RESPONSE OF FOXTAIL MILLET (*Setaria italica*) VARIETIES TO INTEGRATED NUTRIENT MANAGEMENT

IPSITA SAHOO

B.Sc. (Ag.)

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RESPONSE OF FOXTAIL MILLET (*Setaria italica*) VARIETIES TO INTEGRATED NUTRIENT MANAGEMENT

BY

IPSITA SAHOO

B.Sc. (Ag.)

THESIS SUBMITTED TO THE PROFESSOR JAYASHANKAR TELANGANA STATE AGRICULTURAL UNIVERSITY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF

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CHAIRPERSON: Dr. P. SATISH

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PROFESSOR JAYASHANKAR TELANGANA STATE AGRICULTURAL UNIVERSITY

RAJENDRANAGAR, HYDERABAD - 500 030

2020

DECLARATION

I, Ms. **IPSITA SAHOO**, hereby declare that the thesis entitled **"RESPONSE OF FOXTAIL MILLET (*Setaria italica*) VARIETIES TO INTEGRATED NUTRIENT MANAGEMENT"** submitted to the **Professor Jayashankar Telangana State Agricultural University** for the degree of **Master of Science in Agriculture** in the major field of **Agronomy**, is the result of original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

Ipsita Sahoo

Place : RAJENDRANAGAR **(IPSITA SAHOO)**

Date : **ID. No: RAM/2018-17**

CERTIFICATE

Ms. **IPSITA SAHOO** has satisfactorily prosecuted the course of research and that thesis entitled "**RESPONSE OF FOXTAIL MILLET (*Setaria italica*) VARIETIES TO INTEGRATED NUTRIENT MANAGEMENT**" submitted, is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by her for a degree of any University.

Date : **(Dr. P. SATISH)**

Place : **Chairperson**

CERTIFICATE

This is to certify that the thesis entitled **"RESPONSE OF FOXTAIL MILLET (*Setaria italica*) VARIETIES TO INTEGRATED NUTRIENT MANAGEMENT"** submitted in partial fulfillment of the requirements for the award of degree of "**Master of Science in Agriculture**" in AGRONOMY to the Professor Jayashankar Telangana State Agricultural University, Hyderabad, is a record of the bonafide original research work carried out by Ms. IPSITA SAHOO under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all assistance and help received during the course of the investigations have been duly acknowledged by the author of the thesis.

Thesis Approved by the Student Advisory Committee

Chairperson : **Dr. P. SATISH**

Assistant Professor

Department of Agronomy

College farm, College of Agriculture, PJTSAU

Rajendranagar, Hyderabad-500030 ________________

Member : **Dr. S. A. Hussain**

Professor

Department of Agronomy

College farm, College of Agriculture, PJTSAU

Rajendranagar, Hyderabad-500030 ________________

Member : **Dr. S. Harish Kumar Sharma**

Professor

Department of Soil Science and Agricultural Chemistry

College of Agriculture, PJTSAU

Rajendranagar, Hyderabad-500030 ________________

Date of final viva-voce:

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Ipsita Sahoo

Date:

Place: **(Ipsita Sahoo)**

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LIST OF SYMBOLS AND ABBREVATIONS

%	:	Per cent
@	:	At the rate of
B.D.	:	Bulk Density
$^{\circ}$C	:	Degree Celsius
CD	:	Critical Difference
Cm	:	Centimetre
DAS	:	Days After Sowing
dS m^{-1}	:	Decisiemen per metre
EC	:	Electrical Conductivity
et al.,	:	And others people
etc.	:	And so on
Fig.	:	Figure
FYM	:	Farmyard manure
g	:	Gram
g cm^{-3}	:	Gram per cubic metre
GDD	:	Growing degree days
ha	:	Hectare
HI	:	Harvest index
i.e.,	:	That is
INM	:	Integrated nutrient management
kg ha^{-1}	:	Kilograms per hectare
K_2O	:	Potassium
l	:	Litre
LAI	:	Leaf Area Index

m	:	Metre
$metre^{-1}$	:	Per metre
mm	:	Milli metre
m^2	:	Metre square
MJ	:	Mega Joules
N	:	Nitrogen
NS	:	Non-Significant
OC	:	Organic Carbon
P_2O_5	:	Phosphorous
P.D.	:	Particle Density
pH	:	Negative logarithm of Hydrogen ion concentration
$Plant^{-1}$	:	Per plant
$Panicle^{-1}$	:	Per panicle
RDF	:	Recommended dose of fertilizer
RDN	:	Recommended dose of nitrogen
q ha^{-1}	:	Quintals per hectare
Rs. ha^{-1}	:	Rupees per hectare
SEm±	:	Standard error of mean
t ha^{-1}	:	Tonnes per hectare
T max	:	Maximum temperature
T min	:	Minimum temperature
viz.,	:	Namely
W.H.C.	:	Water Holding Capacity

ABSTRACT

Author	:	**IPSITA SAHOO**
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A field experiment entitled "Response of foxtail millet (*Setaria italica*) varieties to integrated nutrient management" was conducted during *kharif*, 2019 at College farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad. The soil was sandy loam in texture, neutral in soil reaction, low in available nitrogen and organic carbon, low in available phosphorus and high in available potassium. Experiment was carried out with two varieties *viz.*, SiA 3085 (C_1) and SiA 3156 (C_2) as first factor and seven integrated nutrient management practices *viz.*, Control (100% RDF - 40-20-20 kg NPK ha^{-1}) (T_1), 25% RDN through Vermicompost + 75% RDF (T_2), 25% RDN through Farm Yard Manure + 75% RDF (T_3), 25% RDN through Sheep Manure + 75% RDF (T_4), 50% RDN through Vermicompost + 50% RDF (T_5), 50% RDN through FYM + 50% RDF (T_6), 50% RDN through Sheep Manure + 50% RDF (T_7) as second factor comprising fourteen treatment combinations, laid out in randomized block design with factorial concept, replicated thrice.

Influence of the different varieties, application of integrated nutrient management and their interaction had no significant effect on initial and final plant population. Growth parameters *viz.*, plant height, number of tillers m^{-2} and dry matter production were found to be non-significant with the choice of varieties. Days to 50% flowering remained non-significant in response to varieties and integrated nutrient management practices.

Among the two varieties, at all the stages of observation, SiA 3085 (C_1) produced significantly higher LAI compared to the other variety *viz.*, SiA 3156 (C_2).

With respect to integrated nutrient management, 25% RDN through Vermicompost + 75% RDF (T_2) had shown significantly higher plant height, leaf area index, number of tillers m^{-2} and dry matter production among all the combinations of organic and inorganic treatments and control (100% RDF), except 50% RDN through Vermicompost + 50% RDF (T_5), which was statistically at par with it.

Yield attributes *viz.*, length of panicle, number of grains panicle^{-1}, number of filled grains panicle^{-1} were found to be higher with the variety SiA 3085 (C_1) compare to the other variety *viz.*, SiA 3156 (C_2). Whereas the number of panicles m^{-2}, test weight, grain yield and straw yield remained non-significant with the choice of varieties.

As regard to integrated nutrient management, number of panicles m^{-2} (45), length of panicle (25.4 cm), number of grains panicle^{-1} (2327), number of filled grains panicle^{-1} (2200), test weight (3.26 g), grain yield (2324 kg ha^{-1}) and straw yield (4353 kg ha^{-1}) were found significantly higher with 25% RDN through Vermicompost + 75% RDF (T_2) over other combinations of organic and inorganic treatments as well as control (100% RDF) and was statistically at par with 50% RDN through Vermicompost + 50% RDF (T_5). Harvest index remained non-significant with respect to both varieties and integrated nutrient management practices.

Application of 25% RDN through Vermicompost + 75% RDF recorded significantly higher nitrogen, phosphorous and potassium uptake at 30, 60 DAS and at harvest (grain and straw) over all other combinations of integrated nutrient management and control (100% RDF), however it was on par with 50% RDN through Vermicompost + 50% RDF (T_5). Both the varieties were equally effective in nutrient uptake in response to INM.

Organic carbon content in soil after harvest of the crop was found to be maximum with 50% RDN through Vermicompost + 50% RDF (T_5) and was on par with other combinations of 50% inorganic + 50% organic treatments as well as 25% RDN through Vermicompost + 75% RDF (T_2). Maximum value of available nitrogen, phosphorus and potassium in post-harvest soil were also observed with 50% RDN through Vermicompost + 50% RDF (T_5). There was no significant effect of varieties on any of these properties of post-harvest soil.

Higher values of gross returns (37467 Rs. ha^{-1}), net returns (22345 Rs. ha^{-1}) and benefit cost (B:C) ratio (2.48) were obtained with application of 25% RDN through Vermicompost + 75% RDF (T_2).

In conclusion, the study has revealed that higher productivity of foxtail millet could be obtained with cultivation of any of the two varieties SiA 3085 and SiA 3156 with application of 25% RDN through Vermicompost + 75% RDF and 50% RDN through Vermicompost + 50% RDF (T_5).

