by application of 500 lit ha^{-1} (S_2), 750 lit ha^{-1} (S_3), 1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} compost tea at 60 DAS-harvest stage, respectively.

Foliar application: The data presented in Table 4.4 reveal that the crop growth rate is significantly influenced by application of different concentrations of compost tea between 30-60 DAS interval and 60 DAS-harvest. However, highest crop growth rate (8.15 g m^{-2} day^{-1}) and (8.39 g m^{-2} day^{-1}) between 30-60 DAS interval and 60 DAS-harvest time interval, respectively was recorded with application of 100% compost tea (F_5) as foliar spray which was found at par with 75% compost tea (F_4) treatment. The crop growth rate is increased by 6.56, 11.08, 13.67 and 14.77 per cent over control at 61DAS- harvest time interval.

4.1.5 Relative growth rate: The data presented in the Table 4.5 reveal that the relative growth rate calculated between 30-60 DAS interval and 60 DAS-harvest time interval does not significantly influenced by application of compost tea in soil and as well as in foliar application. However, increasing concentration of compost tea in both soil and on foliage increases the relative growth rate in soybean plant.

4.1.6 Number of effective root nodules $plant^{-1}$

Soil application: The perusal of data given in Table 4.6 indicate that the number of effective root nodules $plant^{-1}$ at 60 DAS is significantly affected by the application of different doses of compost tea in soil. However, maximum root nodules $plant^{-1}$ (40.00) were recorded with application of 1250 lit ha^{-1} compost tea (S_5) in soil. The number of effective nodules $plant^{-1}$ is increased by 4.17, 12.09, 17.11 and 20.95 per cent over control by application of application of 500 lit ha^{-1} (S_2), 750 lit ha^{-1} (S_3), 1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} compost tea in soil, respectively.

Foliar application: Data (Table 4.6) reveal that the number of effective root nodules $plant^{-1}$ at 60 DAS is significantly affected by the application of various concentrations of compost tea as foliar spray. Number of root nodules $plant^{-1}$ is increasing by increasing the concentrations of compost tea. However, maximum root nodules $plant^{-1}$ (38.89) were recorded with application of 100% compost tea (F_5) which was found at par with 75% compost tea (F_4) (38.30) application. The number of effective root nodules $plant^{-1}$ is increased by 7.24, 12.72, 16.06 and 17.84 per cent over control by application of 25% compost tea (F_2), 50% compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application respectively.

4.1.7 Chlorophyll content

Soil application: The perusal of data given in Table 4.7 indicate that increasing the dose of compost tea application in soil significantly increases the chlorophyll content at 60 DAS in soybean plant. Significantly maximum chlorophyll content (2.83 mg g^{-1}) was recorded with application of 1250 lit ha^{-1} (S_5) compost tea in soil at 60 DAS in soybean plant over other treatments. Data further indicated that chlorophyll content is increased by 6.01, 12.03, 23.61 and 35.25 per cent over control by application of 500 lit ha^{-1} (S_2), 700 lit ha^{-1} (S_3),1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest stage, respectively.

Foliar application: Data presented in Table 4.7 reveal that with increasing concentrations of compost tea as foliar spray significantly increased the chlorophyll content at 60 DAS. However, maximum chlorophyll content at 60 DAS (2.65 mg g^{-1}) was recorded with the application of 100 % compost tea (F_5) which was found at par with chlorophyll content (2.65 mg g^{-1}) in foliar application of 75 % compost tea (F_4). The chlorophyll content is increased by 6.25, 12.05, 17.85 and 18.30 per cent over control by application of 25% compost tea (F_2), 50% compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application respectively.

4.2 EFFECT OF COMPOST TEA ON YIELD ATTRIBUTES

Yield attributes *viz.* number of primary branches $plant^{-1}$, number of pods $plant^{-1}$, number of seeds $plant^{-1}$ and 1000 seed weight (g) were recorded during the course of field experiment and the obtained results are described here.

4.2.1 Number of primary branches $plant^{-1}$

Soil application: The perusal of data given in Table 4.8 indicate that increasing the dose of compost tea application in soil significantly increases the number of primary branches $plant^{-1}$ at harvest in soybean plant. Significantly, highest number of primary branches $plant^{-1}$ (4.24) were recorded with application of 1250 lit ha^{-1} (S_5) compost tea which was found at par with primary branches $plant^{-1}$ (4.11) in application of 1000 lit ha^{-1} (S_4) compost tea in soil. Data further indicated that number of primary branches $plant^{-1}$ is increased by 9.28, 20.43, 27.24 and 31.26 per cent over control by application of 500 lit ha^{-1} (S_2), 700 lit ha^{-1} (S_3),1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest stage, respectively.

Foliar application: Data presented in Table 4.7 reveal that with increasing concentrations of compost tea as foliar spray significantly increased the number of primary branches plant^{-1} at harvest. However, highest primary branches plant^{-1} (4.17) were recorded with the application of 100 % compost tea (F_5) which was found at par with foliar application of 75 % compost tea (F_4).The number of primary branches plant^{-1} is increased by 8.57, 12.13, 18.04 and 23.37 per cent over control by application of 25% compost tea (F_2), 50% compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application, respectively.

4.2.2 Number of pods plant^{-1}

Soil application: Data presented in Table 4.7 reveal that increasing the dose of compost tea application in soil significantly increases the number of pods plant^{-1} at harvest in soybean plant. Significantly, maximum pods plant^{-1} (33.87) were recorded with application of 1250 lit ha^{-1} (S_5) compost tea in soil. Data further indicated that number of pods plant^{-1} is increased by 13.79, 28.14, 37.62 and 45.99 per cent over control by application of 500 lit ha^{-1} (S_2), 700 lit ha^{-1} (S_3), 1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest stage, respectively.

Foliar application: Data presented in Table 4.7 reveal that with increasing concentrations of compost tea as foliar spray significantly increased the number of pods plant^{-1} at harvest. However, maximum pods plant^{-1} (31.00) were recorded with the application of 100 % compost tea (F_5) which was found at par with pods plant^{-1} (30.73) with foliar application of 75 % compost tea (F_4). The number of branches plant^{-1} is increased by 7.48, 14.14, 18.51 and 19.55 per cent over control by application of 25% compost tea (F_2), 50% compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application, respectively.

4.2.3 Number of seeds pod^{-1}

Soil application: A perusal of data presented in Table 4.7 show that the number of seeds pod^{-1} varies from 1.79 to 2.45 during study by applying different doses of compost tea in soil. An application of 1250 lit ha^{-1} (S_5) compost tea recorded significantly maximum number of seeds pod^{-1} (2.45) which was followed by the 1000 lit ha^{-1} (S_4) treatment. The application of compost tea increases the number of seeds pod^{-1} by 12.29, 23.46, 29.60 and 36.87 per cent over control by application of 500 lit ha^{-1} (S_2), 700 lit ha^{-1} (S_3),1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest stage, respectively.

Foliar application: It is clear from the data in Table 4.7 that the increasing concentrations of compost tea up to 100% as foliar spray significantly increases the number of seeds pod^{-1} in soybean plant. The maximum number of seeds pod^{-1} (2.43) was found with application of 100% compost tea (F_5) which was found at par with application of 75% compost tea (F_4). The application of compost tea increases the number of seeds pod^{-1} by 10.49, 20.44, 29.83 and 34.25 per cent over control by application of 25% compost tea (F_2), 50% compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application, respectively.

4.2.4 1000 seed weight: The data given in Table 4.7 show that the recorded 1000 weight of soybean was not significantly affected by soil application and foliar application of compost tea. However, 1000 weight is improving with increasing doses of compost tea. The maximum 1000 weight recorded (81.47 g) and (81.67 g) treatment application of 1250 lit ha^{-1} (S_5) compost tea in soil and 100% compost tea (F_5) on foliage.

4.3 EFFECT OF COMPOST TEA ON YIELD

Yield of soybean *viz.* seed yield (kg ha^{-1}), haulm yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%) were recorded during the course of field experiment and the obtained results are described here.

4.3.1 Seed yield

Soil application: Data presented in Table 4.8 indicate that the application of different doses of compost tea in soil significantly affected the seed yield in soybean. The significant maximum seed yield (1665 kg ha^{-1}) was recorded under the application of 1250 lit ha^{-1} (S_5) compost tea over control (934 kg ha^{-1}) and other treatments.

Foliar application: A perusal of data given in Table 4.8 indicate that the seed yield is significantly affected by different concentrations of compost tea as foliar application in soybean. The maximum seed yield (1578 kg ha^{-1}) was found under the application of 100% compost tea (F_5) which was found at par with application of 75% compost tea (F_4) with seed yield of (1533 kg ha^{-1}

4.3.2 Haulm yield

Soil application: A perusal of data indicate in Table 4.8 clearly states that increasing dose of compost tea in soil significantly increases the haulm yield in soybean. The significant maximum haulm yield (3189 kg ha^{-1}) was recorded under the application of 1250 lit ha^{-1} (S_5) compost tea over control (1848 kg ha^{-1}) and other treatments. The increases in haulm yield by 32.92, 61.61, 70.60 and 81.12 per cent over control by application of 500 lit ha^{-1} (S_2), 700 lit ha^{-1} (S_3),1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest, respectively.

Foliar application: Data given in Table 4.8 reveal that the seed yield is significantly affected by different concentrations of compost tea as foliar application in soybean. The maximum haulm yield (3003 kg ha^{-1}) was found under the application of 100% compost tea (F_5) which was found at par with application of 75% compost tea (F_4) with seed yield of (2969 kg ha^{-1}). The application of compost tea increases the number of seeds pod^{-1} by 29.32, 39.98, 51.24 and 58.60 per cent over control by application of 25% compost tea (F_2), 50% compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application, respectively.

4.3.3 Biological yield

Soil application: A perusal of data indicate in Table 4.8 clearly states that increasing dose of compost tea in soil significantly increases the biological yield in soybean. The significant maximum biological yield (4746 kg ha^{-1}) was recorded under the application of 1250 lit ha^{-1} (S_5) compost tea over control (2635 kg ha^{-1}) and other treatments. The increases in biological yield by 31.84, 58.10, 69.79 and 80.11 per cent over control by application of 500 lit ha^{-1} (S_2), 700 lit ha^{-1} (S_3),1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest, respectively.

Foliar application: Data given in Table 4.8 reveal that the biological yield is significantly affected by different concentrations of compost tea as foliar application in soybean. The maximum haulm yield (4509 kg ha^{-1}) was found under the application of 100% compost tea (F_5) which was found superior over the other treatments and control. The application of compost tea increases the biological yield by 28.96, 40.30, 52.77 and 58.32 per cent over control by application of 25% compost tea (F_2), 50%

compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application, respectively.

4.3.4 Harvest index

The perusal of data given in Table 4.8 show that the harvest index of soybean was not significantly affected by the soil application of compost tea and foliar application of compost tea.

4.4 QUALITY PARAMETERS

4.4.1 Protein content in seed

Soil application: It is clear from the data given in Table 4.9 which shows that the application of different doses of compost tea in soil significantly increases the protein content in soybean. The maximum protein content (40.57%) was recorded with the application of 1250 lit ha^{-1} (S_5) compost tea over the rest of the treatments. It was further noticed that the increase in protein content by 0.33, 1.90, 4.19 and 7.05 per cent over control by application of 500 lit ha^{-1} (S_2), 700 lit ha^{-1} (S_3),1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest, respectively.

Foliar application: Data given in Table 4.9 reveal that the application of different concentrations of compost tea as foliar spray significantly increases the protein content in soybean over control. The maximum protein content (40.49%) was recorded with the application of 100% compost tea (F_5) which was found statistically at par with protein content (40.23%) with application of 75% compost tea (F_4). The application of compost tea increases the protein content by 2.75, 4.61, 6.68 and 7.31 per cent over control by application of 25% compost tea (F_2), 50% compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application, respectively.

4.4.2 Oil content in seed

Soil application: It is clear from the data given in Table 4.9 which shows that the application of different doses of compost tea in soil significantly increases the oil content in soybean. The maximum oil content (20.59%) was recorded with the application of 1250 lit ha^{-1} (S_5) compost tea over treatments. It was further noticed that the increase in protein content by 2.93, 4.11, 8.63 and 11.84 per cent over control by application of 500 lit ha^{-1} (S_2), 700 lit ha^{-1} (S_3),1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest, respectively.

Foliar application: Data given in Table 4.9 reveal that the application of different concentrations of compost tea as foliar spray significantly increases the oil content in soybean over control. The maximum oil content (20.13%) was recorded with the application of 100% compost tea (F_5) over the other treatments. The application of compost tea increases the protein content by 2.58, 4.51, 6.99 and 8.28 per cent over control by application of 25% compost tea (F_2), 50% compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application, respectively.

4.5 EFFECT OF COMPOST TEA ON PHYSICO-CHEMICAL PROPERTIES OF SOIL

4.5.1 pH

Soil application: Results reveal that all doses of compost tea in soil did not show any significant effect on pH of soil (Table 4.10).

Foliar application: Results reveal that all the concentrations of compost tea as foliar spray had no significant effect on pH of soil (Table 4.10)

4.5.2 EC

Soil application: Results revealed that all doses of compost tea in soil did not show any significant effect on EC of soil (Table 4.10).

Foliar application: Results revealed that all the concentrations of compost tea as foliar spray had no significant effect on EC of soil (Table 4.10)

4.5.3.1 Bacterial population

Soil application: It is apparent from the data presented in Table 4.11 reveal that the available bacterial population in soil after harvest of soybean was significantly increased by application of different doses of compost tea in soil as compared to control. The maximum bacterial population (69.76×10^6) was recorded in 1250 lit ha^{-1} (S_5) compost tea application in soil which was significantly superior over other treatments. It was further noticed that the increase in bacterial population by 1.97, 4.16, 5.82 and 9.15 per cent over control by application of 500 lit ha^{-1} (S_2), 750 lit ha^{-1} (S_3), 1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest, respectively.

Time of application: Further examination of data given in Table 4.11 show that the application of 25%, 50%, 75% and 100% compost tea as foliar application increased the bacterial population to the extent of 4.21, 6.24, 8.00 and 9.33 per cent at harvest, respectively over control. However, maximum bacterial population (68.99 x10^6) after harvest of crop was recorded with application of 100% compost tea (F_5) which was found at par with (F_5).

4.5.3.2 Fungal population

Soil application: Based on the measured data presented in Table 4.11 it is infer that the available fungal population in soil after harvest of soybean was significantly increased by application of different doses of compost tea in soil as compared to control. The maximum fungal population (28.27 x10^4) was recorded in 1250 lit ha^{-1} (S_5) compost tea application in soil which was significantly superior over control. It was further noticed that the increase in fungal population by 11.22, 16.52, 20.38 and 26.94 per cent over control by application of 500 lit ha^{-1} (S_2), 750 lit ha^{-1} (S_3), 1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest, respectively.

Time of application: Further examination of data given in Table 4.11 show that the application of 25%, 50%, 75% and 100% compost tea as foliar application increased the bacterial population to the extent of 6.40, 10.08, 14.60 and 15.97 per cent at harvest, respectively over control. However, maximum fungal population (27.15 x10^4) after harvest of crop was recorded with application of 100% compost tea (F_5) which was found at par with (F_5).

4.5.3.3 Actinomycetes population

Soil application: Data presented in Table 4.11 infer that the available actinomycetes population in soil after harvest of soybean was significantly increased by application of different doses of compost tea in soil as compared to control. The maximum actinomycetes population (37.45 x10^5) was recorded in 1250 lit ha^{-1} (S_5) compost tea application in soil which was significantly superior over control. Data further indicated that the increase in actinomycetes population by 5.61, 9.40, 13.10 and 17.43 per cent over control by application of 500 lit ha^{-1} (S_2), 750 lit ha^{-1} (S_3), 1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest, respectively.

Time of application: Data given in Table 4.11 further reveal that the application of 25%, 50%, 75% and 100% compost tea as foliar application increased the bacterial population to the extent of 4.91, 9.31, 12.17 and 13.72 per cent at harvest, respectively over control. However, maximum actinomycetes population (36.63 x10^5)

after harvest of crop was recorded with application of 100% compost tea (F_5) which was found at par with (F_5).

4.6 EFFECT OF COMPOST TEA ON NUTRIENT CONTENT

4.6.1 Nitrogen content

4.6.1.1 Nitrogen content in seed

Soil application: It is apparent from the data (Table 4.12) that nitrogen content in seed of soybean is influenced by soil application of different doses of compost tea over control. Significantly, maximum nitrogen content in seed (6.47%) were recorded with application of 1250 lit ha^{-1} (S_5) compost tea which was followed by 1000 lit ha^{-1} (S_4) compost tea. The increase in nitrogen content by 0.32, 2.44, 4.23 and 5.37 per cent over control by application of 500 lit ha^{-1} (S_2), 750 lit ha^{-1} (S_3), 1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest, respectively.

Foliar application: Data analysed in Table 4.12 indicate that the application of different concentrations of compost tea as foliar spray significantly increases the nitrogen content in soybean seed over control. The maximum nitrogen content (6.48%) was recorded with the application of 100% compost tea (F_5) over the other treatments. The application of compost tea increases the nitrogen content in seed by 2.64, 4.30, 6.12 and 7.28 per cent over control by application of 25% compost tea (F_2), 50% compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application, respectively.