Chapter I

INTRODUCTION

In recent years there has been a steady increase in recognition of the importance of small millets as a substitute for major cereal crops to ensure food security to the younger generations. Most important cause for giving such priority to millets is the changing climatic scenario *viz.,* global warming, water scarcity etc. coupled with health disorders. Being drought, temperature and pest tolerant crops, small millets are considered as the grains for the future. Currently, they sustain the livelihood of over 60 per cent of small and marginal farmers of arid areas in the world. During the last four decades, small millets, which were the nutritious crops were substantially replaced by the major cereals. Since, there has been stagnation in the yield of major cereals, it is time to exploit the underutilized crops like foxtail millet, barnyard millet and little millet etc.

Foxtail millet (*Setaria italica* L.) is known as Italian millet, German millet, Korralu, Kangu, Kangani, Koni and Kaon in different parts of India. It is one of the oldest crop cultivated for grain, hay and pasture. It is native to China and regarded as an elite drought–tolerant crop (Cheng and Liu, 2003). This crop ranks second in the total world production of millets and it continues to have an important place in world agriculture providing food for millions of people in arid and semiarid regions. In India it is largely grown in Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, Uttar Pradesh and Southern Rajasthan. It is mostly consumed by the rural/tribal population of warmer region.

It is generally grown as a rainfed crop in India. It has an erect leafy stem that grows 60-75 cm tall and droop a little at maturity due to heavy weight of ear head. It can be cultivated under diverse conditions of soil, temperature, rainfall and occupies niches where option for diversification of crop is less. Also it has been ideal for early, normal and even late sown conditions.

In 100 g of foxtail millet grain contains excellent source of good fiber 8 g, protein 12.3 g, carbohydrates 60.9 g, fat 4.3 g, calcium 31 mg, Iron 2.8 mg, phosphorus 290 mg, vitamins 3.3 g, amino acids, minerals 3.3 g and food energy 323-350 K Cal (Vanithasri *et al.,* 2012). It is a rich source of protein, iron and β-carotene, which is a precursor of Vitamin A (Murugan and Nirmalakumari, 2006). Unlike rice, foxtail millet releases glucose steadily without affecting the metabolism of the human body has low glycemic index (Thathola *et al*., 2010). Thus it is used for preparation of low glycemic index biscuits and burfi (a sweet product) and also it is an ideal food for people suffering from diabetes. Hence the demand for foxtail millet is increasing in recent years.

Improvement and maintenance of soil quality is necessary for enhancing and sustaining agricultural production, which is of utmost importance for India's food and nutritional security. As a result of burgeoning population pressure, the demand for food, fodder, fiber, fuel etc. is increasing day by day. To meet the future demand, better planning and resource management is necessary. One of the way to achieve this goal is to raise productivity through improved varieties along with following production technology to sustain soil fertility and crop productivity in future.

Now a days, use of chemical or inorganic fertilizers is increasing to boost up crop production but it may lead to adverse effect on long term usage like deterioration of soil structure, soil health and environmental pollution and along with this the cost of chemical fertilizers is also increasing constantly. High production cost and reliance on loans to purchase inputs are the major risks especially in rainfed areas where yields are uncertain (Eyhorn *et al*., 2007).

Use of organic manure alone, as a substitute to inorganic fertilizer is not realistic and profitable as it may not be capable to maintain present level crop productivity of high yielding varieties and meet the increasing food requirement. Application of organic manures along with inorganic fertilizers to soil increases the productivity of the system and also sustains the soil health for a longer period (Gawai and Panwar, 2007). Thus integration of inorganic and organic fertilizers plays a vital role for enhancing crop productivity and sustaining soil fertility and proves as a great promise for farmers.

Organic manures like vermicompost and FYM are good sources of macro and micro plant nutrients. They also improve the availability of nutrients present in soil and improve the microbial activity and physical properties of the soil.

The soils in arid and semiarid regions are mainly deficient in nitrogen and inherently low in organic carbon because of rapid turnover rates of organic material due to higher soil temperature. With harsh climatic conditions and low soil fertility, effective nutrient management is of considerable importance to overcome the situations of limited yields in these areas. The low productivity in farmers' field in foxtail millet can be increased by adopting improved production technologies like integrated nutrient management. Integrated nutrient management includes the intelligent use of organic, inorganic and biological resources to sustain optimum yields, improve or maintain the soil physical and chemical properties and provide crop nutrition packages which are technically sound, economically attractive, practically feasible and environmentally safe (Tandon., 1995) .

Hence integrated nutrient supply system involving organic manures like vermicompost, sheep manure, FYM in conjunction with chemical fertilizers is a need of the time to meet the nutrient demand besides improving physico-chemical properties of soil. The newly evolved varieties of foxtail millet have high yielding potential and require high nutrient applications, varieties of different durations also may require different doses of nutrients. Since information pertaining to nutrient management in foxtail millet varieties is meager, the present investigation was carried out to study the effect of integrated nutrient management on growth, nutrient uptake and productivity of foxtail millet with following objectives.

Objectives:

- To study the growth and performance of foxtail millet varieties with different organic and inorganic sources of nutrients.
- To find out the optimal combination of organic and inorganic sources of nutrients for foxtail millet varieties.
- To work out economics of foxtail millet varieties in relation to integrated nutrient management.

Chapter II

REVIEW OF LITERATURE

In order to elucidate importance of maintaining optimum fertility status of soils through application of organic and inorganic fertilizers for foxtail millet an attempt has been made to review the research work done by various workers on individual or combined effect of inorganic fertilizers, farmyard manure, vermicompost, sheep manure on various growth parameters, yield attributes, yield, nutrient uptake and economics. Since the available literature suggest meagre information on foxtail millet, combined and individual use of organic and inorganic fertilization literature on the pearl millet, finger millet, proso millet, barnyard millet and little millet etc. were included in this chapter which were considered as millets of same growing pattern, generally grown during *kharif* under rainfed conditions.

2.1 GROWTH AND YIELD ATTRIBUTES OF MILLETS AS INFLUENCED BY VARIETIES

2.1.1 Growth parameters

2.1.1.1 Plant height

Divya *et al*. (2017) observed that highest plant height recorded with PHB-3 (C3) which was significantly higher than Dhanashakti and ICMV 221 in summer pearl millet at Rajendranagar, Hyderabad on sandy loam soils grown during summer.

Jyothi *et al*. (2016) conducted an experiment on foxtail millet varieties on sandy loam soils at Tirupati, Andhra pradesh found that the tallest plants were produced by the variety SiA 3156 followed by SiA 3085 without any significant difference between them, at all the crop growth stages, while the shortest plants were produced by SiA 3088.

Saini and Thakur (1997) found that among the three little millet varieties (Co-2, Local, BAU 2) tested, the local variety produced the tallest plants while Co-2 produced the smallest plants on sandy loam soils of Leo, Himachal Pradesh during summer season.

Saini and Negi (1996) inferred that significantly higher plant height was recorded with the foxtail millet varieties HKC 9 and HKC 6 compared to HKC 8 and local genotypes tried in sandy loam soils, during summer season at Millet Research Station, Leo, Himachal Pradesh.

Intodia (1994) conducted a study on medium black soils of Chittorgarh, Rajasthan on the performance of foxtail millet cultivars *viz.,* SR 11, SR 16 and SiA 326 found that SiA 326 produced the maximum plant height compared to SR 11 and SR 16.

2.1.1.2 Dry matter production

Significantly higher dry matter production was recorded with PHB-3 which was higher than Dhanashakti and ICMV 221 in summer pearl millet in an experiment conducted by Divya *et al*. (2017) on sandy loam soils at Rajendranagar, Hyderabad.

Jyothi *et al*. (2016) observed that highest dry matter production in foxtail millet was recorded with the variety SiA 3085 which was however comparable with that of SiA 3156 and the lowest with SiA 3088 on sandy loam soils at Tirupati.

Local variety of little millet resulted in higher dry matter accumulation as compared to PRC-3 variety in sandy loam soils of Dharwad, Karnataka (Raghavendra and Halikatti, 1998).

Intodia (1994) observed that dry matter production was significantly higher with genotype SiA 326 over SR 11 and SR 16 genotypes on black soils of Chittorgarh, Rajasthan.

2.1.1.3 Number of tillers m^{-2}

Effective number of tillers m^{-2} recorded with PHB-3 were higher than Dhanashakti and ICMV 221 in summer pearl millet in an experiment conducted by Divya *et al*. (2017) at Rajendranagar, Hyderabad.

Jyothi *et al.* (2016) observed that total number of tillers m^{-2} were not significantly influenced by the varieties in foxtail millet on sandy loam soils at Tirupati.

Among the six kodo millet varieties tested, maximum number of tillers m^{-2} were recorded with GPUK 3 variety while the minimum number of tillers m^{-2} were recorded with the variety, RK 106 at Rewa, Madhya Pradesh on sandy loam soils (Divya and Maurya, 2013).

Saini and Thakur (1997) opined that the little millet variety, BAU 2 produced the highest number of tillers m^{-2} than local and Co-2 varieties in sandy loam soils of Leo, Himachal Pradesh during summer season.

2.1.1.4 Leaf area index

Saini and Negi (1996) conducted an experiment on sandy loam soils of Leo, Himachal Pradesh and observed that HKC 9 recorded significantly higher LAI compared to other genotypes tried during summer season.

Intodia (1994) conducted a trail with four genotypes at Chittorgarh, Rajasthan on medium black soils revealed that the genotype, SR 326 produced significantly higher LAI compared to SR 11and SR 16 genotypes.

2.1.1.5 Days to 50 per cent flowering

Jyothi *et al*. (2016) conducted an experiment on foxtail millet recorded days to 50 per cent flowering was minimum with foxtail millet variety, SiA 3088 and these parameters were maximum with Srilaxmi on sandy loam soils at Tirupati.

Yadav and Yadav (2013) observed that among the barnyard millet varieties tested (VL -207, VL-172, PRB 401, PRJ 1), the maximum number of days to 50 per cent flowering was recorded with VL-172 while the minimum number of days to 50 per cent flowering was registered with PRJ 1, on silty clay loam soils of Ranichauri, Uttarakhand.

2.1.2 Yield Attributes

2.1.2.1 Number of panicles m^{-2}

Divya *et al*. (2017) found that the number of effective tillers m^{-2} in summer pearl millet were highest with PHB-3 which was significantly higher than Dhanashakti and ICMV 221 at Rajendranagar, Hyderabad.

Jyothi *et al*. (2016) revealed that the number of panicles m^{-2} at harvest were found to be non-significant with the choice of variety in foxtail millet during *kharif*, 2014 on sandy loam soils of Tirupati.

Divya and Maurya (2013) found that GPUK 3 variety of kodo millet recorded significantly higher number of panicles m^{-2} compared to the other varieties tried (RK-65, RK-80, RK-92,RK-48 and RK106) in an experiment conducted at Rewa, Madhya Pradesh on sandy loam soils.

Saini and Negi (1996) observed that the cultivars HKC 6 and HKC 9 were resulted in higher number of effective tillers m^{-2} compared to HKC 8 and Local genotypes) conducted a field experiment on sandy loam soils of Leo, Himachal Pradesh during summer season.

Gurunadha Rao *et al*. (1990) in a study conducted on clay loam soils of Nandyal, Andhra Pradesh observed that SiA 326 recorded significantly more number of productive shoots m^{-2} over other varieties of foxtail millet.

2.1.2.2 Length of panicle

In a trial with three pearl millet varieties on sandy loam soils at Rajendranagar, Hyderabad during summer, the highest ear head length was recorded with PHB-3 which was significantly higher than Dhanashakti and ICMV 221 (Divya *et al*., 2017).

Jyothi *et al.* (2016) conducted an experiment in foxtail millet during *kharif* on sandy loam soils at Tirupati, found that maximum panicle length was registered with the variety SiA 3085 which was significantly superior to the other varieties tried, while the shortest panicle length was observed with SiA 3088 variety.

In an experiment with three little millet varieties (Co-2, Local, BAU 2) at Leo, Himachal Pradesh during summer season on sandy loam soils, the highest panicle length was reported with BAU 2 over the other varieties tested (Saini and Thakur, 1997).

Saini and Negi (1996) in a trail with four genotypes of foxtail millet conducted at Millet Research Station, Leo, Himachal Pradesh during summer season noticed that genotypes, HKC 9 and HKC 6 produced significantly higher panicle length compared to HKC 8 and local genotypes.

Intodia (1994) conducted a field experiment on medium black soils of Chittorgarh, Rajasthan and observed that the genotype, SiA 326 produced significantly the longest panicles compared to SR 11 and SR16.

2.1.2.3 Number of grains panicle^{-1}

Divya *et al*. (2017) observed that the number of grains per ear head were maximum with PHB-3 and it was significantly higher than the other two varieties *i.e.,* Dhanashakti and ICMV 221 on sandy loam soils of Rajendranagar, Hyderabad.

2.1.2.4 Number of filled grains panicle^{-1}

Jyothi *et al*. (2016) found that the foxtail millet variety SiA 3085 recorded highest number of filled grains panicle^{-1} and was statistically at par with that of SiA 3156, while the lowest were number of filled grains panicle^{-1} was produced with SiA 3088 and was comparable with that of the variety Srilaxmi.

In an experiment with six kodo millet varieties conducted at Rewa, Madhya Pradesh, the highest number of grains panicle^{-1} were recorded with RK 106 compared to the other varieties tried on sandy loam soils (Divya and Maurya, 2013).

2.1.2.5 Test Weight

Foxtail millet variety SiA 3085 recorded highest value of thousand grain weight, which was statistically at par with that of SiA 3156 and the lowest value of thousand grain weight was with SiA 3088 which was however comparable with that of the variety Srilaxmi in an experiment conducted by Jyothi *et al*. (2016) on sandy loam soils of Tirupati.

Divya and Maurya, (2013) observed that the maximum test weight was recorded with the varieties GPUK 3 and RK 48 compared to the rest of the kodo millet varieties

(RK-65, RK-80, RK-92, RK-48 and RK106) tried on sandy loam soils of Rewa, Madhya Pradesh.

Saini and Negi (1996) conducted an experiment at Millet Research Station, Leo, Himachal Pradesh on sandy loam soils revealed that the higher 1000-grain weight was obtained with genotypes, HKC 9 and HKC 6 compared to HKC 8 and local genotypes during summer season.

Intodia (1994) conducted an experiment on the performance of three genotypes of foxtail millet on medium black soils at Chittorgarh, Rajasthan observed that the genotype, SiA 326 produced significantly higher test weight compared to rest of the varieties tried.

2.1.2.6 Grain yield

Jyothi *et al*. (2016) observed that the highest grain yield was by the variety SiA 3085 which was however comparable with that of SiA 3156, while grain yield was found to be lowest with Srilaxmi and SiA 3088 with no significant difference between them on sandy loam soils of Tirupati.

Divya and Maurya (2013) conducted an experiment to study the performance of kodo millet varieties (GPUK 3, RK-65, RK-80, RK-92, RK- 48 and RK 106) on the sandy loam soils of Rewa, Madhya Pradesh and observed that the GPUK 3 produced significantly higher grain yield followed by RK -80 and RK- 48.

Munirathnam *et al*. (2006) conducted a study under low fertility conditions of Nandyal, Andhra Pradesh on heavy black soils under rainfed conditions revealed that SiA 2803 variety of foxtail millet performed better with respect to grain yield than the rest of the varieties tried.

Experiment carried out at Leo, Himachal Pradesh on sandy loam soils during summer season revealed that little millet variety BAU 2 recorded the significantly higher grain yield compared to the local and Co-2 varieties (Saini and Thakur, 1997).

Intodia (1994) conducted an experiment on performance of three genotypes of foxtail millet at Chittorgarh, Rajasthan revealed that SiA 326 produced significantly higher grain yield followed by SR 11 with significant disparity between them.

Gurunadha Rao *et al*. (1990) observed that the grain yield of SiA 326 was significantly higher followed by SiA 36 and ISe 377, which were comparable to each other and all of them were significantly superior over the local variety, Arjuna on sandy loam soils of Nandyal, Andhra Pradesh.

2.1.2.7 Straw yield

Divya *et al*. (2017) revealed that highest stover yield in pearl millet was reported with PHB-3 which was significantly higher than the other two varieties Dhanashakti and ICMV 221 on sandy loam soils of Rajendranagar, Hyderabad.

Significantly higher straw yield was produced by the variety SiA 3085 and was on par with SiA 3156, while lowest straw yield was with Srilaxmi and SiA 3088 with no significant difference between them on sandy laom soils of Tirupati, Andhra Pradesh. (Jyothi *et al.*, 2016).

Kodo millet variety GPUK 3 produced significantly higher straw yield compared to the other varieties (RK-65, RK-80, RK-92, RK-48 and RK106) tried at Rewa, Madha Pradesh on sandy loam soils (Divya and Maurya, 2013).

Munirathnam *et al*. (2006) revealed that SiA 2803 variety of foxtail millet recorded significantly higher straw yield than the rest of the varieties tried in heavy black soils of Nandyal, Andhra Pradesh.

Saini and Negi (1996) during the three consecutive years of study conducted at Millet Research Station, Leo, Himachal Pradesh with four foxtail millet varieties *viz.*, HKC 9, HKC 6, HKC 8 and local on sandy loam soils during summer revealed that the significantly highest straw yield was registered with HKC 9 compared to the rest of the varieties tried.

Intodia (1994) inferred that there was no significant difference in straw yield among the foxtail millet genotypes *viz.*, SiA 326, SR11 and SR16 at Chittorgarh, Rajasthan.

2.1.2.8 Nutrient uptake

Divya *et al*. (2017) conducted an experiment during summer on sandy loam soils at Rajendranagar, Hyderabad on three pearl millet varieties found that higher nutrient uptake in grain and stover (N,P, and K) was with PHB-3 and lowest with ICMV 221.

Jyothi *et al*. (2016) observed that the nitrogen and phosphorous uptake was highest with the variety SiA 3085 which was at par with that of SiA 3156 and the potassium uptake was highest with SiA 3085 and all the other three varieties were at par for potassium uptake, while lowest nutrient uptake was obtained with the variety SiA 3088 on sandy loam soils of Tirupati.

2.1.2.9 Economics

Divya *et al*. (2017) observed that highest gross returns, net returns and B:C ratio were obtained with PHB-3 variety of pearl millet while these were reported lowest with ICMV 221 on sandy loam soils of Rajendranagar, Hyderabad.

Jyothi *et al*. (2016) revealed that highest gross returns, net returns and B:C ratio were realized with the variety SiA 3085, while they were found to be the lowest with SiA 3088 among the four varieties of foxtail millet on sandy loam soils of Tiruapti.