4.6.1.2 Nitrogen content in haulm

Soil application: Data given in Table 4.12 show that nitrogen content in haulm of soybean after harvest is influenced by soil application of different doses of compost tea over control. Significantly, maximum nitrogen content in haulm (1.65 %) were recorded with application of 1250 lit ha^{-1} (S_5) compost tea which was followed by 1000 lit ha^{-1} (S_4) compost tea. The increase in nitrogen content by 8.87, 16.93, 25.80 and 33.06 per cent over control by application of 500 lit ha^{-1} (S_2), 750 lit ha^{-1} (S_3), 1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest, respectively.

Foliar application: Data analysed in Table 4.12 indicate that the application of different concentrations of compost tea as foliar spray significantly increases the nitrogen content in haulm over control. The maximum nitrogen content (1.50 %) was recorded with the application of 100% compost tea (F_5) followed by other treatments. The application of compost tea increases the nitrogen content in haulm by 2.91, 6.56, 8.75 and 9.48 per cent over control by application of 25% compost tea (F_2), 50% compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application, respectively.

4.6.2 Phosphorus content

4.6.2.1 Phosphorus content in seed

Soil application: Data given in Table 4.12 that phosphorus content in seed of soybean after harvest is influenced by soil application of different doses of compost tea over control. Significantly, maximum phosphorus content in seed (0.78 %) were recorded with application of 1250 lit ha^{-1} (S_5) compost tea which was followed by 1000 lit ha^{-1} (S_4) compost tea. The increase in nitrogen content by 8.33, 16.66, 21.66 and 30.00 per cent over control by application of 500 lit ha^{-1} (S_2), 750 lit ha^{-1} (S_3), 1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest, respectively.

Foliar application: Data analysed in Table 4.12 indicate that the application of different concentrations of compost tea as foliar spray significantly increases the phosphorus content in seed over control. The maximum phosphorus content (0.72 %) was recorded with the application of 100% compost tea (F_5) followed by other treatments. The application of compost tea increases the nitrogen content in haulm by 9.52, 11.11, 12.69 and 14.28 per cent over control by application of 25% compost tea (F_2), 50% compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application, respectively.

4.6.2.2 Phosphorus content in haulm

Soil application: It is inferred from the data (Table 4.12) that phosphorus content in haulm of soybean after harvest is influenced by soil application of different doses of compost tea over control and varies in range of 0.13-0.20 per cent. Significantly, maximum phosphorus content (0.20 %) in haulm were recorded with application of 1250 lit ha^{-1} (S_5) compost tea which was followed by 1000 lit ha^{-1} (S_4) compost tea. The increase in nitrogen content by 15.38, 23.07, 46.15 and 53.84 per cent over control by application of 500 lit ha^{-1} (S_2), 750 lit ha^{-1} (S_3), 1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest, respectively.

Foliar application: Data analysed in Table 4.12 indicate that the application of different concentrations of compost tea as foliar spray significantly increases the phosphorus content in haulm over control. The maximum phosphorus content (0.72 %) in haulm was recorded with the application of 100% compost tea (F_5) followed by other treatments. The application of compost tea increases the nitrogen content in haulm by 14.28, 35.71, 42.85 and 57.14 per cent over control by application of 25% compost tea (F_2), 50% compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application, respectively.

4.6.3 Potassium content

4.6.3.1 Potassium content in seed

Soil application: Data in Table 4.12 show that potassium content in seed of soybean is influenced by soil application of different doses of compost tea over control. Significantly, maximum potassium content in seed (1.68 %) were recorded with application of 1250 lit ha^{-1} (S_5) compost tea which was followed by 1000 lit ha^{-1} (S_4) compost tea. The increase in potassium content by 5.00, 10.71, 15.00 and 20.00 per cent over control by application of 500 lit ha^{-1} (S_2), 750 lit ha^{-1} (S_3), 1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest, respectively.

Foliar application: Data analysed in Table 4.12 indicate that the application of different concentrations of compost tea as foliar spray significantly increases the nitrogen content in soybean seed over control. The maximum potassium content (1.60 %) was recorded with the application of 100% compost tea (F_5) over the other treatments. The application of compost tea increases the nitrogen content in seed by 5.51, 8.27, 8.96 and 13.79 per cent over control by application of 25% compost tea (F_2), 50% compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application, respectively.

4.6.3.2 Potassium content in haulm

Soil application: Data in Table 4.12 show that potassium content in haulm of soybean is influenced by soil application of different doses of compost tea over control. Significantly, maximum potassium content in seed (0.85 %) were recorded with application of 1250 lit ha^{-1} (S_5) compost tea which was followed by 1000 lit ha^{-1} (S_4) compost tea. The increase in potassium content by 1.35, 4.05, 8.10 and 14.86 per cent over control by application of 500 lit ha^{-1} (S_2), 750 lit ha^{-1} (S_3), 1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest, respectively.

Foliar application: Data analysed in Table 4.12 indicate that the application of different concentrations of compost tea as foliar spray significantly increases the nitrogen content in soybean seed over control. The maximum potassium content (0.82 %) was recorded with the application of 100% compost tea (F_5) over the other treatments. The application of compost tea increases the nitrogen content in seed by 2.70, 6.75, 8.10 and 10.81 per cent over control by application of 25% compost tea (F_2), 50% compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application, respectively.

4.7 EFFECT OF COMPOST TEA ON NUTRIENT UPTAKE

4.7.1 Nitrogen uptake

4.7.1.1 Nitrogen uptake by seed

Soil application: It is apparent from the data presented in Table 4.13 show that nitrogen uptake in seed of soybean is influenced by soil application of different doses of compost tea over control. Significantly, highest nitrogen uptake by seed (110.40 kg ha^{-1}) were recorded with application of 1250 lit ha^{-1} (S_5) compost tea which was followed by 1000 lit ha^{-1} (S_4) compost tea. The increase in nitrogen uptake in seed by 25.11, 54.81, 67.64 and 81.57 per cent over control by application of 500 lit ha^{-1} (S_2), 750 lit ha^{-1} (S_3), 1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest, respectively.

Foliar application: Data analysed in Table 4.13 indicate that the application of different concentrations of compost tea as foliar spray significantly increases the nitrogen uptake by soybean seed over control. The highest nitrogen uptake in seed (95.93 kg ha^{-1}) was recorded with the application of 100% compost tea (F_5) over the other treatments. The application of compost tea increases the nitrogen uptake in seed by 20.78, 28.29, 33.65 and 35.24 per cent over control by application of 25% compost tea (F_2), 50% compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application, respectively.

4.7.1.2 Nitrogen uptake by haulm

Soil application: Data given in Table 4.13 show that nitrogen uptake by haulm of soybean after harvest is influenced by soil application of different doses of compost tea over control. Significantly, highest nitrogen uptake by haulm (54.93 kg ha^{-1}) were recorded with application of 1250 lit ha^{-1} (S_5) compost tea which was followed by 1000 lit ha^{-1} (S_4) compost tea. The increase in nitrogen content by 14.22, 51.25, 81.36 and 96.88 per cent over control by application of 500 lit ha^{-1} (S_2), 750 lit ha^{-1} (S_3), 1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest, respectively.

Foliar application: Data analysed in Table 4.13 indicate that the application of different concentrations of compost tea as foliar spray significantly increases the nitrogen uptake by haulm over control. The highest nitrogen uptake by haulm (43.63 kg ha^{-1}) was recorded with the application of 100% compost tea (F_5) followed by other treatments. The application of compost tea increases the nitrogen uptake in haulm by 27.56, 35.21, 42.20 and 43.19 per cent over control by application of 25% compost tea (F_2), 50% compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application, respectively.

4.7.2 Phosphorus uptake

4.7.2.1 Phosphorus uptake by seed

Soil application: The explicit of data given in Table 4.13 show that phosphorus uptake by seed of soybean at harvest significantly influenced by application of different doses of compost tea in soil as compared to other treatments. Significantly, maximum phosphorus uptake by seed (13.53 kg ha^{-1}) were recorded with application of 1250 lit ha^{-1} (S_5) compost tea followed by other treatments. There is an increase of phosphorus uptake by 44.50, 89.72, 107.02 and 143.70 per cent over control by application of 500 lit ha^{-1} (S_2), 750 lit ha^{-1} (S_3), 1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest, respectively over control.

Foliar application: Data analysed in Table 4.13 indicate that the application of different concentrations of compost tea as foliar spray significantly increases the phosphorus uptake by seed over control. Significantly, maximum phosphorus uptake (11.70 kg ha^{-1}) were recorded with the application of 100% compost tea (F_5) followed by other treatments. The foliar application of compost tea increases the phosphorus uptake in seed by 54.49, 70.28, 87.26 and 98.64 per cent over control by application of 25% compost tea (F_2), 50% compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application, respectively.

4.7.2.2 Phosphorus uptake by haulm

Soil application: It is inferred from the data presented in Table 4.13 show that phosphorus uptake by haulm of soybean after harvest is influenced by soil application of different doses of compost tea over control. Significantly, maximum phosphorus uptake (4.80 kg ha^{-1}) in haulm were recorded with application of 1250 lit ha^{-1} (S_5) compost tea which was followed by 1000 lit ha^{-1} (S_4) compost tea. The increase in phosphorus uptake in haulm by 22.67, 49.79, 70.04 and 94.33 per cent over control by application of 500 lit ha^{-1} (S_2), 750 lit ha^{-1} (S_3), 1000 lit ha^{-1} (S_4) and 1250 lit ha^{-1} (S_5) compost tea at harvest, respectively.

Foliar application: Data analysed in Table 4.13 indicate that the application of different concentrations of compost tea as foliar spray significantly increases the phosphorus uptake in haulm over control. The maximum phosphorus uptake (4.80 kg ha^{-1}) in haulm was recorded with the application of 100% compost tea (F_5) followed by other treatments. The application of compost tea increases the phosphorus uptake in haulm by 41.12, 65.32, 85.48 and 93.54 per cent over control by application of 25% compost tea (F_2), 50% compost tea (F_3), 75% compost tea (F_4), and 100% compost tea (F_5), as foliar application, respectively.

4.7.3 Potassium uptake

4.7.3.1 Potassium uptake by seed

Soil application: Data presented in Table 4.13 show that potassium uptake by seed of soybean is influenced by soil application of different doses of compost tea over control. Significantly, maximum potassium uptake (14.14 kg ha^{-1}) were recorded with application of 1250 lit ha^{-1} (S_5) compost tea which was followed by 1000 lit ha^{-1} (S_4) compost tea.

Foliar application: Data given in Table 4.13 reveal that maximum potassium uptake (12.93 kg ha^{-1}) in seed were recorded with the application of 100% compost tea (F_5) over the other treatments.

4.7.3.2 Potassium uptake by haulm

Soil application: Data presented in Table 4.13 show that maximum potassium uptake in haulm (28.39 kg ha^{-1}) were recorded with application of 1250 lit ha^{-1} (S_5) compost tea which was followed by 1000 lit ha^{-1} (S_4) compost tea.

Foliar application: Data analysed in Table 4.13 indicate that the maximum potassium uptake (23.79 kg ha^{-1}) were recorded with the application of 100% compost tea (F_5) over the other treatments.

4.8 ECONOMIC ANALYSIS

4.8.1 Net return

Soil application: A perusal of data in Table 4.14 reveal that with the application of 1250 lit ha^{-1} (S_5) compost tea in soil recorded significantly highest net return (67566 ha^{-1}) and which was significantly followed by net return in application of 1000 lit ha^{-1} (S_4) compost tea in soil.

Foliar application: The data given in the Table 4.14 indicate that the highest return (₹ 62565 ha^{-1}) was recorded in application of 100% compost tea (F_5) as foliar spray which was significantly followed by net return in application of 75% compost tea (F_4) as foliar application.

4.8.2 Benefit-cost ratio

Soil application: A perusal of data in Table 4.14 reveal that the application of 1250 lit ha^{-1} (S_5) compost tea gave maximum benefit cost ratio (2.30) which was found statistically at par with benefit cost ratio (2.13) in application of 1000 lit ha^{-1} (S_4) compost tea in soil.

Foliar application: The data given in the Table 4.14 indicate that that application of 100% compost tea (F_5) gave maximum benefit cost ratio (2.13) which was found statistically at par with benefit cost ratio (2.03) in application of 75% compost tea (F_4) as foliar spray.

5. DISCUSSION

During the course of presenting the results of experimented entitled **"Effect of Soil and Foliar Application of Compost Tea on Growth, Yield and Quality of Soybean [*Glycine max* (L.) Merill]"** in the previous chapter the significant variations were recorded in number of crop parameters due to the effect of different treatments. In this chapter, an attempt is being made to discuss the significant results obtained and reconcile them in to some tangible concept. Experimental findings and observation of other workers within and outside the country on related aspect of present investigation. The entire discussion has been confined to following headings:

5.1 GROWTH ATTRIBUTES

5.1.1 Soil application of compost tea:

The results showed that the application of different doses of compost tea in soil significantly influenced the biomass production of soybean at all growth stages. It could be seen from the preceding chapter that all the components of plant biomass were favourably influenced by the application of various doses of compost tea in soil (Table 4.1-4.6). Significantly, higher plant height *i.e.* 33.27 cm, 46.80 cm and 68.77 cm were recorded with the application of 1250 lit ha^{-1} compost tea in soil at 30 DAS, 60 DAS and at harvest. The soil application of 1250 lit ha^{-1} compost tea have recorded maximum dry matter accumulation *i.e.* 3.09 g $plant^{-1}$, 15.71 g $plant^{-1}$ and 26.27 g $plant^{-1}$ at 30 DAS, 60 DAS and at harvest, respectively. Maximum number of effective root nodules $plant^{-1}$ at 60 DAS were observed under the treatment application of 1250 lit ha^{-1} compost tea in soil.

The possible reason behind this may be an increased availability of nutrients at initial stage through organic manures in addition to nutritional and other benefits from compost tea.. Higher dry matter production was perhaps due to more leaves $plant^{-1}$, leaf area and number of primary branches $plant^{-1}$. This result can be related to the findings of Siddiqui *et al.* (2008) revealed that the application of rice straw compost extract had a significant enhancement effect on morphological characters of okra such as shoot length, tap root length, number of leaves $plant^{-1}$ and leaf area variations. The plant growth analysis indices *i.e.*, CGR and RGR also found maximum in treatment application of 1250 lit ha^{-1} compost tea followed by 1000 lit ha^{-1} compost tea application in soil. Above results related to plant growth analysis indices found similar with the findings of Mahmoud *et al.* (2015) in which the results showed that the application of greater amount of compost extract significantly increased bulb and plant dry weight of onion. The same outcomes that were recorded by Geires *et al.* (2012) supported the obtained results. Microbial enriched compost tea contains macro and micronutrients such as N, P, K, Ca, Fe and Mn (Naidu *et al.*, 2010). These properties might have indirect role in improving fertility, physical and chemical condition of soil, acting as a powerful chelator to make nutrients available to the plant and contributed to the enhancement of plant growth (Siddiqui *et al.*, 2008, 2011). Maximum number of root nodules were found with soil application of 1250 lit ha^{-1} compost tea which was followed by of 1000 lit ha^{-1} compost tea. This might be due to the uptake and accumulation of nutrient elements in the plant and microbial community present in compost tea stimulate nutrient uptake and plant growth (Ingham, 2005).

5.1.2 Foliar application of compost tea:

A significant increase in plant height and dry matter accumulation $plant^{-1}$ at 30, 60 DAS and at harvest, crop growth rate and relative growth rate at 30-60 DAS and 60-harvest, total chlorophyll and effective root nodules $plant^{-1}$ increased under foliar application of 100% compost tea in soybean which was found at par with 75% compost tea application and superior from other treatments and control. In the present study the maximum vegetative growth was observed with foliar application of 100% compost tea can be accounted for the fact that it contain higher amount of organic carbon, N, P, K, Fe and Mn and plant growth promoting hormones which is responsible for rapid growth and development of plants and the similar results were found by Naidu *et al.* (2010). Microbial enriched compost tea is a fermented liquid leachate of organic decomposed compost and is rich in micro and macronutrients such as nitrogen, potassium, phosphorus, calcium, iron and manganese (Naidu *et al.*, 2010) and growth hormones like '*auxins*' (Ertani *et al.*, 2013), '*cytokinins*' (Zhang *et al.*, 2013).

The observed increase in chlorophyll content with foliar application of compost tea in the study might be associated with the supply of essential nutrients to the plants. Since, chlorophyll synthesis in the plants are directly related to the availability of physiologically active Fe, N, P and S nutrients. Compost tea contains various salts rich in N, P, K, S and micronutrients in plant available form. Hence, availability of these nutrients to plants help in the formation of chlorophyll in the leaves. Significant increase in plant height, chlorophyll content and dry matter accumulation were observed by 75% diluted foliar spray of compost tea (Sutar *et al.*, 2019). Higher chlorophyll content and plant growth due to application of compost tea has also been observed by Loganthan and Wahab (2014). Nutrients required by plants are applied through foliage, there is enhancement in uptake, translocation and synthesis of photosynthetic assimilates which results into increase in various plant growth characters such as plant height, leaf area, root length and total dry matter accumulation.