Divya and Maurya (2013) observed that the cultivation of GPUK 3 variety of kodo millet realized the highest net returns compared to other varieties tested under rainfed condition on sandy loam soils of Madhya pradesh.

Munirathnam *et al*. (2006) conducted an experiment for the evaluation of foxtail millet varieties under low fertility conditions and recorded that variety SiA 2803 gave the highest net returns compared to other varieties tested under low fertility condition.

2.2 GROWTH AND YIELD ATTRIBUTES OF MILLETS AS INFLUENCED BY INTEGRATED NUTRIENT MANAGEMENT

Since continuous use of inorganic fertilizers injurious to soil health and lowers it's productivity, an integrated approach of combined use of inorganic fertilizers along with organic manures has become an established agro-technique for enhancing yield and restoring soil physical, chemical and biological health.

2.2.1 Growth parameters

2.2.1.1 Plant height

Ojha *et al*. (2018) conducted a study at Lamjung, revealed that highest plant height (165 cm) was observed in treatment FYM 6 t ha^{-1} + 60: 30: 20 kg NPK ha^{-1} compared to all other treatments in foxtail millet.

Thesiya *et al*. (2019) observed that application of 100% RDF significantly increased the growth in terms of plant height in little millet, which was at par with 75% RDN through chemical fertilizer + 25% RDN through vermicompost during pooled analysis in little millet-green gram cropping system at Waghai, Gujarat.

Basavaraj *et al*. (2017) conducted a study during *kharif*, 2014 at Shivamogga, for nutrient management practices for organic cultivation of finger millet (*Eleusine coracana* L.) under southern transitional zone of Karnataka. Among the different treatments, application of farmyard manure (FYM) at 10 t ha^{-1} + Biodigester Liquid Manure Equivalent (BDLME with two splits) at 75 kg N ha^{-1} recorded significantly higher plant height (132.2 cm) as compared to all the treatments and which was on par with control (FYM 7.5 t ha^{-1} + RDF: 50:40:25 kg NPK ha^{-1}) and FYM at 10 t ha^{-1} + BDLME (Two splits) at 50 kg N ha^{-1}.

Ramesh (2017) observed that plant height in foxtail millet was highest in treatment having 125% RDN + FYM @ 5 t ha^{-1} compared to rest of the treatments and was on par with 125% RDN on clay soils at Prakasam, Andhra Pradesh.

Thimmaiah *et al.* (2016) revealed that Recommended NPK + FYM at 7.5 t ha^{-1} + PGPR at 2 kg ha^{-1} + vermicompost and Frond compost both at 3.75 t ha^{-1} as top dress at 25 DAT recorded significantly higher plant height (145.27 cm) in finger millet on red sandy loam soils of Shivamogga, Karnataka.

Jyothi *et al*. (2016) observed that among the nitrogen levels tried, application of 50 kg N ha^{-1} resulted in the highest plant height in foxtail millet while lowest plant height recorded in treatment with no nitrogen application during *kharif* on sandy loam soils of Tirupati.

Giribabu *et al*. (2010) revealed that application of 100% RDF (60:30:20 kg NPK ha^{-1}) + FYM 3 t ha^{-1} significantly increase the plant height (93.9 cm) of finger millet over 75% RDF + FYM 3 t ha^{-1} (88.8 cm) and individual application of FYM (84.3 cm) and 100% RDF (88.5 cm) in a study conducted at Bapatla.

Narolia *et al.* (2009) found that application of 2 t ha^{-1} vermicompost incorporation significantly increased the plant height of pearl millet over the control in loamy sands of Bikaner.

Basavarajappa *et al*. (2002) observed that significant increase in plant height of foxtail millet with enriched FYM + Azospirilllum @ 10 kg ha^{-1} (86.35 cm) over individual application of enriched FYM (84.16 cm) and glyricidia GLM (81.93 cm) in shallow alfisols of Hanumanamathi, Dharwad.

Arunachalam *et al*. (1995) reported that application of 45 kg N ha^{-1} + FYM @ 5 t ha^{-1} produced significantly higher plant height in finger millet over control in both 1989 and 1990 at Killikulam, Tamil Nadu.

Subramanian and Ganesaraja (1992) noticed that highest plant height of foxtail millet with combined application of FYM @ 12.5 t ha^{-1} + 20 kg N ha^{-1} + 10 kg P ha^{-1}

compared to other treatments tested on sandy loam soils of Madurai, Tamil Nadu, during *rabi* season.

2.2.1.2 Dry matter production

Thesiya *et al.* (2019) conducted an experiment on little millet-green gram cropping system at Waghai, Gujarat found that significant increase in dry matter accumulation of little millet with application of 100% RDF, which was at par with 75% RDN through chemical fertilizer + 25% RDN through vermicompost.

Divya *et al.* (2017) reported that maximum dry matter accumulation in pearl millet was found significantly higher in treatment with 75% RDF + biofertilizer @ 5 kg ha^{-1} incubated with vermicompost @ 500 kg ha^{-1} compared to 75% RDF + 25% N through vermicompost and 100% RDF in sandy loam soils of Rajendranagar, Hyderabad.

Ramesh (2017) found that maximum dry matter accumulation in foxtail millet was with the treatment 125% RDN + FYM @ 5 t ha^{-1} compared to rest of the treatments and was on par with 125% RDN on clay soils at Prakasam, Andhra Pradesh.

Thimmaiah *et al.* (2016) observed that Recommended NPK + FYM at 7.5 t ha^{-1} + PGPR at 2 kg ha^{-1} + vermicompost and Frond compost both at 3.75 t ha^{-1} as top dress at 25 DAT recorded significantly higher total dry matter accumulation (59.13 g $plant^{-1}$) in finger millet on red sandy loam soils of Shivamogga, Karnataka during *kharif*, 2014.

Jyothi *et al*. (2016) revealed that among the nitrogen levels tried, application of 50 kg N ha^{-1} resulted in maximum total dry matter production while lowest total dry matter production recorded in treatment with no nitrogen application in foxtail millet during *kharif* on sandy loam soils of Tirupati.

Significantly higher dry matter of 44.3 g $plant^{-1}$ was recorded with conjunctive use of RDF (100:50:50 kg NPK ha^{-1} + 7.5 t FYM ha^{-1}) followed by 37.3 g $plant^{-1}$ of dry matter of finger millet with 100% RDF by Kumar *et al.* (2007).

Naik *et al*. (1995) carried out an experiment on sandy loam soils and revealed that the application of 30 kg N + 15 kg P_2O_5 ha^{-1} to foxtail millet recorded significantly higher dry matter production at 60 DAS and at harvest compared to the rest of the lower level of fertilizers tried at Bangalore, Karnataka.

At Madurai, Tamil Nadu, Subramanian and Ganesaraja (1992) conducted an experiment during *rabi* season and found that combined application of FYM @ 12.5 t ha^{-1} + 20 kg N ha^{-1} + 10 kg P ha^{-1} showed higher dry matter production in foxtail millet compared to other treatments.

2.2.1.3 Number of tillers m^{-2}

Thesiya *et al.* (2019) observed that there was significant increase in number of tillers m^{-2} of little millet with application of 100% RDF, which was at par with 75% RDN through chemical fertilizer + 25% RDN through vermicompost during pooled analysis in little millet-green gram cropping system at Waghai, Gujarat.

Divya *et al*. (2017) observed that maximum number of tillers m^{-2} in pearl millet were found significantly higher in treatment with 75% RDF + biofertilizer @ 5 kg ha^{-1} incubated with vermicompost @ 500 kg ha^{-1} compared to 75% RDF + 25% N through vermicompost and 100% RDF in sandy loam soils of Rajendranagar, Hyderabad.

Naik *et al*. (2017) observed that application of FYM @ 10 t ha^{-1} + Biodigester Liquid Manure Equivalent(BLME) @ 75 kg ha^{-1} recorded highest number of tillers per hill (5.4) compared to FYM @ 5 t ha^{-1} + BLME @ 25 kg ha^{-1} .

Ramesh (2017) observed that number of tillers m^{-2} in foxtail millet were highest in 125% RDN + FYM @ 5 t ha^{-1} compared to rest of the treatments and was on par with 125% RDN on clay soils at Prakasam, Andhra Pradesh.

Thimmaiah *et al.* (2016) found that Recommended NPK + FYM at 7.5 t ha^{-1} + PGPR at 2 kg ha^{-1} + vermicompost and Frond compost both at 3.75 t ha^{-1} as top dress at 25 DAT recorded significantly higher number of tillers (4.07 plant^{-1}) compared to all other treatments in finger millet on red sandy loam soils of Shivamogga, Karnataka.

In an experiment conducted by Patel *et al*. (2014) revealed that maximum number of tillers plant^{-1} (4.83) were with application of 100% RDN through urea and was at par with 100% RDN (75% through urea and 25% through vermicompost) (4.77) in pearl millet at Gujurat during *kharif* season.

In foxtail millet Subramanian and Ganesaraja (1992) found that significantly higher number of tillers m^{-2} were with the basal application of FYM @ 12.5 t ha^{-1} + 20 kg N ha^{-1} + 10 kg P ha^{-1} compared to other treatments tried during *rabi* on sandy clay loam soils of Madurai, Tamil Nadu.