The results of the present study are also in line with Kim *et al.* (2015) who also studied the effect of compost tea on the growth parameters such as root length and biomass, shoot length and biomass, number of root nodules per plant on soybean (*Glycine max*). Arsode *et al.* (2014) reported that the two foliar spray of growth hormones on mustard increased plant height and number of branches per plant. It might be due to moderated and constant supply of carbohydrates within the plant as a result of increased vegetative growth. Increased vegetative growth might be due to increased uptake of NPK and all essential nutrients. Siddiqui *et al.* (2008) also revealed that the rice straw compost extracts promoted significant enhancement on morphological characters of okra (*Abelmoschus esculentus*) such as shoot length, tap root length, number of leaves per plant, leaf area variations in respect to other treatments.

5.2 YIELD ATTRIBUTES AND YIELD

5.2.1 Soil application of compost tea:

A significant increase in number of primary branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, test weight, seed yield and haulm yield of soybean were observed due to application of 1250 lit ha^{-1} compost tea as compared with control and other treatments (Table 4.7 and 4.8). The easy transfer of nutrients and growth stimulants to plants through soil application was more effective due to compost tea might be the reason of enhancement in yield attributes. There are several reasons for increased yield in soybean due to soil application of compost tea. Smaller quantities of IAA and GA present in compost tea which could have created stimuli in the plant system which in turn increased the production of growth regulator in cell system and the action of growth regulators in plant system stimulated the necessary growth and development, leading to better yield. Similar results were also observed that soil application of compost tea @ 25% RDF + 75% compost tea as soil drench were found best to enhance the total number of pods per plant, pod length, number of seeds per pod, seed weight, straw weight and harvest index of cowpea (Hegazi and Algahrib, 2014).

Crop yield is a complex function of physiological processes and biochemical activities which modify plant anatomy and morphology of the growing plants. Seed and haulm yield of soybean was significantly influenced by different treatments of compost tea application in soil. Soil application of 1250 lit ha^{-1} recorded the maximum seed yield (1665 kg ha^{-1}) and haulm yield (3081 kg ha^{-1}) of soybean. This might be due to the favourable effect of compost tea on vegetative growth *viz.* number of branches per plant and reproductive growth *viz.* pods $plant^{-1}$, seeds pod^{-1} and 1000 seed weight, which were the important yield attributes having significant positive correlation with seed and haulm yield.

The results are in agreement with those reported by Khaled *et al.* (2012) who found that a combined soil application of organic fertilizers (compost, compost tea, humic acid) or with the different mineral N fertilizers rates markedly increased number of sesame capsules per plant, seed weight per plant, seed yield and test weight.

5.2.2 Foliar application of compost tea:

A significant increase in number of branches $plant^{-1}$, number of pods $plant^{-1}$, number of seeds pod^{-1}, test weight, seed yield and haulm yield of soybean were observed due to foliar application of 100% compost tea which was found at par with treatment of 75% compost tea.

In the present investigation, foliar application of 100% compost tea recorded significantly higher seed yield (1578 kg ha^{-1}) which was followed by seed yield (1538 kg ha^{-1}). Similarly, significantly higher straw yield was also recorded with 100% compost tea application (2931 kg ha^{-1}) which was followed by haulm yield (2795 kg ha^{-1}) in 75% compost tea application. The increase in grain yield and straw yield of wheat due to application of 100% compost tea could be due to better availability of nutrients and plant growth hormones during the critical period of crop growth. These findings are in accordance with Hegazi and Algahrib (2014) results showed in cowpea field 25% NPK + 75% compost tea as foliar spray significantly increase the seed yield compared with other foliar treatments. Similar results were reported by Mostafa *et al.* (2009) the yield and fruit quality significantly increased when applied compost tea as foliar application and used on Washington navel orange trees and on Thompson seedless grapevines.

Similar results were obtained by Sutar *et al.* (2019) the results showed that the maximum number of pods plant^{-1} (32.43) at pod formation stage and (35.90) at harvest stage, respectively were observed under the treatment application of RDF + 75% compost tea foliar spray. This increase in number of pods might be due to foliar application of compost tea which helped in acceleration of various metabolic processes in plants. Similar observation reported by Loganthan and Wahab (2014) and Vimalendran and Wahab (2013) that the application of recommended dose of fertilizer and compost tea foliar spray at different stage of crop lead to better photosynthesis activity of the plant and more extensive root system and thus, enabled the plant to extract nutrients from soil thereby resulting in better development of yield.

Mahmoud *et al.* (2014) reported similar results in onion crop which showed the application of compost extract thrice at 40, 60 and 80 DAT increased bulb and plant dry weight, marketable yield on onion. These increases may be due to effect of nitrogen which produced by bacteria in microbial enriched compost teas in addition to cytokinin, GA_3 and indole acetic acid which increases vegetative growth and ultimately yield. These results were coinciding with those of Khalid *et al.* (2006) and Gharib *et al.* (2008). They all showed that compost extract increased reproductive growth and essential oil content of *Ocimum basilium* and marjoram plants, respectively. Beneficial effects of compost tea may be due to both supply of nutrients and microbial functions. It can provide chelated microelements and make them easier for plant to absorb and increasing soil aeration. Compost extract applied as foliar, increase the permeability of cellular membrane in plants to vitamins within the cell (Kaya *et al.*, 2005) which increased plant growth and yield. And, when compost extracts are applied to foliage, there may be direct effects on the pathogens and indirect effects through improvement in plant resistance (Litterick *et al.*, 2004) which probably increase plant growth and yield.

5.3 NUTIENT CONTENT, UPTAKE AND QUALITY OF SOYBEAN

5.3.1 Soil application of compost tea:

Application of compost tea in soil significantly improved nitrogen, phosphorus, potassium contents in seed and haulm, their uptake and protein and oil content in seed of soybean over control. As discussed in Table 3.5 that compost tea contains pH (6.76), EC (0.905 Ds m^{-1}), N (205 ppm), P (7.6 ppm), K (206 ppm). Chemolithotrophs and autotrophic nitrifiers (ammonifers and nitrifers) present in compost tea which increase nutrient content, uptake and protein content in seed and haulm of soybean. Similar results as seed quality improvement was recorded by Khafaga *et al.*, (2014).

More nutrient content and uptake in haulm by application of higher level of compost tea application in soil contributed by higher leaf nitrogen, phosphorus and potassium content in soil treatment with compost tea as compare to control by Mostafa *et al.* (2009). Similar results were observed by Sheren and Ghieth (2017) in peach leaves and Fayek *et al.* (2014) in pear leaves. The application of compost tea as soil drench to a level of 1250 lit ha^{-1} leads to increase the NPK content of seed and haulm. These results are in agreement with those attained by Hussein and Radwan (2001). The obtained increases in macronutrient concentration of haulm and seeds may be due to the decrease of soil pH, soil salinity, and the increased activity of microorganisms in soil Lobna *et al.* (2006). Compost tea contains beneficial microorganisms like *azobacter, agrobacterium and rhizobium* species, P solublising bacteria reported by El Gizawy (2013). Increasing the soil nitrogen boost up the production of endogenous phytohormones, that have a significant role in profuse root structure formation that allows more nutrient uptake by plant.

Quality parameters like seed oil and seed protein is also influenced by application of various doses of compost tea in soil. Maximum oil content found in treatment application of 1250 lit ha^{-1} compost tea. The reason behind this is promotional effect of compost tea on nutrient uptake especially phosphorus, sulphur.

5.3.2 Foliar application of compost tea:

Foliar application of compost tea significantly influenced the nutrient content, uptake in seed and haulm as well oil and protein content in seed. The treatment application of 100% compost tea as foliar spray at branching and 10% flowering stage significantly enhances the nutrient content, uptake and quality parameters which was found at par with treatment application of 75% compost tea. Compost tea contains ammonifers, nitrifers and rhizobium species bacteria which has a stimulatory effect on root nodulation, further improves symbiotic nitrogen fixation that lead an increase in nitrogen content in plant treated with compost tea. (Fritz *et al.*, 2012; El-Gizawy *et al.*, 2013). Ali (2015) also found that treated faba bean plants with compost tea caused significant increases in the absorption rates of nutrients. Regarding the nutrient uptake, compost tea exhibit potential of increasing the root growth which improves nutrient uptake from soil. Abo-Sedera *et al.* (2016) reported similar results in spraying seaweed compost extract in bean plants three times that increase all assayed chemical constituents of plant foliage. Increase in chemical constituents seaweed compost extract may be due to presence of micro and macronutrients, growth regulators like IAA, GA_3, humic acid etc that affect positively on nutrient uptake and accumulation in cells. (Zewail and Ahmed, 2015; Mansori *et al.* 2015).

In application of 100% compost tea as foliar spray, maximum nitrogen content (6.48%), phosphorus content (0.72 %) and potassium content (0.82%) was observed in seed. Similar findings were reported by Hegazi and Algahrib (2014) application of 25% NPK + 75% compost tea (foliar spray) in cowpea plant significantly increased the NPK content in seed and suggested that application of high amounts of composted materials meets the crop N demand and it is the main yielding factor as N is the chief constituent of functional plasma, integral part of chlorophyll, amino acids, protein molecules, enzymes, alkaloids, vitamins and hormones (Castellnos *et al.*, 2000).

Soybean oil content and quality is linearly increased with increase in compost tea concentration. Soybean oil mainly contains five fatty acids (palmitic acid, stearic acid acid, oleic acid, linoleic acid and linolenic acid). Application of compost leachates on foliage and flowers improves the content and quality of these fatty acids in soybean seed. These results are in line with the findings of El-Din *et al* (2010) as content and quality of oil of *Borage officinalis* plant increased with application of higher dose of compost tea.

5.4 NET RETURN AND BENEFIT COST RATIO

5.4.1 Soil application of compost tea:

Application of 1250 lit ha^{-1} increased the net return of ₹ 67566 ha^{-1} and Benefit cost ratio (2.30) in soybean plant as compared to control and other treatments (Table 4.14). The increased net return could be explained because maximum seed yield (1665 kg ha^{-1}) and maximum haulm yield (3081 kg ha^{-1}) was observed under treatment application of 1250 lit ha^{-1} compost tea. Similar results were observed by Shaheen *et al.* (2013) who reported that soil application of higher levels of compost tea was found effective in enhancing the plant height, fresh weight, dry weight of plant, total bulb yield, marketable yield, net return and B C ratio in onion plant.

5.4.2 Foliar application of compost tea:

Application of 100% compost tea increased the net return of ₹ 62565 ha^{-1} and B-C ratio (2.13) which was found at par with foliar application of 75% compost tea with net return of ₹ 59657 ha^{-1} and B-C ratio (2.03) but superior from other treatments and control. The increase in net returns and B C ratio could be explained as highest seed yield (1578 kg ha^{-1}) and haulm yield (2931 kg ha^{-1}) under treatment application of 100% compost tea as foliar spray. These findings are in accordance with the findings of Ali (2015) who reported that foliar application of compost tea as compare to control treatment (without compost tea) found best in enhancing the plant height, number of branches $plant^{-1}$, leaf area, leaf dry weight, early flowering, pods number $plant^{-1}$, 100 seed wight, seed yield, net realization and B C ratio of faba beans.

6. SUMMARY

A field experiment entitled **"Effect of Soil and Foliar Application of Compost Tea on Growth, Yield and Quality of Soybean [*Glycine max* (L.) Merill]"** was conducted at Organic farm Unit, Rajasthan College of Agriculture, Udaipur during *Kharif*, 2019. The salient conclusions of investigation presented and discussed in the preceding chapters are briefed under below section:

6.1 SOIL APPLICATION OF COMPOST TEA

6.1.1 Growth attributes

- Significant increase in plant height at 30 DAS, 60 DAS and at harvest was found with the soil application of 1250 lit ha^{-1} compost tea over control and other treatments.
- Dry matter accumulation $plant^{-1}$ recorded at 30 DAS, 60 DAS and at harvest has a significant increment by the soil application of 1250 lit ha^{-1} over control and other treatments.
- Relative growth rate recorded at 30-60 DAS and 60 DAS-harvest was not significantly influenced by the soil application of compost tea.
- Significantly maximum number of effective root nodules $plant^{-1}$ and total chlorophyll content was observed with the soil application of 1250 lit ha^{-1} as compared to control and other treatments.

6.1.2 Yield attributes and yield

- Soil application of 1250 lit ha^{-1} compost tea significantly increased number of primary branches in soybean plant as compare to control and other treatments.
- Application of compost tea at 1250 lit ha^{-1} in soil recorded significantly maximum number of pods $plant^{-1}$, seed pod^{-1} and test weight in soybean.
- Application of 1250 lit ha^{-1} compost tea significantly recorded the maximum seed and haulm yield (kg ha^{-1}) as compared to the other treatments and control.
- Harvest index of soybean was significantly influenced by the soil application of compost tea.

6.1.3 Quality parameters

- Soil application of 1250 lit ha^{-1} compost tea significantly increased the protein (%) and oil (%) in seeds of soybean.

6.1.4 Nutrient content and uptake

- Application of 1250 lit ha^{-1} compost tea in soil significantly improved the nitrogen, phosphorus and potassium content and uptake in seeds and haulm of soybean as compared to control and other treatments.

6.1.5 Economics

- Application of 1250 lit ha^{-1} compost tea in soil gave maximum net return (₹ 67566 ha^{-1}) and B C ratio (2.30) as compare to control and other treatments.

6.2 FOLIAR APPLICATION OF COMPOST TEA

6.2.1 Growth attributes

- Significant increase in plant height at 30 DAS, 60 DAS and at harvest was found with the foliar application of 100 % compost tea over control.
- Dry matter accumulation $plant^{-1}$ recorded at 30 DAS, 60 DAS and at harvest has a significant increment by the foliar application of 100 % compost tea over control.
- Relative growth rate recorded at 30-60 DAS and 60 DAS-harvest was not significantly influenced by the foliar application of compost tea.
- Significantly maximum number of effective root nodules $plant^{-1}$ and chlorophyll content was observed with the foliar application of 100 % compost tea as compared to control.

6.2.2 Yield attributes and yield

- Foliar application of 100 % compost tea significantly increased number of primary branches in soybean plant as compare to control. It is found at par with the treatment application of 75 % compost tea application on foliage.

- Application of 100 % compost tea as foliar spray significantly increases the number of pods plant^{-1} as compare to control that was statistically at par with the foliar application of 75 % compost tea.
- Among the total treatments applied on foliage, application of 100 % compost tea significantly increased the number of seeds pod^{-1} in soybean which found at par with the application of 75 % compost tea as foliar spray.
- Application of 100 % compost tea on soybean plant recorded significantly highest test weight over the control while followed by treatment application of 75 % compost tea.
- Foliar application of 100 % compost tea significantly recorded the maximum seed yield (kg ha^{-1}) as compared to the control.
- Maximum haulm yield was recorded under the treatment application of 100 % compost tea on soybean plant over the control and followed by the treatment application of 75 % compost tea,
- Harvest index of soybean was significantly influenced by the foliar application of compost tea.

6.2.3 Quality parameters

- Foliar application of 100 % compost tea significantly increased the protein (%) and oil (%) in seeds of soybean.

6.1.4 Nutrient content and uptake

- Foliar application of 100 % compost tea significantly improved the nitrogen, phosphorus and potassium content in seeds and haulm of soybean as compared to control. Significantly maximum uptake of nitrogen, phosphorus and potassium was recorded under the treatment application of 1250 lit ha^{-1} compost tea in soil as compared to the control and other treatments
- Significantly, maximum uptake of nitrogen, phosphorus and potassium was recorded under the treatment application of 100 % compost tea which was statistically found at par with the foliar application of 75 % compost tea.

6.2.4 Economics

- Foliar application of 100 % compost tea gave maximum net return (₹ 62565 ha^{-1}) and B C ratio (2.13) as compare to control and other treatments.

7. CONCLUSION

On the basis of results of one year experimentation, above findings could be concluded that soil application of 1250 lit ha^{-1} compost tea in soybean resulted into significantly highest seed yield (1665 kg ha^{-1}) and net return (₹ 67,566 ha^{-1}) and foliar application of 100 % compost tea recorded the highest seed yield (1578 kg ha^{-1}) and net return (₹ 62,565 ha^{-1}) in soybean over the rest of the treatments and control which was found at par with the foliar application of 75 % compost tea. Soil and foliar application of compost tea had no significant effect on the soil pH, EC. Microbial population is significantly affected by application of compost tea. However, these results are only indicative and require further experimentation to arrive at more and final conclusion

LITERATURE CITED

Abo-Sedera, F. A., Shams, A. S., Mohamed, M. H. and Hamoda, A. H. 2016. Effect of organic fertilizer and foliar spray with some safety compounds on growth and productivity of snap bean. *Annals of Agricultural Science*, *Moshtohor* **54**(1): 105-118.

AOAC (1975). Official method of analysis (12th ed.). Washington, DC: Association of Official Analysis Chemists.

Arnon, D. 1. 1949. Copper enzymes in isolated chaloroplasts. Poly-phenoloxidase in Beta vulgaris. *Plant Physiology* **24**:1-15.

Arsode, S. V., Deotale, R. D., Sawant, P. P., Sahane, A. N. and Banginwar, A. D. 2014. Influence of foliar sprays of humic acid through cowdung wash and NAA on morpho-physiological parameters, growth and yield of mustard. *Journal of Soils and Crops* **24**(1): 119-127.

Black, C. A. 1965. Methods of soil analysis. Part II. American Society of Agronomy. INC Publisher, Madison, Wisconsin, USA: 1025.

Bouycous, G. J. 1962. Hydrometer method improved for making particle size analysis of soil. *Agronomy Journal* **54**: 406-465.

Brady, N. C. 1983. The nature and properties of soil. MacMillan Publishing Company, New York and Collier MacMillan Publishers, London: 750.

Castellanos, J. Z., Uvalle-Bueno, J. X. and AguilarSantelises, A. 2000. Manual de interpretacion de analisis de suelos, aguas agricolas, plantas ECP. 2^{a} ed.INIFAP, Chapingo, Mexico.

Derbyshire, E., Wright, D. J. and Boulter, D. 1976. Legumin and vicilin, storage proteins of legume seeds. *Phytochemistry* **15**(1): 3-24.

Directorate of Economics and Statistics 2017, MOA & FW, New Delhi pp: 2-3.

Donald, C. M. and Hamblin, J. 1974. The relationships between plant form, competitive ability and grain yield in a barley cross. *Euphytica* **23**(3): 535-542.

El-Din, A. A. and Hendawy, S. F. 2010. Effect of dry yeast and compost tea on growth and oil content of *Borago officinalis* plant. *Research Journal of Agriculture and Biological Sciences* **6**(4): 424-430.

El-Din, R. A., Ahmed, A. A. and Ghazi S. M. 2008. Effect of seaweed extract on the growth and yield of faba bean (*Vicia faba* L.). *Egyptian Journal of Phycology* **9**: 25-38.

El-Gizawy, E. S., Atwa, A. A., Talha, N. I. and Mostafa, R. A. 2013. Effect of compost and compost tea application on faba bean crop and some soil biological and chemical properties. *Journal of Soil Sciences and Agricultural Engineering* **4**(9): 863-874.

Ertani, A., Pizzeghello, D., Baglieri, A., Cadili, V., Tambone, F., Gennari, M. and Nardi, S. 2013. Humic-like substances from agro-industrial residues affect growth and nitrogen assimilation in maize (*Zea mays* L.) plantlets. *Journal of Geochemical Exploration* **129**: 103-111.

Farrag, D. K., Mehesen, A. A., Kasem, M. H. and El-Din, O. A. 2017. Impact of cyanobacteria filtrate, compost tea and different rates of nitrogen fertilizer on growth, fruit yield and quality of cantaloupe plants. *Microbiology Research Journal International* pp 1-10.

Fayed, T. A. 2010. Effect of compost tea and some antioxidants applications on leaf chemical constituents, yield and fruit quality of pomegranate. *World Journal of Agriculture Science* **6**: 402-411.

Fayek, M. A., Fayed, T. A., El-Fakhrani, E. M. and Sayed, S. N. 2014. Yield and fruit quality of "Le-conte" pear trees as affected by compost tea and some antioxidants applications. *Journal of Horticultural Science & Ornamental Plants* **6**(1): 01-08.

FiBL & IFOAM, 2020. The World of Organic Agriculture pp 67.

Fisher, R. A. (1950). Statistical methods for research workers. Edinburgh, UK: Oliver & Boyd.

Fritz, J. I., Franke-Whittle, I. H., Haindl, S., Insam, H. and Braun, R. 2012. Microbiological community analysis of vermicompost tea and its influence on the growth of vegetables and cereals. *Canadian Journal of Microbiology* **58**: 836-847.

Gea, F. J., Santos, M., Dianez, F., Tello, J. C. and Navarro M. J. 2012. Effect of spent mushroom compost tea on mycelial growth and yield of button mushroom. *World Journal of Microbiology and Biotechnology* **28**: 2765-2769.

Geries, L. S. M., Elgizawy, E. S., Abo-Dahab, A. M. A. and Karam, S. S. 2012. Productivity and quality of two onion cultivars under organic, slow release and mineral fertilizers. *Journal of Plant Production* **3**(5): 835-846.

Gharib, F. A., Moussa, L. A. and Massoud, O. N. 2008. Effect of compost and bio-fertilizers on growth, yield and essential oil of sweet marjoram (*Majorana hortensis*) plant. *International Journal Agriculture and Biol*ogy **10**(4): 381-382.

GOI Report, 2013. State of Indian Agriculture 2012-13, Ministry of Agriculture, Department of Agriculture and Cooperation, Directorate of Economics and Statistics, Government of India, New Delhi.

Hafez, E. and Geries, L. 2018. Effect of Nitrogen Fertilization and Biostimulative Compounds on Onion Productivity. *Cercetari Agronomice in Moldova* **51**(1): 75-90.

Hargreaves, J. C., Adl, M. S. and Warman, P. R., 2009. The effects of municipal solid waste compost and compost tea on mineral element uptake and fruit quality of strawberries. *Compost Science & Utilization* **17**(2): 85-94.

Hegazi, A. Z. and Algharib, A. M. 2014. Study of utilizing compost tea as a nutrient amendment in open field cowpea seed production system. *Journal of Biology and Environmental Science* **2**: 318-328.

Hegazy, M. I., Ali, A. S. and Abbas, E. A. 2013. Evaluation of compost and compost extract efficiency as bio-control agents on damping-off disease incidence of fenugreek (*Trigonella foenum-greacum*). *Zagazig Journal of Agricultural Research* **40**(2): 239-249.

Hussein, A. H., Said-Al, A. and Khalid, K. A. 2010. Response of *Coriandrum sativum* L. essential oil to organic fertilizers. *Journal of Essential Oil-Bearing Plants* **13**: 37-44.

Hussein, H. F. and Radwan, S. M. 2001. Effect of bio-fertilization with different levels of nitrogen and phosphorus on wheat and associated weeds under weed control treatments. *Journal of Biological Science* **4**(4): 435-441.

IFOAM, 2008. Definition of Organic Farming. http://www.ifoam.org/growing organic/definions/doa/index.html. Retrieved 2011-09-3.

Indian Council of Agriculture Research, Indian Institute of Soybean Research Annual Report 2019-20.

Ingham, E. R. 2000. The Compost Tea Brewing Manual, Soil Food Web Incorporated, Corvallis, Oregon, USA pp: 59-63.

Ingham, E. R. 2005. The Compost Tea Brewing Manual: Latest Methods and Research Soil Food Web.

Islam, M. R., Mondal, C., Hossain, I. and Meah, M. B. 2014. Compost tea as soil drench: an alternative approach to control bacterial wilt in brinjal. *Archives of Phytopathology and Plant Protection*, **47**(12): 1475-1488.

Jackson, M. L. 1973. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi.

Kaya, M., Atak, M., Khawar, K. M., Çiftçi, C. Y. and Ozcan, S. 2005. Effect of pre-sowing seed treatment with zinc and foliar spray of humic acids on yield of common bean (*Phaseolus vulgaris* L.). *International Journal of Agriculture and Bio*logy **7**(6): 875-878.

Khafaga, E. E., Hasanin, S. A. and El-Shal, R. 2014. Fffect of foliar application with ascorbic, humic acids and compost tea on nutrients content and faba bean productivity under sandy soil conditions. *Journal of Soil Sciences and Agricultural Engineering* **5**(6): 767-778.

Khaled, A. S., Mona, G. A. and Zeinab, M. K. 2012. Effect of soil amendments on soil fertility and sesame crop productivity under newly reclaimed soil conditions. *Journal of Applied Sciences Research* **21**(2)1568-1575.

Khalid, K. A., Hendawy, S. F. and El-Gezawy, E. 2006. *Ocimum basilicum* (L.) production under organic farming. *Research Journal of Agriculture and Biological Sciences* **2**(1): 25-32.

Khan, S. H., Nafees, M., Ali, Z. and Ali, A. 2011. Comparative study of the effect of compost tea (aerated and non-aerated) of agro-sieved-waste on germination and biomass yield of maize, mungbean and cauliflower. *Journal of Science and Technology* **35**: 31-38.

Lindsay, W. L. and Norvell, W. A. 1978. Development of a DTPA soil test for zinc, iron, manganese, and copper. *Soil Science Society of America Journal* **42**(3): 421-428.

Litterick, A. M., Harrier, L., Wallace, P., Watson, C. A. and Wood, M. 2004. The role of uncomposted materials, composts, manures, and compost extracts in reducing pest and disease incidence and severity in sustainable temperate agricultural and horticultural crop production—a review. *Critical Reviews in Plant Sciences* **23**(6): 453-479.

Liu, K. 1997. Chemistry and nutritional value of soybean components. In Soybeans pp (25-113). Springer, Boston, MA.

Lobna, A., Moussa, S. S. and Shaltout, M. 2006. Evaluation of some bacterial isolates and compost tea for biocontrolling *Macrophomina phaseolina* and *Sclerotium rolfsii* infected sunflower. *Egyptian Journal of Agricultural Research* **48**(5): 1331-1344.

Mahmoud, E., El-Gizawy, E. and Geries, L. 2015. Effect of compost extract, N2-fixing bacteria and nitrogen levels applications on soil properties and onion crop. *Archives of Agronomy and Soil Science* **61**(2): 185-201.

Manjunatha, G. S., Upperi, S. N., Pujari, B. T., Yeledahalli, N. A. and Kuligod, V. B. 2009. Effect of farm yard manure treated with jeevamrutha on yield attributes, yield and economics of sunflower (*Helianthus annuus* L.). *Karnataka Journal of Agricultural Sciences* **22**(1): 198-199.

Mansori, M., Chernane, S., Latique, A., Benaliat, D. and El-Kaoua, M. 2015. Seaweed extract effect on water deficit and antioxidative mechanisms in bean plants (*Phaseolus vulgaris* L.). *Journal of Applied Phycology* **27**(4):1689-1698.

Morales-Corts, M. R., Pérez-Sánchez, R. and Gómez-Sánchez, M. Á. 2018. Efficiency of garden waste compost teas on tomato growth and its suppressiveness against soilborne pathogens. *Scientia Agricola* **75**(5): 400-409.

Mostafa, M. F., El-Boray, M. S. S., Abd Elwahab, A. F. and Barakat, R. A. 2009. Effect of enriched compost tea on Washington navel orange trees. *Journal of Agricultural Science*, *Mansoura Univ*ersity **34**(10): 10085-10094.

Naidu, Y., Meon, S., Kadir, J. and Siddiqui, Y. 2010. Microbial starter for the enhancement of biological activity of compost tea. *International Journal of Agriculture and Biology* **12**(1): 51-56.

National Mission on Oilseeds and Oil Palm Report, 2018.

Olsen, S.R., Watanabe, F.S., Cosper, H.R., Larson, W.E. and Nelson, L.B. 1954. Residual phosphorus availability in long-time rotations on calcareous soils. *Soil Science* **78**(2): 141-152.

Pane, C., Palese, A. M., Celano, G. and Zaccardelli, M. 2014. Effects of compost tea treatments on productivity of lettuce and kohlrabi systems under organic cropping management. *Italian Journal of Agronomy* **9**(3): 153-156.

Panse, V. S. and Sukhatme, P. V. 1985. Statistical methods for Agricultural workers (4th Edition) ICAR Publications, New Delhi.

Piper, C. S. 1950. Soil and Plant Analysis Inter. Publ. Inc. New York: 368.

Recycled Organics Unit (ROU), 2003. Recycled organics products in intensive.

Redford, P. J. 1967. Growth analysis formulae - their use 3nd abuse. *Crop Science* **7**:171-175.

Richards L. A. 1968. Diagnosis and Improvement of Saline and Alkaline Soils. USDA. Hand Book No. 60, Oxford and IBH Publishing, New Delhi.

Sacks, F. M., Lichtenstein, A., Van Horn, L., Harris, W., Kris-Etherton, P. and Winston, M. 2006. Soy protein, isoflavones, and cardiovascular health: an American Heart Association Science Advisory for professionals from the Nutrition Committee. *Circulation* **113**(7): 1034-1044.

Scheuerell, S. and Mahaffee, W. 2002. Compost tea: Principles and prospects for plant disease control. *Compost Science and Utilization* **10**: 313-338.

Scheuerell, S. and Mahaffee, W. 2004. Compost tea as a container medium drench for suppressing seedling damping off caused by Pythium ultimatum. *Phytopathology* **94**: 1156-1163.

Scheuerell, S., 2003. Understanding how compost tea can control disease. *BioCycle* **44**(2): 20-20.

Schmidt, E. L. and Caldwell, A. C. 1967. Practical manual of soil microbiology laboratory methods.

Shaheen, A. M., Rizk, F. A., Sawan, O. M. and Bakry, M. O. 2013. Sustaining the quality and quantity of onion productivity throughout complementarity treatments between compost tea and amino acids. *Middle East Journal of Agricultural Research* **2**(4): 108-115.

Sheren, A. and Ghieth, W. M., 2017. Use of magnetized water and compost tea to improve peach productivity under salinity stress of north Sinai conditions, Egypt. *Egyptian Journal of Desert Research* **67**(2): 231-254.

Siddiqui, Y., Meon, S., Ismail, R., Rahmani, M. and Ali, A. 2008. Bio-efficiency of compost extracts on the wet rot incidence, morphological and physiological growth of okra [*Abelmoschus esculentus* (L.) Moench]. *Scientia Horticulturae* **117**(1): 9-14.

Siddiqui, Y., Islam, T. M., Naidu, Y. and Meon, S. 2011. The conjunctive use of compost tea and inorganic fertiliser on the growth, yield and terpenoid content of *Centella asiatica* (L.) urban. *Scientia Horticulturae* **130**(1): 289-295.

Snell, F.D. and Snell, C.T. 1949. Colorimetric methods of analysis, II. Von Nostrand, New York: 804.

Subbiah, B.V. and Asija, G. L. 1956. A rapid method for the estimation of nitrogen in soil. *Current Science* **26**: 259-260.

Suganthi, A. and Jayanandhan, D. 2015. Effect of tea compost on the growth of *Vigna radiate* (L.) R. Wilczek. *International Journal of Agricultural Research* **1**(12): 968-972.

Sutar, A. U., Vaidya, P. H., Deshmukh, A. V., Lilhare, M. A. and Landge, R. B. 2019. Effect of foliar application of vermiwash, compost tea and panchagavya on yield and quality of soybean in inceptisol. *Journal of Pharmacognosy and Phytochemistry* **8**(5): 1228-1230.

Vela-Cano, M., Catellano-Hinojosa, A., Vivas, A. F. and Toledo, M. V. M. 2014. Effect of heavy metals on the growth of bacteria isolated from sewage sludge compost tea. *Advances in Microbiology* **4**: 644-655.

Vimalendran, L. and Wahab, K. 2013. Effect of Foliar Spray of Panchagavya on Yield Attributes Yield and Economics of Babycorn. *Journal of Agron*omy **12**:109-112.

Vimalendran, L. and Wahab, K. 2014. Influence of Panchagavya foliar spray on the growth attributes and yield of baby corn (*Zea mays*). *Journal of Applied and Natural Science* **6**(2): 397-401.

Walkley, A. and Black, I. A. 1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil science* **37**(1): 29-38.

Wolke, R. L. 2007. Where There's Smoke, There's a Fryer. The Washington Post.

Zaccardelli, M., Pane, C., Villecco, D. and Palese, A. M. 2018. Compost tea spraying increase yield performance of pepper (*Capsicum annum* L.) grown in greenhouse under organic farming system. *Italian Journal of Agronomy* **13**: 229-234.

Zewail, R.M.Y. and Ahmed, H.S.A. 2015. Effect of some biofertilizers (pgpr, biosoal and compost tea) on growth, yield, fiber quality and yarn properties of egyptian cotton. (promising hybrid 10229xg86). *Annals of Agriculture Sciences*, Moshtohor **53**(2):199-210.

Zhang, H., Tan, S.N., Wong, W.S., Ng, C.Y.L., Teo, C.H., Ge, L., Chen, X. and Yong, J.W.H. 2014. Mass spectrometric evidence for the occurrence of plant growth promoting cytokinins in vermicompost tea. *Biology and Fertility of Soils* **50**(2): 401-403.

Effect of Soil and Foliar Application of Compost Tea on Growth, Yield and Quality of Soybean [*Glycine max* (L.) Merrill]

Priya Sidana* Research Scholar

Dr. M.K. Kaushik** Major Advisor

ABSTRACT

A field experiment entitled **"Effect of Soil and Foliar Application of Compost Tea Growth, Yield and Quality of Soybean [*Glycine max* (L.) Merrill]"** was conducted during *Kharif* 2019-20 at Instructional Organic Farm Unit of Rajasthan College of Agriculture, MPUAT, Udaipur. The soil of the experimental site was clay loam in texture with 242.2, 21.2 and 350.5 kg ha^{-1} available nitrogen, phosphorus and potassium, respectively in 0-30 cm soil depth with pH 8.1. The factorial randomized block experimental design was taken with three replications and 25 treatment combinations containing control and four doses of compost tea in soil (500 lit ha^{-1} compost tea, 750 lit ha^{-1} compost tea, 1000 lit ha^{-1} compost tea and 1250 lit ha^{-1} compost tea) as growth enhancer and five foliar applications done twice at 10 % branching stage and flowering stage that containing control and four concentrations of compost tea (25 % compost tea, 50 % compost tea, 75 % compost tea and 100 % compost tea). The soybean variety RKS -24 was sown on 13 July 2019 at 30 cm row to row and 10 cm plant to plant spacing by using recommended seed rate of 80 kg ha^{-1}.