2.2.1.4 Leaf area index

Divya *et al*. (2017) revealed that the leaf area index (LAI) in pearl millet was significantly higher with 75% RDF + Biofertilizer @ 5 kg ha^{-1} incubated with vermicompost @ 500 kg ha^{-1} compared to 75% RDF + 25% N through vermicompost and 100% RDF in sandy loam soils, Hyderabad.

A study conducted by Thimmaiah *et al.* (2016) on red sandy loam soils of Shivamogga, Karnataka observed that Recommended NPK + FYM at 7.5 t ha^{-1} + PGPR at 2 kg ha^{-1} + vermicompost and Frond compost both at 3.75 t ha^{-1} as top dress at 25 DAT recorded significantly higher leaf area (1177.30 cm^2 $plant^{-1}$) compared to all other treatments in finger millet.

Jyothi *et al.* (2016) observed that leaf area index was highest with application of 50 kg N ha^{-1} compared to all other treatments while lowest in treatment with no nitrogen in foxtail millet during *kharif*, in sandy loam soils of Tirupati, Andhra Pradesh.

Intodia (1994) conducted an experiment on medium black soils of Chittorgarh, Rajasthan and revealed that the highest LAI of foxtail millet was obtained with the application of 60 kg N ha^{-1} which was on par with 40 kg N ha^{-1} and both of them were significantly higher compared to the application of 20 and 0 kg N ha^{-1}.

Experiment conducted by Subramanian and Ganesaraja (1992) at Madurai, Tamil Nadu on sandy clay loam soils during *rabi* season revealed that the increase in leaf area of foxtail millet was observed with the basal application of FYM @ 12.5 t ha^{-1} + 20 kg N ha^{-1} + 10 kg P ha^{-1} compared to other treatments.

2.2.1.5 Days to 50% flowering

Divya *et al.* (2017) observed that days to 50% flowering was significantly higher with 75% RDF + Biofertilizer @ 5 kg ha^{-1} incubated with vermicompost @ 500 kg ha^{-1} compared to 75% RDF + 25% N through vermicompost and 100% RDF in pearl millet on sandy loam soils, Hyderabad.

Jyothi *et al.* (2016) revealed that minimum and maximum number of days to 50 per cent flowering was registered with 50 kg N ha^{-1} and no nitrogen application, respectively in foxtail millet during *kharif*, in sandy loam soils of Tirupati, Andhra Pradesh.

Giribabu (2006) observed that flowering occurred much earlier at 70.8 days in 100% RDF (60:30:20 kg NPK ha^{-1}) + 3 t FYM ha^{-1} compared to 73.2, 73.4 and 76.0 days with 75% RDF + 3 t FYM ha^{-1}, 100% RDF and FYM respectively.

2.2.2 Yield attributes

2.2.2.1 Number of panicles m^{-2}

Monisha *et al*. (2019) found that maximum number of productive tillers m^{-2} were with application of 50% RDF + 25% Neem cake N based + 25% biofertilizer (7.2) followed by 50% RDF + 25% Poultry manure N Based + 25% Bio-fertilizer in red soils of Madurai.

Thesiya *et al*. (2019) observed that application of 100% RDF significantly increased the number of panicles per m^2 in little millet, which was at par with 75% RDN through chemical fertilizer + 25% RDN through vermicompost during pooled analysis in little millet-green gram cropping system at Waghai, Gujarat.

Jyothi *et al*. (2016) conducted an experiment in foxtail millet on sandy loam soils at Tirupati during *kharif* recorded that higher number of panicles m^{-2} were recorded with 50 kg N ha^{-1}, while the lower number of panicles m^{-2} were recorded with no nitrogen application.

The results of the experiment conducted by Hasan *et al*. (2013) on sandy loam soils of Mymensingh, Bangladesh revealed that the number of effective tillers $plant^{-1}$ of foxtail millet were not significant with nitrogen level from 0 to 40 kg ha^{-1}.

Saini and Thakur (1997) observed that the number of panicles m^{-2} in little millet increased significantly with increase in nitrogen level up to 60 kg N ha^{-1} in sandy loam soils of Leo, Himachal Pradesh.

Significantly higher number of effective tillers m^{-2} in foxtail millet were observed with application of N up to 60 kg ha^{-1} over no nitrogen in sandy loam soils (Saini and Negi, 1996).

Gurunadha Rao *et al*. (1983) observed that the level and time of nitrogen application had a beneficial effect in producing number of effective tillers m^{-2} under irrigated condition of clay loam soil of Nandyal, Andhra Pradesh.

2.2.2.2 Length of panicle

Monisha *et al*. (2019) observed that progressive increase in panicle length with the highest panicle length (17.8 cm) recorded at 50% RDF + 25% Neem cake N Based + 25% Bio-fertilizer, followed by 50% RDF + 25% Poultry manure N Based + 25% Bio-fertilizer in red soils of Madurai.

Thesiya *et al*. (2019) found that application of 100% RDF significantly increased the main panicle length in little millet, which was at par with 75% RDN through chemical fertilizer + 25% RDN through vermicompost during pooled analysis in little millet-green gram cropping system at Waghai, Gujarat.

According to Ramesh (2017) panicle length in foxtail millet was highest in 125% RDN + FYM @ 5 t ha^{-1} compared to rest of the treatments and it was on par with 125% RDN on clay soils at Prakasam, Andhra Pradesh.

According to Saini and Negi (1996), application of nitrogen up to 60 kg N ha^{-1} significantly increased the ear length of foxtail millet on sandy loam soils at Leo, Himachal Pradesh.

Subramanian and Ganesaraja (1992) noticed that significantly higher panicle length of foxtail millet was obtained with the basal application of FYM @ 12.5 t ha^{-1} + 20 kg N ha^{-1} + 10 kg P ha^{-1} compared to other manure and fertilizer levels tried on sandy clay loam soils of Madurai, Tamil Nadu, during *rabi* season.

The results of an experiment conducted by Gurunadha Rao *et al*. (1983) revealed that significantly higher panicle length of foxtail millet was seen with increase in nitrogen levels from 0 to 60 kg N ha^{-1} on clay loam soils of Nandyal, Andhra Pradesh.

2.2.2.3 Number of grains $panicle^{-1}$

Divya *et al.* (2017) observed that number of grains per ear head were significantly higher with 75% RDF + Biofertilizer @ 5 kg ha^{-1} incubated with vermicompost @ 500 kg ha^{-1} (2339) compared to 75% RDF + 25% N through vermicompost (2210) and 100% RDF (2154) in pearl millet on sandy loam soils, Hyderabad.

In a field experiment conducted by Togas (2016) recorded that significantly higher number of grains per ear head (1369) with application of vermicompost @ 2.5 t ha^{-1} + 50% RDF compared to 100% RDF (1261) in pearl millet at Jobner, Rajasthan.

2.2.2.4 Number of filled grains panicle^{-1}

Ramesh (2017) reported that highest number of filled grains per panicle in foxtail millet were highest in 125% RDN + FYM @ 5 t ha^{-1} compared to rest of the treatments and was on par with 125% RDN on clay soils at Prakasam, Andhra Pradesh.

Hasan *et al*. (2013) reported that application of N_{30} P_{24} K_{15} significantly increased the number of grains per panicle over rest of the lower levels studied in foxtail millet on sandy loam soils of Mymensingh, Bangladesh.

Basavarajappa *et al*. (2002) inferred that a non-significant difference in number of grains panicle^{-1} of foxtail millet was observed with increase in nitrogen levels from 0 to 60 kg N ha^{-1} in clay loam soils of Bursa, Turkey.

Subramanian and Ganesaraja (1992) reported that maximum number of grains panicle^{-1} were recorded when the foxtail millet crop was fertilized with FYM @ 12.5 t ha^{-1} + 20 kg N ha^{-1} + 10 kg P ha^{-1} compared to other manure and fertilizer levels tried on sandy clay loam soils of Madurai, Tamil Nadu.

2.2.2.5 Test weight

Monisha *et al*. (2019) revealed that among the various combinations application of 50% RDF + 25% Neem cake N Based + 25% Bio-fertilizer recorded higher grain weight (2.73 g) and this was followed by 50% RDF + 25% Poultry manure N Based + 25% Bio-fertilizer in red soils of Madurai.

Thesiya *et al*. (2019) revealed that application of 100% RDF significantly increased the test weight in little millet, which was at par with 75% RDN through chemical fertilizer + 25% RDN through vermicompost during pooled analysis in little millet-green gram cropping system at Waghai, Gujarat.

Ojha *et al*. (2018) noticed that 1000 grain weight in foxtail millet was significantly superior with application of FYM 6 tons ha^{-1} + 60: 30: 20 kg NPK ha^{-1} that is 1.79 g over all the treatments but at par with application of FYM 6 tons + 60: 40: 0 kg NPK ha^{-1}) at Lamjung, Sundarbazar.

Significantly higher test weight in foxtail millet was found in 125% RDN + FYM @ 5 t ha^{-1} compared to rest of the treatments and was on par with 125% RDN on clay soils at Prakasam, Andhra Pradesh in an experiment conducted by Ramesh (2017).

Significant increase in 1000-grain weight in kodo millet was observed with increase in nitrogen level from 0 to 40 kg N ha^{-1} on sandy loam soils of Rewa, Madhya Pradesh (Divya and Maurya, 2013).