A significant increase in plant height, dry matter accumulation at 30, 60 DAS and at harvest, crop growth rate at 30-60 DAS and 60 DAS-harvest, number of effective root nodules plant^{-1} at 60 DAS, total chlorophyll content at 50 DAS, number of primary branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, test weight, seed yield, haulm yield, protein and oil content in seed, microbial biomass (bacteria, fungi and actinomycetes) in soil, nitrogen, phosphorus, potassium content in seed and haulm and their uptake was observed with the soil application of 1250 lit ha^{-1} compost tea over control, 500 lit ha^{-1} compos tea, 750 lit ha^{-1} compos tea and 1000 lit ha^{-1} compost tea. The significantly higher seed yield (1665 kg ha^{-1}) and net return (₹ 67,566 ha^{-1}) in soybean was obtained with the soil application of 1250 lit ha^{-1} compost tea. While, soil application of compost tea had no significant effect on harvest index.

---

* M.Sc. Research Scholar, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur-313 001

** Professor of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur-313 001

Foliar application of compost tea having five treatments with control and four different concentration of compost tea (25 % compost tea, 50 % compost tea, 75 % compost tea and 100 % compost tea) at 10% branching and flowering stage was done. There was a significant increase in plant height and dry matter accumulation at 60 DAS and at harvest, crop growth rate at 60-harvest interval, number of effective root nodules plant^{-1} at 60 DAS, total chlorophyll content at 50 DAS, number of primary branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, test weight, seed yield, haulm yield, protein and oil content in seed, microbial biomass (bacteria, fungi and actinomycetes) in soil, nitrogen, phosphorus, potassium content in seed and haulm by foliar application of 100 % compost tea which was found at par with the treatment application of 75 % compost tea.

The significantly higher seed yield (1578 kg ha^{-1}) and net return (₹ 62565 ha^{-1}) of soybean was obtained with the foliar application of 100 % compost tea. Foliar application of compost tea at different concentrations had no significant effect on harvest index, soil pH, and EC.

[kkn Pkk; ds e`nk o i.khZ; fNM+dko dk Lkks;chu [*Xykblhu eSDl* (,y-½ esfjy] dh o`f)] mit ,oa xq.koÙkk ij izHkko

fiz;k flMkuk[*]
'kks/kdŸkkZ

MkW- eukst dqekj dkSf'kd[**]
eq[; lykgdkj

vuq{ksi.k

---

jktLFkku d`f"k egkfo|ky;] egkjk.kk izrki Ñf'k ,oa izkS|ksfxdh fo'ofo|ky;] mn;iqj ds IL; foKku iz{ks= esa fpduh nkseV e`nk ij o"kZZ] 2019-20 dh [kjhQ _rq esa **^^[kkn Pkk; ds e`nk o i.khZ; fNM+dko dk Lkks;chu [*Xykblhu eSDl* (,y-½ esfjy] dh o`f)] mit ,oa xq.koÙkk ij izHkko**** ds v/;;u ds fy, ,d iz{ks= iz;ksx vuq{ksfir fd;k x;kA Ák;ksfxd iz{ks= dh e`nk ¼0&30 lseh½ d.kkdkj esa fpduh nkseV] vfHkfØ;k esa vYi {kkjh; ¼ih- ,p- 8-1½ ,oa miyC/k u=tu ¼242-2 fdxzk ⁄ gs-½] QkWLQksjl ¼21-2 fdxzk ⁄ gs-½ vkSj iksVk'k ¼350-5
fdxzk ⁄ gs-½ esa ikbZ xbZA bl iz{ks= esa iz;ksx ;k–fPNd [k.M vfHkdYiuk esa 25 mipkjksa dks rhu iqujko`fÙk;ksa esa foU;kflr fd;k x;k] ftlesa fu;af=r [k.M vkSj pkj [kkn Pkk; dh ek=k ¼[kkn Pkk; 500 fYk⁄gs-] [kkn Pkk; 750 fYk⁄gs-] [kkn Pkk; 1000 fYk⁄gs- o [kkn Pkk; 1250 fYk ⁄ gs-½ o`f} izksRlkgd ds :i esa e`nk esa cqokbZ ds le; Mkyk x;k vkSj ikap i.khZ; fNM+dko nks ckj 10 izfr'kr czkfpax voLFkk o Qwy voLFkk ij ftlesa fu;af=r [k.M vkSj pkj [kkn Pkk; dh lkanzrk ¼25 izfr'kr] 50 izfr'kr] 75 izfr'kr] 100 izfr'kr½ fy;k x;kA Lkks;chu dh izrki jkt&24 fdLe dks 80 fdxzk- cht izfr gSDVj dh nj ls

---

[*] 'kks/kdrkZ] IL; foKku foHkkx] jktLFkku Ñf"k egkfo|ky;] e-iz-Ñ-izkS-fo-] mn;iqj ¼jkt-½&313001

[**] vkpk;Z ¼IL; foKku½] jktLFkku Ñf"k egkfo|ky;] e-iz-Ñ-izkS-fo-] mn;iqj ¼jkt-½&313001

13 tqykbZ 2019 dks 30 lseh- dh iafDr ls iafDr o 10 lseh- dh ikS/ks ls ikS/ks dh nwjh ij cqokbZ dh x;hA

cqokbZ ds 30] 60 fnu ckn vkSj dVkbZ ds le; ikni Å¡pkbZ] 'kq"d Hkkj laxzg.k] 30&60 ,oa 60&dVkbZ ds le; varjky esa fodkl nj] cqokbZ ds 60 fnu ckn izHkkoh tM+ xzfUFk;ksa dh la[;k] dqy DyksjksfQy cqokbZ ds 50 fnu ckn] eq[; 'kk[kkvksa dh la[;k⁄ikS/kk] Qfy;ksa dh la[;k⁄ikS/kk] chtksa dh la[;k⁄Qfy] ijh{k.k Hkkj] cht dh mit] MaBy dh iSnkokj] izkSVhu o rsy ek=k] e`nk lw{etho tSo ek=k (thok.kq] dod ,ao ,fDVuksekblhVhl)] nkus ,ao pkjs esa u=tu] QkWLQksjl] iksVk'k dh ek=k ,oa buds mn~xzg.k dk fofHkUu ek=kvksa esa [kkn Pkk; ds mi;ksx dk fufj{k.k fd;k x;kA e`nk esa cqokbZ ds le; [kkn Pkk; 1250 fYk⁄gs-nsus ls lkFkZd vf/kdre cht mit ¼1665 fdyks@gS-½ vkSj dqy equkQk ¼₹ 67566@gs-½ izklr gqvkA [kkn Pkk; nsus ls Lkks;chu dh dVkbZ ds ckn Qly lwpdkad] e`nk dh ih,p rFkk fo|qr pkydrk ij dksbZ lkFkZd izHkko ugha iM+kA

nks ckj 10 izfr'kr czkfpax voLFkk o Qwy voLFkk ij [kkn Pkk; dk i.kZ vkosnu ftlesa fu;af=r [k.M vkSj pkj [kkn Pkk; dh lkanzrk ¼25 izfr'kr] 50 izfr'kr] 75 izfr'kr] 100 izfr'kr½ fy;k x;kA cqokbZ ds 60 fnu ckn vkSj dVkbZ ds le; ikni Å¡pkbZ] 'kq"d Hkkj laxzg.k] 60&dVkbZ ds le; varjky esa fodkl nj] cqokbZ ds 60 fnu ckn izHkkoh tM+ xzfUFk;ksa dh la[;k] cqokbZ ds 50 fnu ckn dqy DyksjksfQy] eq[; 'kk[kkvksa dh la[;k⁄ikS/kk] Qfy;ksa dh la[;k⁄ikS/kk] chtksa dh la[;k⁄Qyh] ijh{k.k Hkkj] cht dh mit] MaBy dh iSnkokj] izkSVhu o rsy ek=k] e`nk lw{etho tSo ek=k (thok.kq] dod ,ao ,fDVuksekblhVhl)] nkus ,ao pkjs esa u=tu] QkWLQksjl] iksVk'k dh ek=k ,oa buds mn~xzg.k dk fofHkUu ek=kvksa esa [kkn Pkk; ds mi;ksx dk fufj{k.k fd;k x;k] ftl esa 100 izfr'kr [kkn Pkk; dk i.khZ; fNM+dko lcls lkFkZd gqvk tks 75 izfr'kr [kkn Pkk; ds i.khZ; fNM+dko ds cjkcj ik;k x;kA [kkn Pkk; 100

izfr'kr nsus ls lkFkZd vf/kdre cht mit ¼1578 fdyks@gS-½ vkSj dqy ykHk ¼₹ 62565@gs-½ izkIr gqvkA [kkn Pkk; nsus ls Lkks;chu dh dVkbZ ds ckn Qly lwpdkad] e`nk dh ih,p rFkk fo|qr pkydrk ij dksbZ lkFkZd izHkko ugha iM+kA

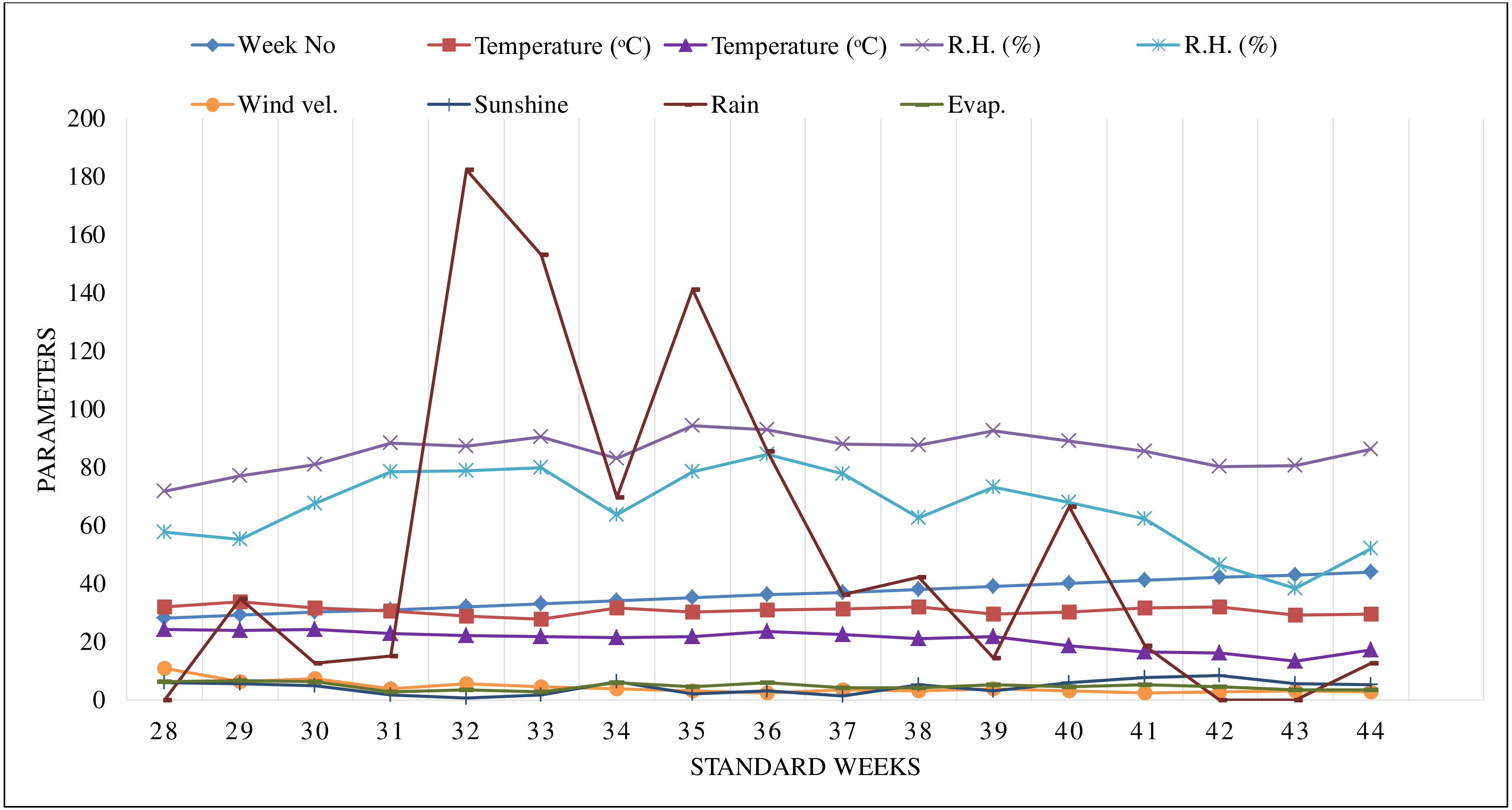


Fig 3.1 Weekly average of meteorological data during experimental period for *Kharif*, 2019

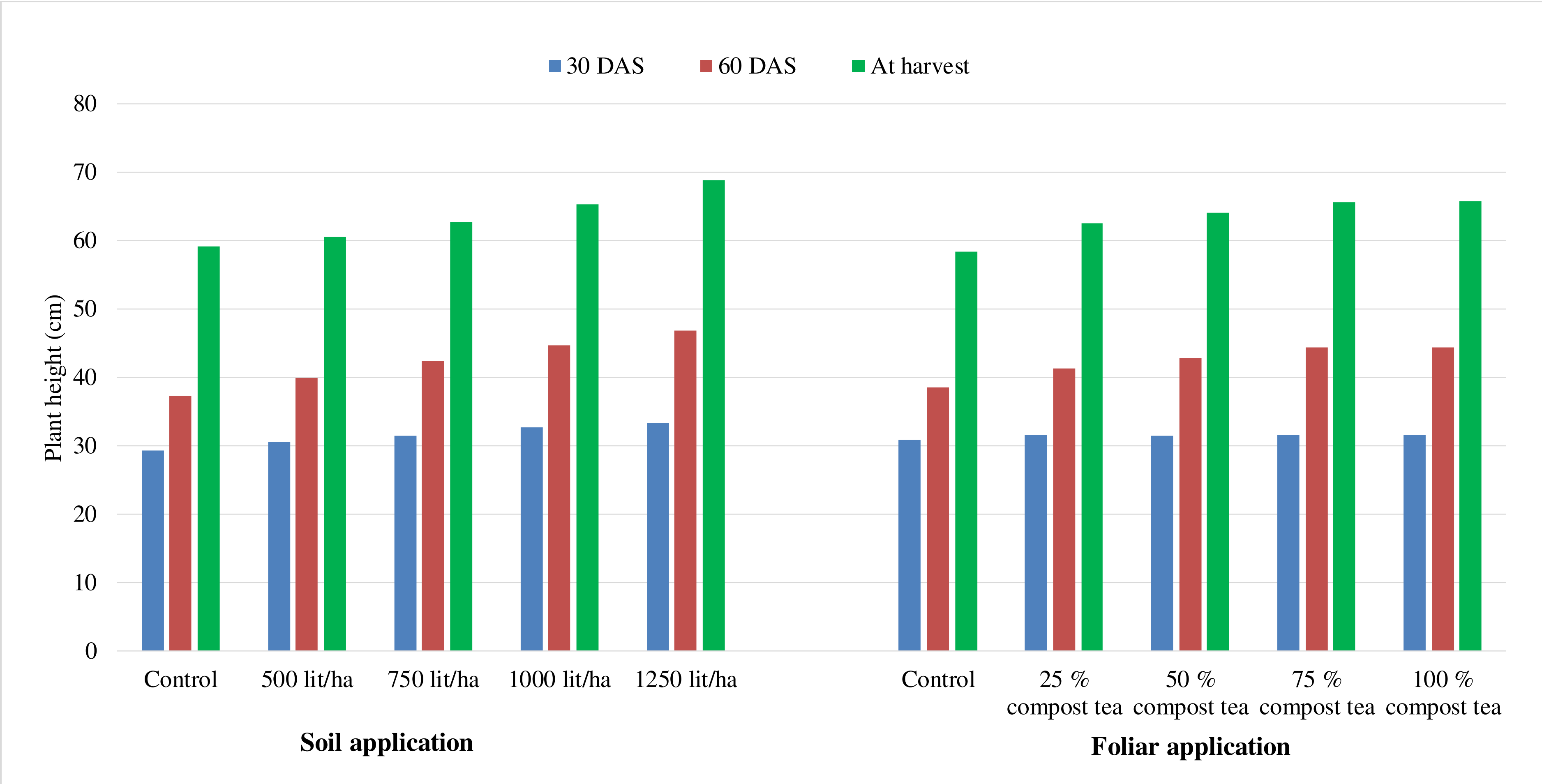


Figure 4.1: Effect of soil and foliar application of compost tea on plant height (cm) in soybean

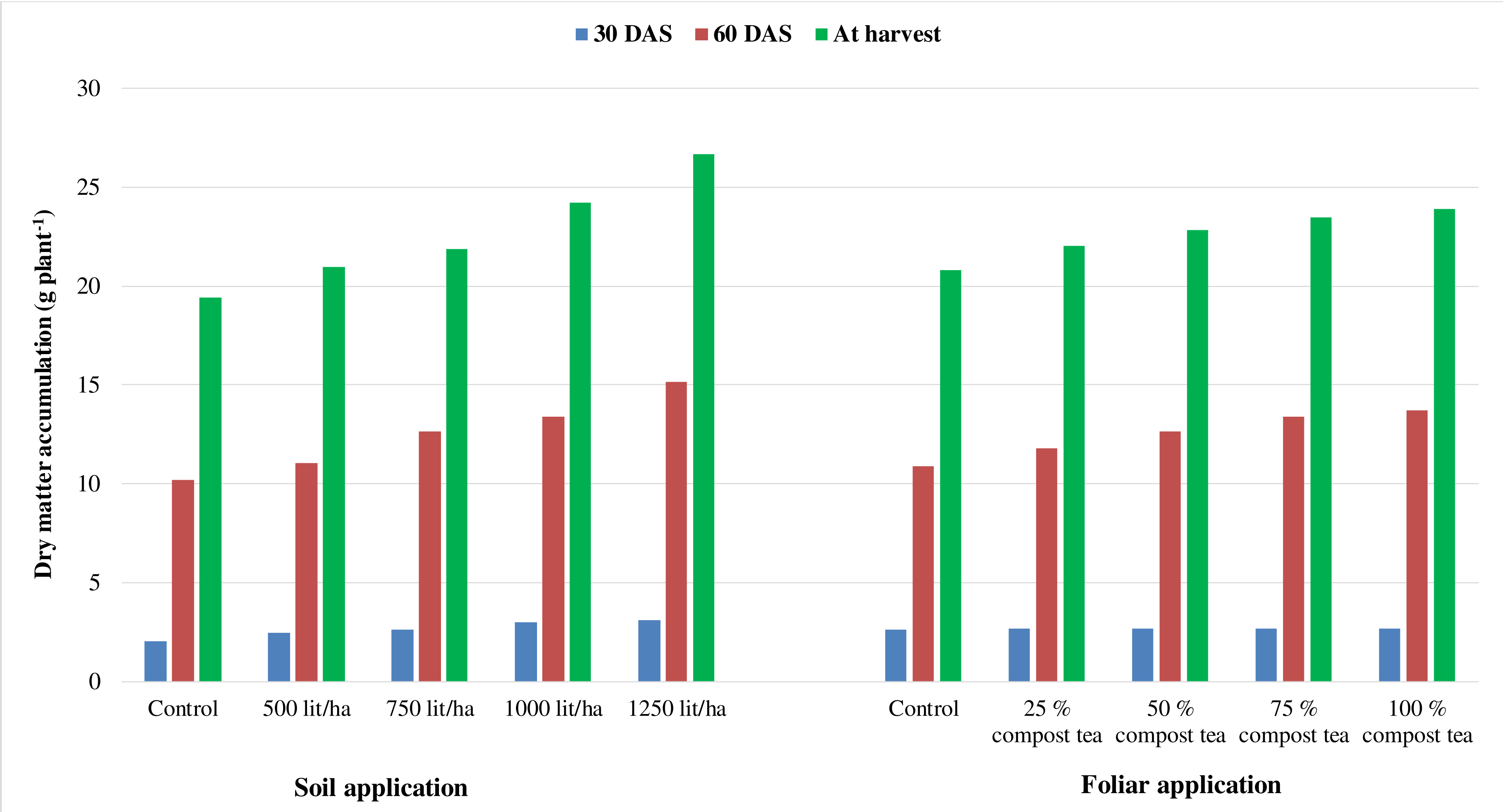


Figure 4.2: Effect of soil and foliar application of compost tea on dry matter accumulation in soybean

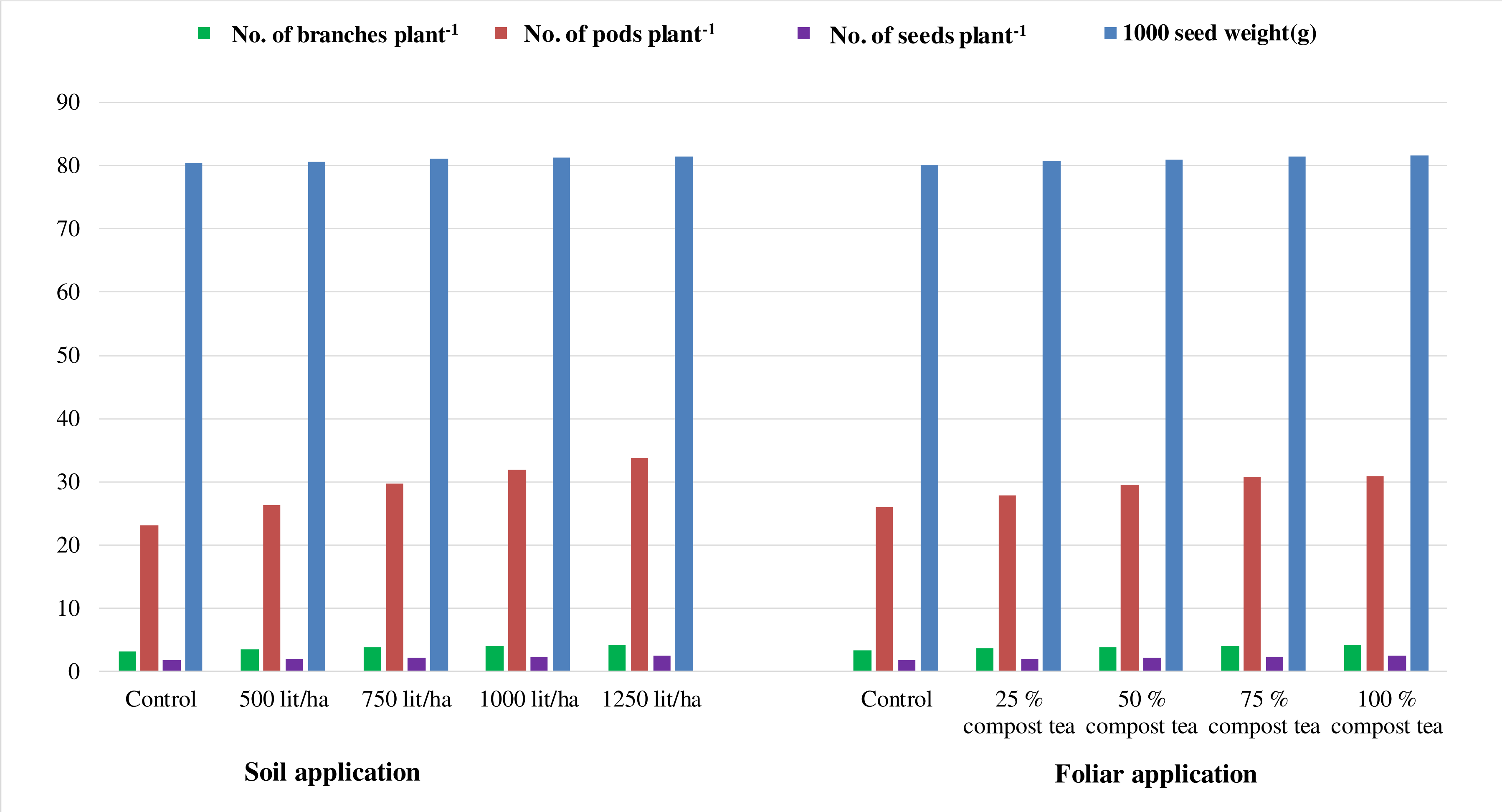


Figure 4.3: Effect of soil and foliar application of compost tea on yield attributes in soybean

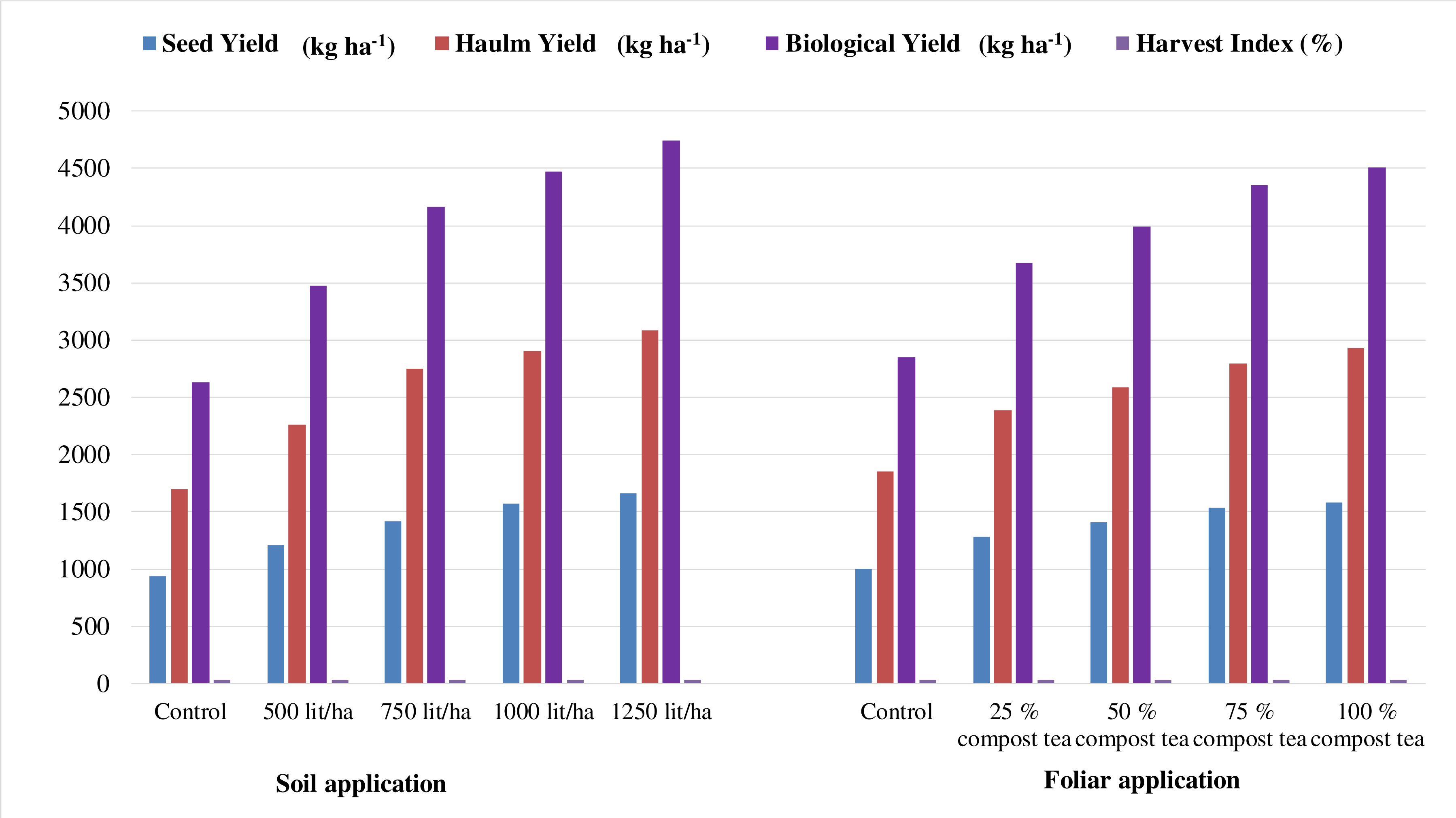


Figure 4.4: Effect of soil and foliar application of compost tea on yield in soybean

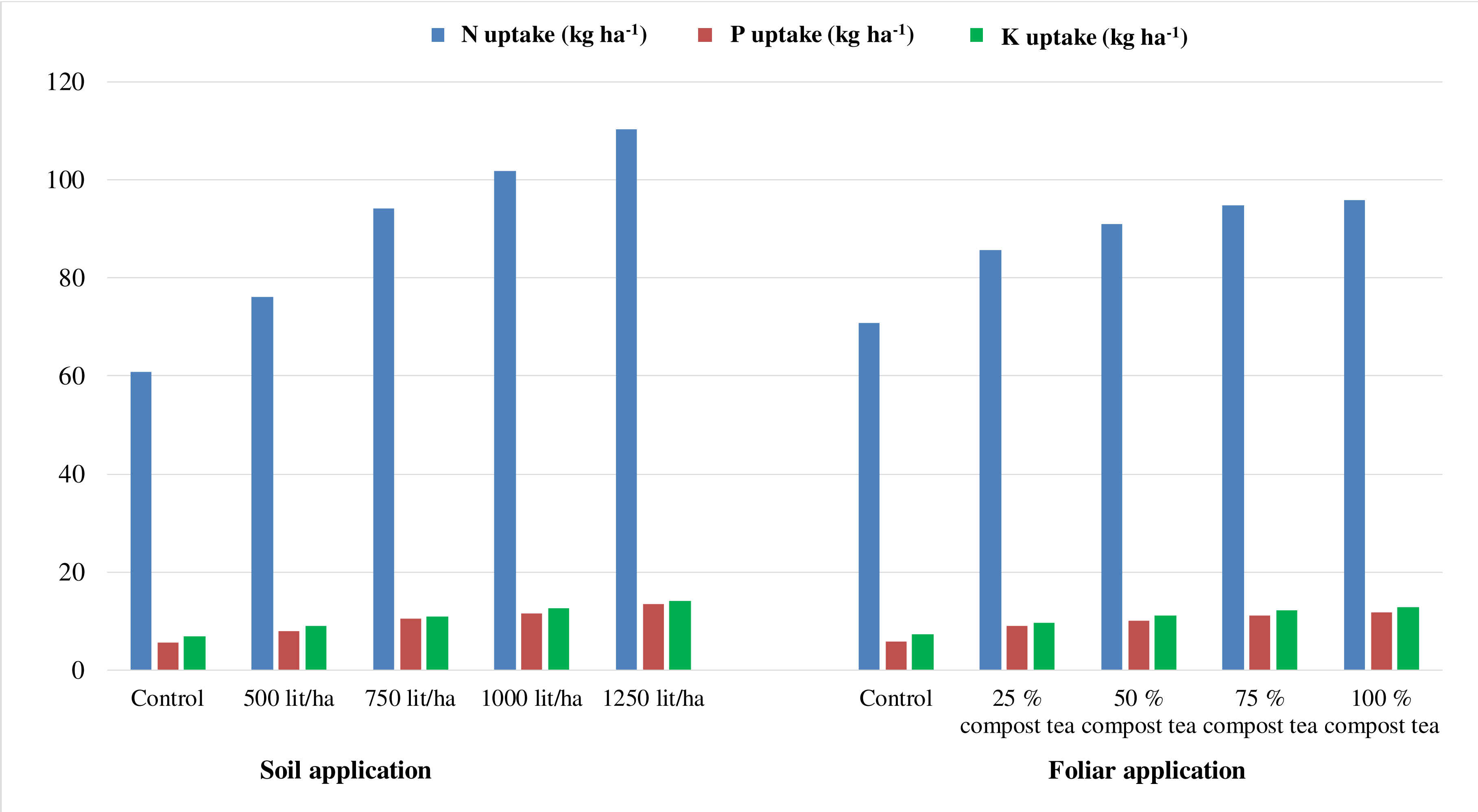


Figure 4.5: Effect of soil and foliar application of compost tea on N, P and K uptake in seeds of soybean

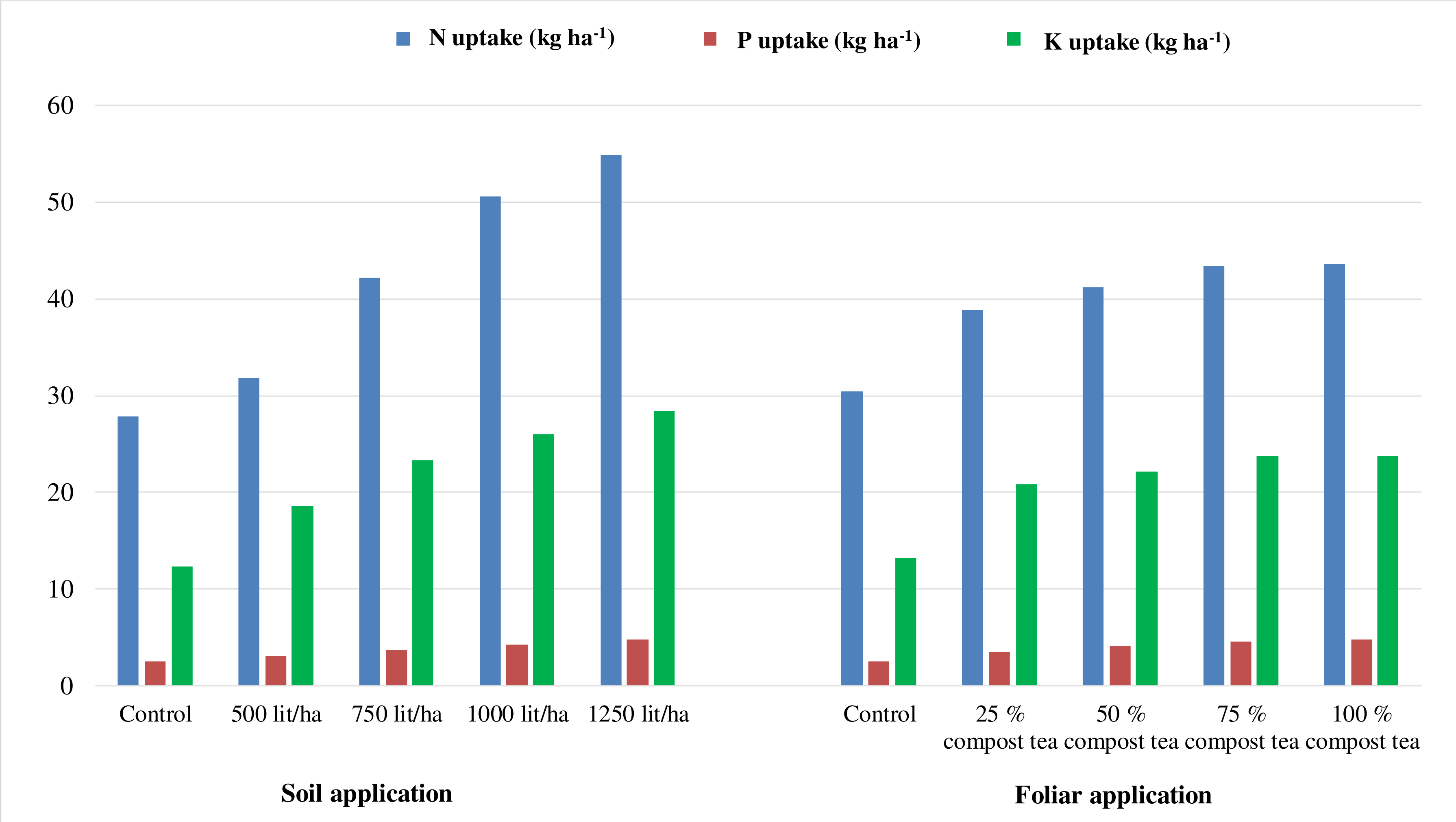


Figure 4.6: Effect of soil and foliar application of compost tea on N, P and K uptake in haulm of soybean