Significantly higher test weight in pearl millet was obtained with application of FYM @ 5 t ha^{-1} along with 40 kg N ha^{-1} (6.95 g) compared to control (6.71 g) and 2.5 t ha^{-1} FYM alone (6.75 g) in a study conducted by Khan *et al*. (2000) at Gwalior, Madhya Pradesh during *kharif.*

Saini and Negi (1996) in a study conducted on sandy loam soils of Himachal Pradesh during summer season observed that 1000-grain weight was significantly increased with application of nitrogen up to 60 kg ha^{-1}.

2.2.2.6 Grain yield

Marwein *et al*. (2019) conducted an experiment on foxtail millet which revealed that integration of inorganic fertilizer of 75% RD N through Urea + 25% N through poultry manure + Azospirillum Seed Inoculation resulted in maximum grain yield (2.31 t ha^{-1}) at Prayagraj, U.P.

Monisha *et al*. (2019) conducted an experiment in foxtail millet on red soils of Madurai, Tamil Nadu found that treatment carrying combinations of 50% RDF + 25% Neem cake N Based + 25% Bio-fertilizer was recorded higher yield (2385 kg ha^{-1}).

Thesiya *et al*. (2019) found that application of 100% RDF resulted in significantly higher grain yield in little millet, which was at par with 75% RDN through chemical fertilizer + 25% RDN through vermicompost during pooled analysis in little millet-green gram cropping system at Waghai, Gujarat.

Roy *et al*. (2018) recorded maximum grain yield (3773 kg ha^{-1}) in finger millet during *kharif* with the combined application of organic, inorganic and biofertilizers *i.e.*, application of FYM (10 t ha^{-1}) + Biofertilizer + $ZnSO_4$ (12.5 kg ha^{-1}) + Borax (5 kg ha^{-1}) + 75% RDF followed by application of FYM (10 t ha^{-1}) + Biofertilizers + $ZnSO_4$ (12.5 kg ha^{-1}) + Borax (5 kg ha^{-1}) + 100 % RDF (3542 kg ha^{-1}) and significantly superior to rest of the treatments in Ranchi.

Upendranaik *et al*. (2018) reported that grain yield (1841 kg ha^{-1}) in foxtail millet increased significantly due to application of jeevamrutha + mulching + IFS compost + vermicompost + panchagavya over control in Raichur.

Ojha *et al*. (2018) observed that highest grain yield in foxtail millet was obtained from treatment having combination of FYM 6 tons ha^{-1} + 60: 30: 20 kg NPK ha^{-1} (2.467 t ha^{-1}) which was statistically at par with treatment having 60: 30: 20 kg NPK ha^{-1} (2.44 t ha^{-1}) at Lamjung, Sundarbazar.

Thimmaiah *et al.* (2016) observed that on red sandy loam soils of Shivamogga, Karnataka recommended NPK + FYM at 7.5 t ha^{-1} + PGPR at 2 kg ha^{-1} + vermicompost and Frond compost both at 3.75 t ha^{-1} as top dress at 25 DAT recorded significantly higher grain yield (63.50 q ha^{-1}) compared to all other treatments in finger millet.

Hasan *et al*. (2013) reported that the grain yield of foxtail millet was gradually increased with increased levels of NPK up to N_{30} P_{24} K_{15} kg ha^{-1}, but it was on par with N_{20} P_{16} K_{20} kg ha^{-1} on sandy loam soils of Bangladesh.

Naik *et al.* (2010) noticed that the application of 30 kg N+15 kg P_2O_5 ha^{-1} gave higher grain yield (1792 kg ha^{-1}) followed by 22.5 kg N ha^{-1} + 11.25 kg P_2O_5 ha^{-1} (1615 kg ha^{-1}) in foxtail millet. It was also observed that application of 950 kg ha^{-1} enriched farm yard manure (FYM) gave higher yield (1696 kg ha^{-1}) when compared to 5,000 kg ha^{-1} of ordinary FYM (1672 kg ha^{-1}).

Munirathnam *et al*. (2006) stated that the application of 25% RDF(100% RDF: 40 N +20 P_2O_5) + 25% recommended FYM + Azospirillum significantly increased the grain yield and it was at par with 50% RDF + Azospirillum on heavy black soils of Nandyal, Andhra Pradesh.

Basavarajapa *et al*. (2002) observed medium tillage and ridging with enriched FYM+Azospirillum+60 kg N ha^{-1} recorded significantly higher grain yield in foxtail millet. The next best treatment was medium tillage and ridging with Glyricidia green manuring+60 kg N ha^{-1}.

Basavaraj *et al*. (1995) obtained highest grain yield with highest NP rate and enriched FYM and lowest with lower NP rate and no FYM in foxtail millet.

The grain yield of foxtail millet was increased significantly with higher levels of nitrogen *i.e.,* 40 kg N ha^{-1} compared to 20 kg N ha^{-1} in an experiment conducted on medium black soils of Chittorgarh, Rajasthan (Intodia, 1994).

At Madurai, Tamil Nadu, Subramanian and Ganesaraja (1992) conducted a field experiment and noticed that higher grain yield was obtained with the application of FYM

@ 12.5 t ha^{-1} + 20 kg N ha^{-1} + 10 kg P ha^{-1} to foxtail millet, which was significantly superior over the other fertilizer levels tried during *rabi* season on sandy clay loam soils.

Gurunadha Rao *et al*. (1990) reported that the grain yield of foxtail millet was increased with increased fertility levels of N, P_2O_5 and K_2O up to 40-20-0 kg ha^{-1} during the two years of study conducted on clay loam soils of Nandyal, Andhra Pradesh.

2.2.2.7 Straw yield

Monisha *et al*. (2019) observed that application of 50% RDF + 25% Neem cake N Based + 25% Bio-fertilizer recorded higher straw yield (4293 kg ha^{-1}) compared to other treatments on red soils of Madurai, Tamil Nadu.

Thesiya *et al*. (2019) found that application of 100% RDF resulted in significantly higher straw yield in little millet, which was at par with 75% RDN through chemical fertilizer + 25% RDN through vermicompost during pooled analysis in little millet-green gram cropping system at Waghai, Gujarat.

Upendranaik *et al*. (2018) conducted an experiment on foxtail millet in Raichur found that stover yield (7066 kg ha^{-1}) increased significantly due to application of jeevamrutha + mulching + IFS compost + vermicompost + panchagavya over control.

Roy *et al.* (2018) observed that maximum straw yield (7695 kg ha^{-1}) was recorded with application of FYM (10 t ha^{-1}) + Biofertilizers + $ZnSO_4$ (12.5 kg ha^{-1}) + Borax (5kg ha^{-1}) + 100 % RDF followed by application of FYM (10 t ha^{-1}) + Biofertilizers + $ZnSO_4$ (12.5 kg ha^{-1}) + Borax (5 kg ha^{-1}) + 75% RDF (6983 kg ha^{-1}) in Ranchi during *kharif.*

Thimmaiah *et al.* (2016) observed that on red sandy loam soils of Shivamogga, Karnataka recommended NPK + FYM at 7.5 t ha^{-1} + PGPR at 2 kg ha^{-1} + vermicompost and Frond compost both at 3.75 t ha^{-1} as top dress at 25 DAT recorded significantly higher straw yield (86.67 q ha^{-1})compared to all other treatments in finger millet during *kharif*.

Significantly higher straw yield of foxtail millet was recorded with N_{40} P_{32} K_{20} kg ha^{-1} compared to the rest of the NPK levels studied (Hasan *et al*., 2013).

Munirathnam *et al*. (2006) found that significantly higher straw yield of foxtail millet crop was obtained with the application of 25% RDF (100% RDF: 40 N +20 P_2O_5)

+ 25% recommended FYM + azospirillum and was closely followed by 50% RDF + azospirillum compared to control and azospirillum alone.

Basavaraj *et al.* (1995) obtained highest straw yield with highest NP rate and enriched FYM and lowest with lower NP rate and no FYM in foxtail millet.

Intodia (1994) found that there was a significant increase in straw yield of foxtail millet with the application of 40 kg N ha^{-1} compared to 20 kg N ha^{-1} on medium black soils of Chittorgarh, Rajasthan.

According to Subramanian and Ganesaraja (1992), straw yield of foxtail millet obtained with the basal application of FYM @ 12.5 t ha^{-1} + 20 kg N ha^{-1}+ 10 kg P ha^{-1} was significantly higher compared to other manures and fertilizers tried during *rabi* season on sandy clay loam soils of Madurai, Tamil Nadu.

2.2.2.8 Nutrient uptake

Roy *et al*. (2018) observed that uptake of NPK by grain and straw as well as total NPK uptake was higher with application of FYM (10 t ha^{-1}) + Biofertilizer + $ZnSO_4$ (12.5 kg ha^{-1}) + Borax (5 kg ha^{-1}) + 75% RDF which was at par with application of FYM (10 t ha^{-1}) + Biofertilizer + $ZnSO_4$ (12.5 kg ha^{-1}) + Borax (5 kg ha^{-1}) + 100% RDF in Ranchi during *kharif*.

Pallavi *et al*. (2016) revealed that nutrient content and uptake (NPK) by grain and straw in finger millet were significantly higher with 100% RDF, 75% RD N + 25% N poultry manure and were on par with sole crop compared to other nutrient combinations and control at Rajendranagar, Hyderabad.

Jyothi *et al*. (2016) observed that application of 50 kg N ha^{-1} recorded highest uptake of N, P and K, while the lowest values were found with no nitrogen application in foxtail millet on sandy loam soils in *kharif* at Tirupati.

Narolia and Poonia (2011) conducted a trial at Bikaner, Rajasthan reported significantly higher N, P and K uptake by application of vermicompost @ 2 t ha^{-1} (57.40, 10.97 and 79.97 kg ha^{-1}) compared to vermicompost drilling @ 1 t ha^{-1} (49.87, 9.92 and 63.89 kg ha^{-1}) and soil incorporation @ 2 t ha^{-1} (50.80, 9.98 and 71.50 kg ha^{-1}) in pearl millet on loamy sands during *kharif* season.

Basavarajappa *et al*. (2002) conducted a study on shallow alfisols of Dharwad, Karnataka to study the response of foxtail millet to different levels of nitrogen found that 60 kg N ha^{-1} recorded significantly higher NPK uptake which was significantly higher than the application of 30 kg N ha^{-1}.

Significantly higher nitrogen, phosphorous and potassium concentrations in both grain and straw of foxtail millet was found on sandy loam soils of Bangalore, Karnataka with application of 30 kg N + 15 kg P_2O_5 ha^{-1} (Naik *et al.*, 1995).

2.2.2.9 Economics

Naik *et al*. (2017) observed that the application of FYM at 10 t ha^{-1} + BDLME (Two splits at 75 kg N ha^{-1} recorded significantly higher gross return (Rs. 34233 ha^{-1}), net returns (Rs. 24793 ha^{-1}) and benefit cost ratio (2.63) in fingermillet compared to all other treatments at Hiriyur, Karnataka.

Thimmaiah *et al.* (2016) observed that on red sandy loam soils of Shivamogga, Karnataka recommended NPK + FYM at 7.5 t ha^{-1} + PGPR at 2 kg ha^{-1} + vermicompost and Frond compost both at 3.75 t ha^{-1} as top dress at 25 DAT recorded significantly higher gross returns (Rs. 1,03,000 ha^{-1}) compared to all other treatments in finger millet during *kharif*.

Jyothi *et al*. (2016) reported that higher values of gross returns, net returns and benefit cost ratio were obtained in foxtail millet with the application of 50 kg N ha^{-1} (N3), which was significantly superior to that of 25 kg N ha^{-1} (N2) and the lowest economic returns were recorded with no nitrogen application (N1) on sandy loam soils at Tirupati.

Divya and Maurya (2013) reported that highest net returns and benefit–cost ratio was obtained with application of 40 kg N ha^{-1} compared to the control and 20 kg N ha^{-1} in kodo millet on sandy loam soils of Rewa, Madhya Pradesh.

Munirathnam *et al*. (2006) observed that the application of 25% RDF (RDF: 40 N +20 P_2O_5) + 25% recommended FYM + Azospirillum fetched the highest net returns with foxtail millet compared to other treatments tried on heavy black soils of Nandyal, Andhra Pradesh.

Chapter III

MATERIAL AND METHODS

The present investigation entitled "Response of foxtail millet (*Setaria italica*) varieties to integrated nutrient management" was conducted during *kharif*, 2019. The materials used and methods adopted during experimentation are presented in this Chapter.

3.1 LOCATION

The field experiment was conducted in Plot No. 15 in 'B' Block of College farm, College of Agriculture, Rajendranagar, Professor Jayashankar Telangana State Agricultural University, which is geographically situated at 17°19' N latitude and 78°23' E longitude at an altitude of 542.6 m above mean sea level falls under Southern Telangana agro-climatic zone of Telangana.

3.2 WEATHER DURING THE CROP GROWTH PERIOD

The weather data during the crop growth period recorded at Agricultural Research Institute (ARI), Rajendranagar, Hyderabad are presented in Table 3.1 and depicted in Fig. 3.1.a, b, c, d, e, f.

The weekly mean maximum temperature during the crop growth period (16.07.2019 to 15.10.2019) ranged from 27.4^{0}C to 33.5 °C with an average of 30.2 °C, while the weekly mean minimum temperature ranged from 14.8 ^{0}C to 18.3 °C with an average of 16.9 °C.

The total rainfall received during the crop growth period was 657.7 mm received in 38 rainy days. The weekly mean relative humidity during the crop period ranged from 69.8 to 85.2 per cent with an average of 79.5 per cent. The weekly mean sunshine hours varied from 1.2 to 6.0 with an average of 3.9 hours per day and mean evaporation ranged from 2.8 to 5.8 mm per day with an average of 3.8 mm per day. The mean wind speed ranged from 0 to 12.6 km hr^{-1} with an average of 4.3 km hr^{-1}. The weather parameters were optimal for foxtail millet. There was no dry spell during the crop growth period.

Table 3.1 Standard week wise mean meteorological data during the crop growth period of foxtail millet (16.07.2019 to 15.10.2019).

Standard meteorological week	Period	Temperature (^{0}C)		Mean Temperature (^{0}C)	Relative Humidity (%)		Mean RH (%)	Mean Sunshine Hours	Wind Speed (Km hr^{-1})	Rainfall (mm)	Rainy Days (mm)	Evaporation (mm)
		Min (^{0}C)	Max (^{0}C)		I	II						
28	16 - 22 July	18.3	33.5	25.9	85.7	54.0	69.8	3.0	2.9	26.5	2	5.8
29	23 - 29 July	18.1	30.7	24.4	84.0	67.7	75.8	4.2	6.8	15.8	3	4.8
30	30 July-5Aug	16.9	27.4	22.1	90.7	79.7	85.2	1.2	10.9	75.8	5	3.3
31	6 - 12 Aug	17.9	29.1	23.5	85.7	69.0	77.3	3.1	12.6	11.8	3	4.0
32	13 - 19 Aug	18.2	30.8	24.5	85.3	61.3	73.2	4.4	4.9	7.0	1	4.2
33	20 - 26 Aug	17.3	30.6	23.9	90.4	64.1	77.3	5.3	6.3	42.0	2	4.2
34	27Aug -2 Sep	16.5	30.3	23.4	90.7	69.1	79.9	6.0	5.0	76.2	4	4.8
35	3 - 9 Sep	16.9	28.4	22.6	86.4	72.1	79.3	1.2	5.9	9.0	1	3.3
36	10 - 16 Sep	16.6	29.9	23.2	90.1	64.8	77.5	5.0	1.1	31.6	3	3.8
37	17 - 23 Sep	17.1	30.7	23.9	96.8	70.3	83.6	4.0	0	61.0	4	3.2
38	24 - 30 Sep	16.1	30.1	23.1	98.1	70.7	84.4	3.7	0	202.0	4	3.0
39	1 - 7 Oct	15.9	31.1	23.5	93.7	73.1	83.4	4.7	0.1	48.4	2	3.1
40	8 - 14 Oct	15.6	31.0	23.3	97.6	67.2	82.4	5.5	0.1	24.4	4	2.8
41	15 - 21 Oct	14.8	28.9	21.8	93.3	74.0	83.6	4.3	0.4	26.2	2	2.9
Total		-	-	-	-	-	-	55.6	-	657.7	38	53.2
Mean		16.9	30.2	23.5	90.6	67.9	79.5	3.9	4.3	46.9	2.9	3.8

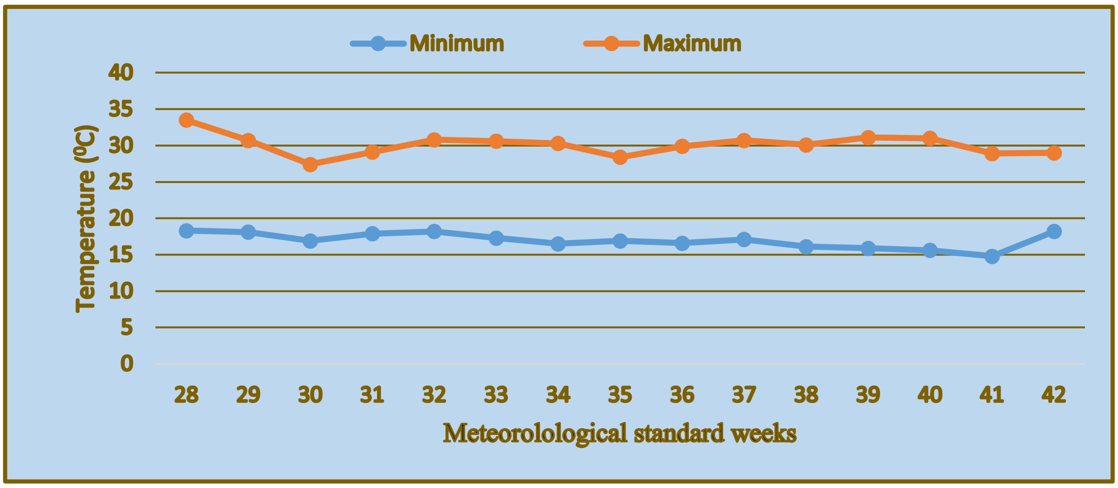

Figure 3.1.a Weekly temperature during crop growth period.