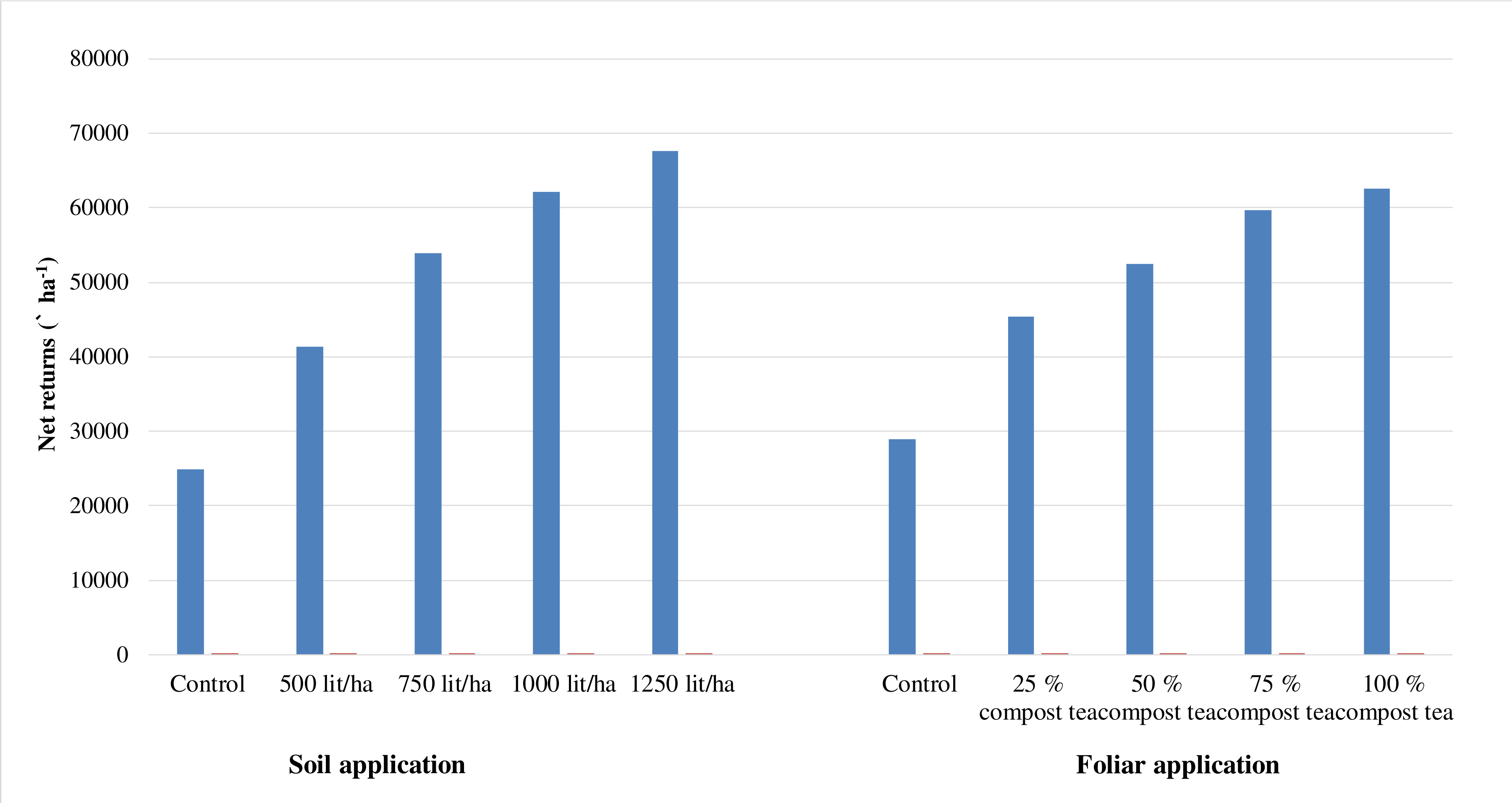


Fig 4.7: Effect of soil and foliar application of compost tea on net returns

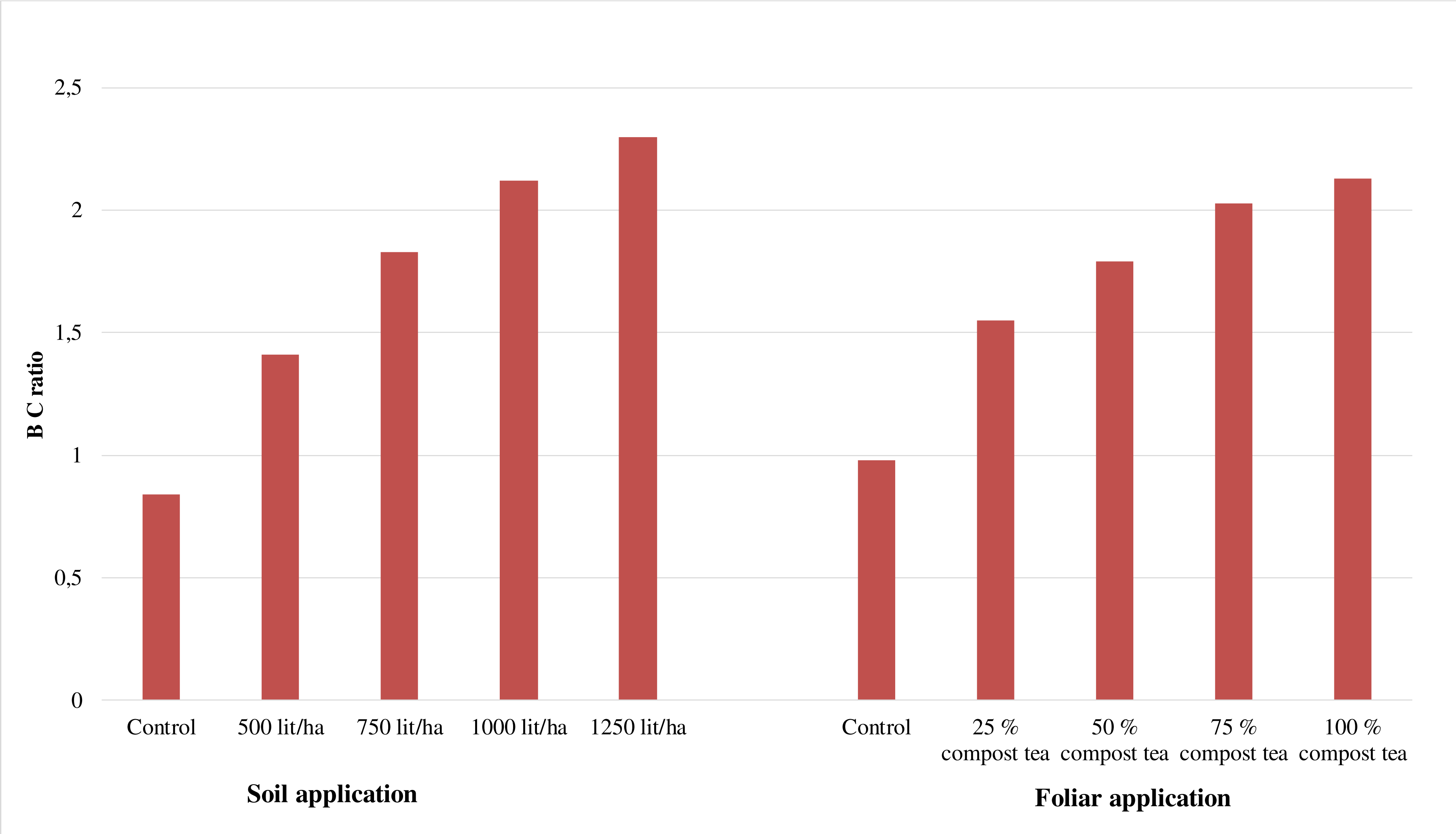


Fig 4.8: Effect of soil and foliar application of compost tea on B C ratio

Table 3.1 Mean weekly meteorological observations during crop period (*kharif* – 2019)

Period	Week No.	Temperature °C		RH (%)		Wind speed (km hr^{-1})	Sunshine (hrs day^{-1})	Total rainfall (mm)	Pan evaporation (mm day^{-1})
		Max	Min	Max	Min				
9 Jul. – 15 Jul.	28	31.8	24.0	71.6	57.8	10.6	5.8	0	6.3
16 Jul. – 22 Jul.	29	33.6	23.7	76.9	55.0	6.1	5.5	34.6	6.7
23 Jul. – 29 Jul.	30	31.5	24.1	81.0	67.6	7.3	4.9	12.6	6.2
30 Jul. – 5 Aug.	31	30.6	22.9	88.4	78.6	3.8	1.7	15.0	2.6
6 Aug. – 12 Aug.	32	28.7	21.9	87.1	78.9	5.6	0.7	182.2	3.3
13 Aug. – 19 Aug.	33	27.6	21.6	90.3	80.0	4.6	1.5	153.0	2.5
20 Aug. – 26 Aug.	34	31.7	21.3	82.9	63.7	3.9	6.3	69.6	5.8
27 Aug. – 2Sep.	35	30.0	21.7	94.3	78.4	3.0	2.0	141.0	4.6
3 Sep. – 9 Sep.	36	30.9	23.3	92.7	84.4	2.4	3.0	85.5	5.8
10 Sep. – 16 Sep.	37	31.2	22.4	87.9	77.6	3.5	1.3	36.1	4.2
17 Sep. – 23 Sep.	38	31.8	21.0	87.7	62.4	3.1	5.2	42.2	4.0
24 Sep. – 30 Sep.	39	29.4	21.8	92.4	73.3	3.9	3.1	14.2	5.2
1 Oct. – 7 Oct.	40	30.2	18.6	89.1	68.0	3.2	5.9	66.4	4.6
8 Oct – 14 Oct	41	31.5	16.3	85.6	62.1	2.2	7.6	18.4	5.1
15 Oct – 21 Oct	42	32.0	16.1	80.1	46.3	2.5	8.2	0	4.5
22 Oct – 28 Oct	43	29.1	13.2	80.6	38.1	3.1	5.6	0	3.5
29 Oct – 4 Nov	44	29.5	17.2	86.1	52	2.5	5.1	12.4	3.4

Source: Agro meteorological observatory, Rajasthan College of Agriculture, Udaipur.

Table 4.1: Effect of soil and foliar application of compost tea on plant population in soybean

Treatment	Plant population (in lakhs ha^{-1})	
	30 DAS	**At harvest**
Soil application (Lit ha^{-1})		
Control	3.03	2.84
500	3.06	2.88
750	3.12	2.82
1000	3.02	2.84
1250	3.03	2.85
S.Em ±	0.03	0.02
C.D (P=0.05)	NS	NS
Foliar application (compost tea)		
Control	3.03	2.80
25 %	3.08	2.83
50 %	3.02	2.84
75 %	3.09	2.85
100 %	3.05	2.89
S.Em ±	0.02	0.02
C.D (P=0.05)	NS	NS

Table 4.2: Effect of soil and foliar application of compost tea on plant height (cm) in soybean

Treatments	Plant height (cm)		
	30 DAS	60 DAS	At harvest
Soil application (Lit ha^{-1})			
Control	29.3	37.3	59.1
500	30.5	40.0	60.5
750	31.4	42.4	62.7
1000	32.7	44.7	65.3
1250	33.3	46.8	68.8
S.Em ±	0.2	0.5	0.5
C.D (P=0.05)	0.6	1.5	1.4
Foliar application (compost tea)			
Control	30.9	38.5	58.4
25 %	31.7	41.3	62.6
50 %	31.5	42.8	64.1
75 %	31.6	44.3	65.6
100 %	31.6	44.3	65.7
S.Em ±	0.2	0.5	0.5
C.D (P=0.05)	0.6	1.5	1.4

Table 4.3: Effect of soil and foliar application of compost tea on dry matter accumulation in soybean

Treatments	Dry matter accumulation (g plant^{-1})		
	30 DAS	60 DAS	At harvest
Soil application (Lit ha^{-1})			
Control	2.03	10.17	19.41
500	2.48	11.07	20.96
750	2.62	12.67	21.89
1000	3.01	13.37	24.23
1250	3.09	15.17	26.67
S.Em ±	0.02	0.24	0.28
C.D (P=0.05)	0.06	0.69	0.78
Foliar application (compost tea)			
Control	2.60	10.87	20.83
25 %	2.66	11.81	22.06
50 %	2.68	12.67	22.85
75 %	2.65	13.37	23.49
100 %	2.65	13.73	23.92
S.Em ±	0.02	0.24	0.28
C.D (P=0.05)	NS	0.69	0.78

Table 4.4: Effect of soil and foliar application of compost tea on crop growth rate in soybean

Treatment	Crop growth rate (g m^{-2} day^{-1})	
	Between 30-60 DAS	Between 60 DAS-Harvest
Soil application (Lit ha^{-1})		
Control	6.94	7.33
500	7.51	7.65
750	7.73	8.07
1000	8.15	8.28
1250	8.56	8.59
S.Em ±	0.07	0.07
C.D (P=0.05)	0.21	0.21
Foliar application (compost tea)		
Control	6.95	7.31
25 %	7.71	7.79
50 %	7.93	8.12
75 %	8.14	8.31
100 %	8.15	8.39
S.Em ±	0.07	0.07
C.D (P=0.05)	0.21	0.21

Table 4.5: Effect of soil and foliar application of compost tea on relative growth rate in soybean

Treatment	Relative growth rate (g g^{-1} day^{-1})	
	Between 30-60 DAS	Between 60 DAS-Harvest
Soil application (Lit ha^{-1})		
Control	0.0448	0.0313
500	0.0489	0.0328
750	0.0459	0.0315
1000	0.0521	0.0321
1250	0.0602	0.0316
S.Em ±	0.0043	0.0012
C.D (P=0.05)	NS	NS
Foliar application (compost tea)		
Control	0.0450	0.0315
25 %	0.0529	0.0297
50 %	0.0573	0.0277
75 %	0.0458	0.0326
100 %	0.0467	0.0315
S.Em ±	0.0043	0.0012
C.D (P=0.05)	NS	NS

Table 4.6: Effect of soil and foliar application of compost tea on number of effective root nodules in soybean

Treatments	Number of effective root nodules plant^{-1}	Chlorophyll content (mg g^{-1} fresh weight)
	60 DAS	60 DAS
Soil application (Lit ha^{-1})		
Control	33.07	2.16
500	34.45	2.29
750	37.07	2.42
1000	38.73	2.67
1250	40.00	2.87
S.Em ±	0.38	0.04
C.D (P=0.05)	1.08	0.13
Foliar application (compost tea)		
Control	33.00	2.24
25 %	35.93	2.38
50 %	37.20	2.51
75 %	38.30	2.64
100 %	38.89	2.65
S.Em ±	0.38	0.04
C.D (P=0.05)	1.08	0.13

Table 4.7: Effect of soil and foliar application of compost tea on yield attributes in soybean

Treatments	Yield attributes			
	No. of primary branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}	1000 Seed weight(g)
Soil application (Lit ha^{-1})				
Control	3.23	23.20	1.79	80.40
500	3.55	26.40	2.01	80.67
750	3.89	29.73	2.21	81.17
1000	4.11	31.93	2.32	81.27
1250	4.24	33.87	2.45	81.47
S.Em ±	0.07	0.24	0.04	0.38
C.D (P=0.05)	0.22	0.69	0.12	NS
Foliar application (compost tea)				
Control	3.38	25.93	1.81	80.13
25 %	3.67	27.87	2.00	80.73
50 %	3.79	29.60	2.18	80.93
75 %	3.99	30.73	2.35	81.50
100 %	4.17	31.00	2.43	81.67
S.Em ±	0.07	0.24	0.04	0.39
C.D (P=0.05)	0.22	0.69	0.12	NS

Table 4.8: Effect of soil and foliar application of compost tea on yield in soybean

Treatments	Yield (kg ha^{-1})			Harvest index (%)
	Seed yield	Haulm yield	Biological yield	
Soil application (Lit ha^{-1})				
Control	934	1701	2635	35.44
500	1213	2261	3474	34.91
750	1417	2749	4166	34.93
1000	1572	2902	4474	35.13
1250	1665	3081	4746	35.08
S.Em ±	17.57	24.67	26.05	0.154
C.D (P=0.05)	49.94	70.15	74.07	NS
Foliar application (compost tea)				
Control	1000	1848	2848	35.11
25 %	1283	2390	3673	34.93
50 %	1407	2587	3994	35.23
75 %	1533	2795	4351	35.23
100 %	1578	2931	4509	34.99
S.Em ±	17.57	24.67	26.05	0.154
C.D (P=0.05)	49.94	70.15	74.07	NS

Table 4.9: Effect of soil and foliar application of compost tea on quality parameters in soybean

Treatment	Quality parameters	
	Protein (%) in seed	Oil (%) in seed
Soil application (Lit ha^{-1})		
Control	38.40	18.41
500	38.53	18.95
750	39.18	19.17
1000	40.01	20.00
1250	40.57	20.59
S.Em ±	0.35	0.18
C.D (P=0.05)	0.99	0.53
Foliar application (compost tea)		
Control	37.73	18.59
25 %	38.77	19.07
50 %	39.47	19.43
75 %	40.23	19.89
100 %	40.49	20.13
S.Em ±	0.35	0.18
C.D (P=0.05)	0.99	0.53

Table 4.10: Effect of soil and foliar application of compost tea on soil parameters in soybean

Treatments	**pH**	**EC (dSm^{-1})**
Soil application (Lit ha^{-1})		
Control	8.03	0.785
500	8.04	0.779
750	7.99	0.787
1000	7.94	0.783
1250	7.98	0.779
S.Em ±	0.03	0.010
C.D (P=0.05)	NS	NS
Foliar application (compost tea)		
Control	8.02	0.766
25 %	8.01	0.773
50 %	8.00	0.785
75 %	7.98	0.793
100 %	7.98	0.794
S.Em ±	0.03	0.010
C.D (P=0.05)	NS	NS

Table 4.11: Effect of soil and foliar application of compost tea on soil microbial biomass in soybean field

Treatments	Soil microbial biomass		
	Bacteria ($\times 10^6$)	Fungi ($\times 10^4$)	Actinomycetes ($\times 10^5$)
Soil application (Lit ha^{-1})			
Control	63.91	22.27	31.89
500	65.17	24.77	33.68
750	66.57	25.95	34.89
1000	67.63	26.81	36.07
1250	69.76	28.27	37.45
S.Em ±	0.37	0.39	0.25
C.D (P=0.05)	1.05	1.11	0.71
Foliar application (compost tea)			
Control	63.10	23.41	32.21
25 %	65.76	24.91	33.79
50 %	67.04	25.77	35.21
75 %	68.15	26.83	36.13
100 %	68.99	27.15	36.63
S.Em ±	0.37	0.39	0.25
C.D (P=0.05)	1.05	1.11	0.71

Table 4.12: Effect of soil and foliar application of compost tea on nutrient content in seeds and haulm of soybean

Treatments	Nutrient content (%)					
	Nitrogen		Phosphorus		Potassium	
	Seed	Haulm	Seed	Haulm	Seed	Haulm
Soil application (Lit ha^{-1})						
Control	5.99	1.24	0.60	0.12	0.69	1.39
500	6.16	1.33	0.65	0.15	0.75	1.47
750	6.26	1.45	0.70	0.16	0.77	1.55
1000	6.40	1.56	0.73	0.19	0.80	1.61
1250	6.47	1.65	0.78	0.20	0.85	1.68
S.Em ±	0.05	0.01	0.02	0.01	0.02	0.02
C.D (P=0.05)	0.16	0.02	0.05	0.03	0.06	0.06
Foliar application (compost tea)						
Control	6.04	1.37	0.63	0.14	0.74	1.45
25 %	6.20	1.41	0.69	0.16	0.76	1.53
50 %	6.30	1.46	0.70	0.19	0.79	1.57
75 %	6.41	1.49	0.71	0.20	0.80	1.58
100 %	6.48	1.50	0.72	0.22	0.82	1.58
S.Em ±	0.05	0.01	0.02	0.01	0.02	0.02
C.D (P=0.05)	0.16	0.02	0.05	0.03	0.06	0.06

Table 4.13: Effect of soil and foliar application of compost tea on nutrient uptake by seeds and haulm in soybean

Treatments	Nutrient uptake (Kg ha^{-1})								
	Nitrogen			Phosphorus			Potassium		
	Seed	Haulm	Total	Seed	Haulm	Total	Seed	Haulm	Total
Soil application (Lit ha^{-1})									
Control	60.80	27.90	81.73	5.55	2.47	8.02	6.91	12.37	19.28
500	76.07	31.87	107.40	8.02	3.03	11.05	9.09	18.61	27.7
750	94.12	42.20	139.00	10.53	3.70	14.23	10.91	23.31	34.22
1000	101.93	50.60	151.60	11.49	4.20	15.69	12.57	26.03	38.60
1250	110.40	54.93	164.00	13.53	4.80	18.33	14.14	28.39	42.54
S.Em ±	2.31	0.83	2.28	0.59	0.16	0.46	0.39	0.57	1.16
C.D (P=0.05)	6.82	2.35	6.49	1.69	0.47	1.33	1.13	1.64	3.30
Foliar application (compost tea)									
Control	70.93	30.47	122.80	5.89	2.48	8.37	7.40	13.24	20.64
25 %	85.67	38.87	127.93	9.01	3.50	12.51	9.75	20.86	30.61
50 %	91.00	41.20	131.67	10.03	4.10	14.63	11.11	22.10	33.21
75 %	94.80	43.33	136.47	11.03	4.60	15.63	12.26	23.73	35.99
100 %	95.93	43.63	136.80	11.70	4.80	16.50	12.93	23.79	36.72
S.Em ±	2.31	0.83	2.28	0.59	0.16	0.46	0.39	0.57	1.16
C.D (P=0.05)	6.82	2.35	6.49	1.69	0.47	1.33	1.13	1.64	3.30

Table 4.14: Effect of soil and foliar application of compost tea on net return and B-C ratio

Treatments	Net return (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Benefit-cost ratio
Soil application (Lit ha^{-1})			
Control	24888	29300	0.84
500 lit/ha	41360	30300	1.41
750 lit/ha	53836	30800	1.83
1000 lit/ha	62117	31300	2.12
1250 lit/ha	67566	31800	2.30
Foliar application (compost tea)			
Control	28864	29300	0.98
25 %	45429	29500	1.55
50 %	52465	29700	1.79
75 %	59657	29900	2.03
100 %	62565	30100	2.13

Appendix I: Analysis of variance for plant population at different growth stages

Source of variation	d.f.	MSS	
		Plant Population (lakhs ha^{-1})	
		30 DAS	At harvest
Replication	2	0.003	0.014
Soil application of compost tea (S)	4	0.023	0.007
Foliar application of compost tea (F)	4	0.016	0.018
S x F	16	0.014	0.018
Error	48	0.010	0.010

* Significant at 5 per cent level of significance

Appendix II: Analysis of variance for plant height at different growth stages

Sources of variation	d.f.	MSS		
		Plant height (cm)		
		30 DAS	60 DAS	At harvest
Replication	2	0.46	0.87	1.26
Soil application of compost tea (S)	4	38.23*	212.07*	222.56*
Foliar application of compost tea (F)	4	1.60	91.25*	137.10*
S x F	16	0.49	7.83	6.19
Error	48	0.62	4.25	3.43

* Significant at 5 per cent level of significance

Appendix III: Analysis of variance for dry matter accumulation at different growth stages

Sources of variation	d.f.	MSS		
		Dry matter accumulation (g $plant^{-1}$)		
		30 DAS	60 DAS	At harvest
Replication	2	0.01	0.55	4.74
Soil application of compost tea (S)	4	2.78*	57.84*	122.20*
Foliar application of compost tea (F)	4	0.1	20.43*	22.55*
S x F	16	0.1	1.42	1.67
Error	48	0.1	0.88	1.17

* Significant at 5 per cent level of significance

Appendix IV: Analysis of variance for root nodules and total chlorophyll content

Sources of variation	d.f.	MSS	
		Root nodules	Total chlorophyll content
		60 DAS	50 DAS
Replication	2	9.09	0.02
Soil application of compost tea (S)	4	125.25*	1.24*
Foliar application of compost tea (F)	4	81.99*	0.43*
S x F	16	3.86	0.06
Error	48	2.16	0.04

* Significant at 5 per cent level of significance

Appendix V: Analysis of variance for yield attributes

Source of variation	d. f.	MSS			
		Yield attributes			
		No. of primary branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}	Test weight
Replication	2	0.1	0.69	0.01	0.36
Soil application of compost tea (S)	4	2.44*	274.59*	1.00*	2.95*
Foliar application of compost tea (F)	4	1.35*	67.69*	0.96*	5.70*
S x F	16	0.15	4.97*	0.05	1.23
Error	48	0.09	0.87	0.03	2.22

* Significant at 5 per cent level of significance

Appendix VI: Analysis of variance for yield

Source of variation	d. f.	MSS			
		Yield (kg ha^{-1})			Harvest index (%)
		Seed	Haulm	Biological	
Replication	2	481.33	4572	1129.33	0.84
Soil application of compost tea (S)	4	1292408.67*	4332022*	10935546.67*	0.67
Foliar application of compost tea (F)	4	804425.33*	2480205*	5033803.33*	0.29
S x F	16	42399.50*	145713	283545.83	0.51
Error	48	4627.17	9130	10180.72	0.36

* Significant at 5 per cent level of significance

Appendix VII: Analysis of variance for quality parameter

Sources of variation	d.f.	MSS	
		Quality parameters	
		Protein (%)	Oil (%)
Replication	2	0.72	0.45
Soil application of compost tea (S)	4	13.16*	12.14*
Foliar application of compost tea (F)	4	18.86*	3.00*
S x F	16	3.25	0.58
Error	48	1.85	0.34

* Significant at 5 per cent level of significance

Appendix VIII: Analysis of variance for soil properties

Sources of variation	d.f.	MSS	
		pH	EC
Replication	2	0.0023	0.0003
Soil application of compost tea (S)	4	0.0036	0.0007
Foliar application of compost tea (F)	4	0.0009	0.0004
S x F	16	0.0017	0.0004
Error	48	0.0031	0.0004

* Significant at 5 per cent level of significance

Appendix IX: Analysis of variance for soil biological properties

Sources of variation	d.f.	MSS		
		Soil biological properties		
		Bacteria ($\times10^6$)	Fungi ($\times10^4$)	Actinomycetes ($\times10^5$)
Replication	2	2.44	11.35	1.28
Soil application of compost tea (S)	4	76.23*	76.95*	68.85*
Foliar application of compost tea (F)	4	79.76*	34.53*	48.51*
S x F	16	3.70	3.69	1.71
Error	48	2.05	2.27	0.95

* Significant at 5 per cent level of significance

Appendix X: Analysis of variance for nitrogen content in soybean

Source of variation	d.f.	MSS	
		Nitrogen content (%)	
		Seed	Haulm
Replication	2	0.23	0.0003
Soil application of compost tea (S)	4	0.319*	0.4266*
Foliar application of compost tea (F)	4	0.453*	0.0393*
S x F	16	0.080	0.0012
Error	48	0.050	0.0009

* Significant at 5 per cent level of significance

Appendix XI: Analysis of variance for phosphorus content in soybean

Source of variation	d.f.	MSS	
		Phosphorus content (%)	
		Seed	Haulm
Replication	2	0.001	0.001
Soil application of compost tea (S)	4	0.073*	0.175*
Foliar application of compost tea (F)	4	0.011*	0.035*
S x F	16	0.007	0.003
Error	48	0.004	0.002

* Significant at 5 per cent level of significance

Appendix XII: Analysis of variance for potassium content in soybean

Source of variation	d.f.	MSS	
		Potassium content (%)	
		Seed	Haulm
Replication	2	0.023	0.007
Soil application of compost tea (S)	4	0.193*	0.028*
Foliar application of compost tea (F)	4	0.047*	0.009*
S x F	16	0.010	0.007
Error	48	0.009	0.005

* Significant at 5 per cent level of significance

Appendix XIII: Analysis of variance for nitrogen uptake in soybean

Sources of variation	d.f.	MSS Nitrogen uptake (kg ha^{-1}) at harvest		
		Seed	Haulm	Total
Replication	2	58.61	2.47	51.05
Soil application of compost tea (S)	4	8478.77*	2615.68*	20592.90*
Foliar application of compost tea (F)	4	666.278*	173.77*	526.97*
S x F	16	159.24	18.51	86.70
Error	48	86.28	10.22	78.04

* Significant at 5 per cent level of significance

Appendix XIV: Analysis of variance for phosphoru uptake by soybean

Sources of variation	d.f.	MSS Phosphorus uptake (kg ha^{-1}) at harvest		
		Seed	Haulm	Total
Replication	2	8.08	0.85	1.36
Soil application of compost tea (S)	4	144.72*	257.43*	957.41*
Foliar application of compost tea (F)	4	28.82*	2.93*	21.39*
S x F	16	5.88	0.71	3.74
Error	48	5.36	0.42	3.30

* Significant at 5 per cent level of significance

Appendix XV: Analysis of variance for potassium uptake by soybean

Sources of variation	d.f.	MSS		
		Potassium uptake (kg ha^{-1}) at harvest		
		Seed	Haulm	Total
Replication	2	1.81	4.07	31.56
Soil application of compost tea (S)	4	609.99*	573.96*	2121.72*
Foliar application of compost tea (F)	4	79.94*	57.60*	199.96*
S x F	16	9.27	3.36	10.65
Error	48	5.04	2.37	20.27

* Significant at 5 per cent level of significance

Appendix XVI: Analysis of variance for economics

Source of variation	d.f.	MSS	
		Net return (₹ ha^{-1})	B-C ratio
Replication	2	1867146	0.0008
Soil application of compost tea (S)	4	705281423*	0.308*
Foliar application of compost tea (F)	4	743199381*	0.332*
S x F	16	97859739	0.044
Error	48	170204732	0.076

* Significant at 5 per cent level of significance

Appendix XVII: Cost of cultivation and prices used to compute economics of soybean crop

S.No.	Particulars	Unit cost (₹)	Cost ha^{-1} (₹)
A.	**Common cost of cultivation**		
1.	Field preparation (Tractor) 4 hrs.	400 hr^{-1}	1600
2.	Layout, bunding and sowing (6 man-day)	350 $manday^{-1}$	2100
3.	NADEP compost (2.5 tonnes ha^{-1})	2500 ton^{-1}	6250
4.	Seed (80 kg ha^{-1})	55 kg^{-1}	4400
5.	Sowing (3 man-days)	350 $manday^{-1}$	1050
6.	Weeding (2), (10 man-days for first and 4 man-days for second)	350 hrs^{-1}	4900
7.	Compost tea (2 spray) (2 man-days per spray)	350 $manday^{-1}$	1400
8.	Neem seed kernel extract (5 %) @ 20 kg ha^{-1}	30 kg^{-1}	600
9.	Harvesting (15 man-days)	350 day^{-1}	5250
10.	Threshing and winnowing (5 man-days)	350 day^{-1}	1750
	Total		**29300**
B.	**Cost of treatments**		
	Soil application of compost tea		
	a. Control (Water spray)	--	--
	b. Compost Tea 500 lit ha^{-1}	2 lit^{-1}	1000
	c. Compost Tea 750 lit ha^{-1}	2 lit^{-1}	1500
	d. Compost Tea 1000 lit ha^{-1}	2 lit^{-1}	2000
	e. Compost Tea 1250 lit ha^{-1}	2 lit^{-1}	2500
	Foliar application of compost tea		
	a. Control (Water Spray)	--	--
	b. Compost Tea 25%	2 lit^{-1}	200
	c. Compost Tea 50%	2 lit^{-1}	400
	d. Compost Tea 75%	2 lit^{-1}	600
	e. Compost Tea 100%	2 lit^{-1}	800
C.	**Price of produce**		
	Seed	48 kg^{-1}	
	Haulm	5.5 kg^{-1}	

Appendix XVIII: Economic evaluation of treatment for soybean

Treatments	Cost of cultivation (₹ ha^{-1})	Net Return (₹ ha^{-1})	B C Ratio
S_1F_1	29300	18532	0.63
S_1F_2	29500	23986	0.81
S_1F_3	29700	24470	0.82
S_1F_4	29900	28330	0.94
S_1F_5	30100	31108	1.03
S_2F_1	30300	24747	0.81
S_2F_2	30500	40271	1.32
S_2F_3	30700	42559	1.38
S_2F_4	30900	48153	1.55
S_2F_5	31100	48102	1.54
S_3F_1	30800	29597	0.96
S_3F_2	31000	46431	1.49
S_3F_3	31200	58176	1.86
S_3F_4	31400	60631	1.93
S_3F_5	31600	65680	2.07
S_4F_1	31300	33343	1.06
S_4F_2	31500	56903	1.80
S_4F_3	31700	66409	2.09
S_4F_4	31900	72206	2.26
S_4F_5	32100	73550	2.29
S_5F_1	31800	34455	1.08
S_5F_2	32000	56261	1.75
S_5F_3	32200	65549	2.03
S_5F_4	32400	83581	2.57
S_5F_5	32600	85325	2.61