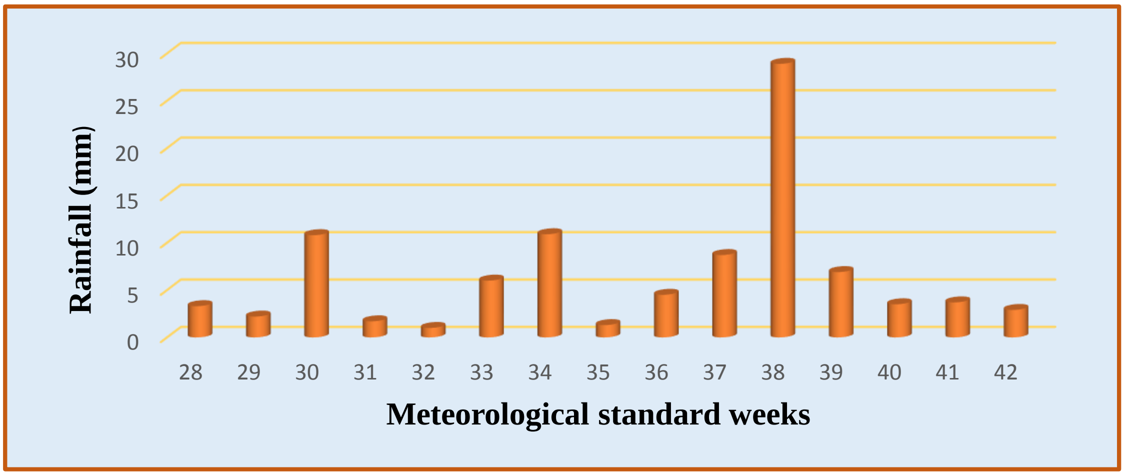

Figure 3.1.b Weekly rainfall during crop growth period.

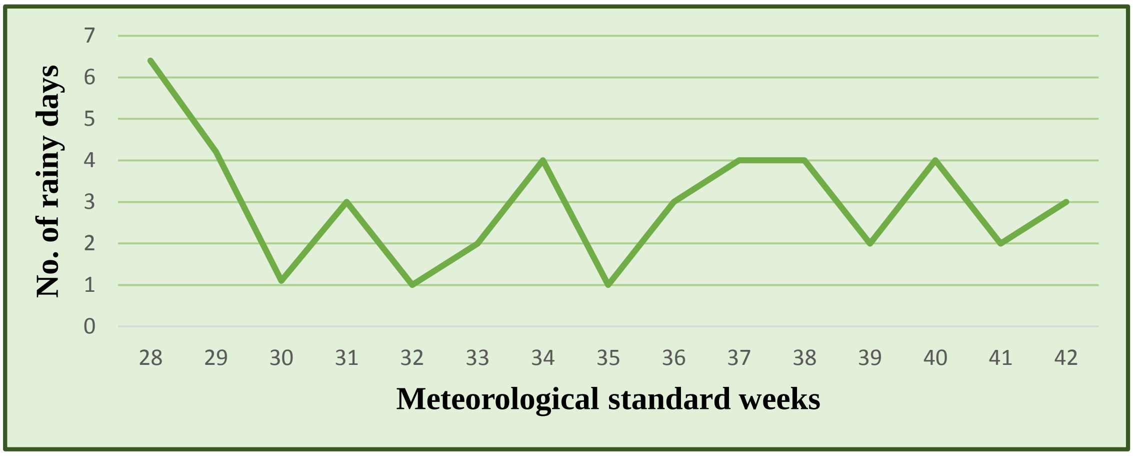

Figure 3.1.c Number of rainy days during crop growth period.

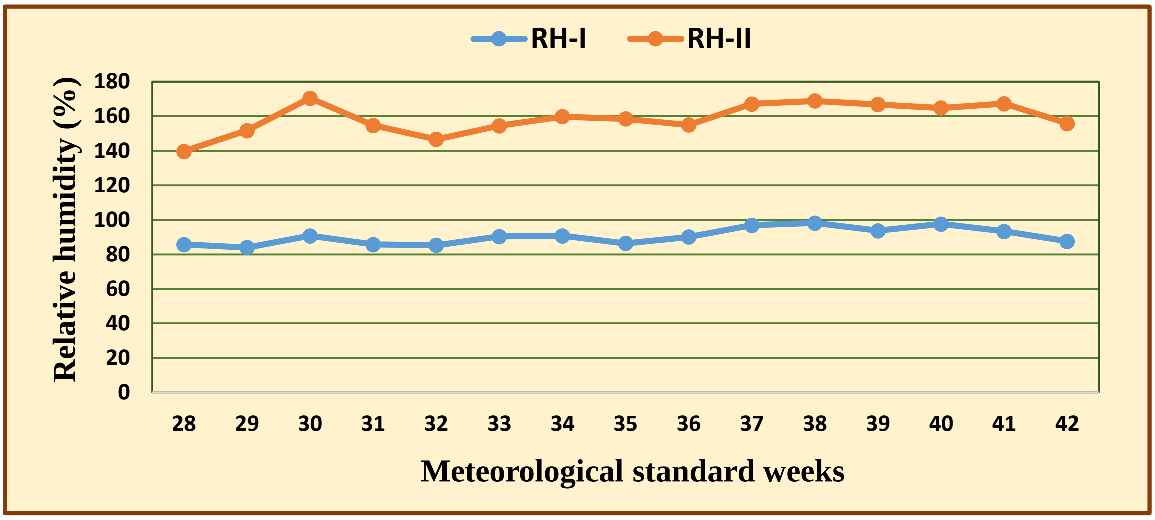

Figure 3.1.d Weekly relative humidity during crop growth period.

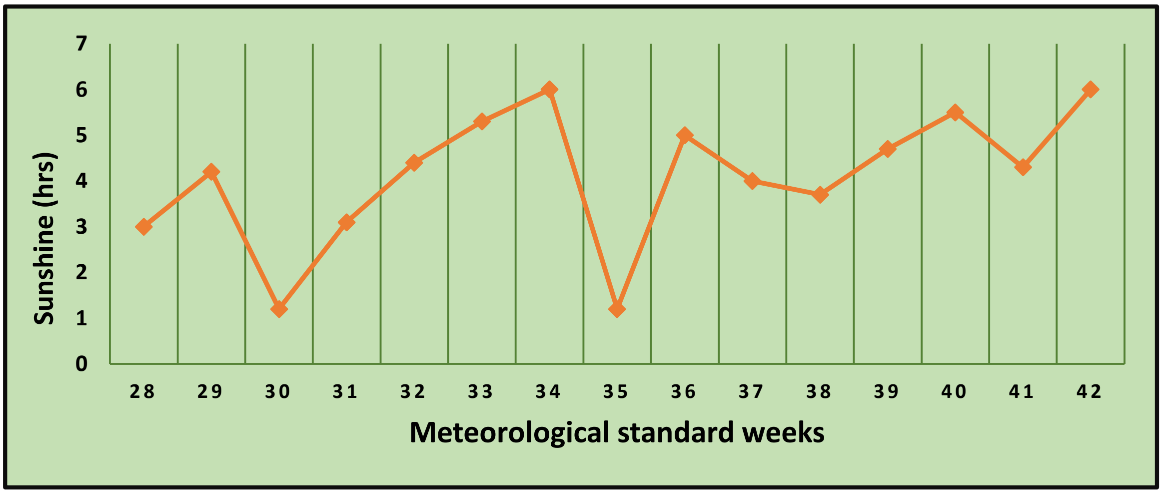

Figure 3.1.e Weekly sunshine hours during crop growth period.

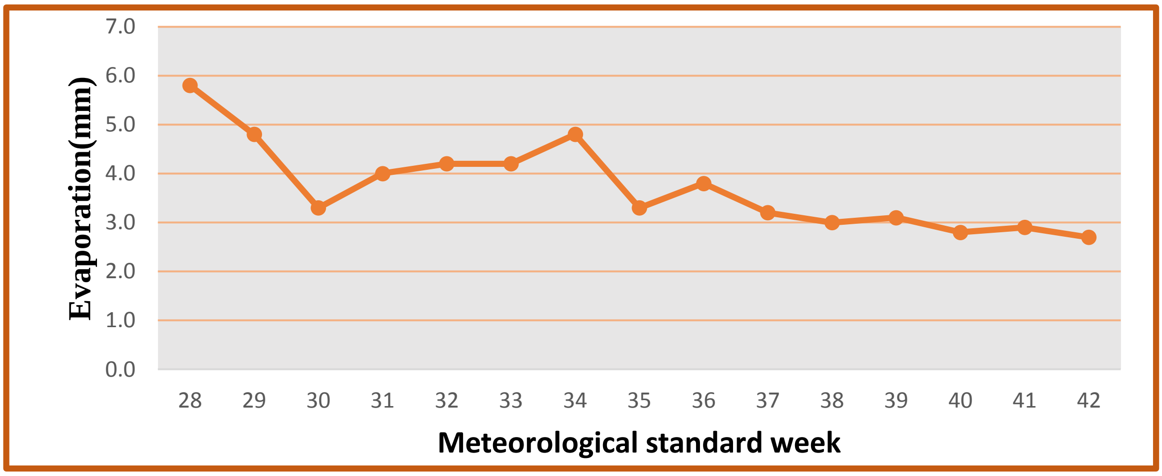

Figure 3.1.f Weekly evaporation (mm) during crop growth period.

3.3 SOIL CHARACTERISTICS OF THE EXPERIMENTAL SITE

Initial soil samples from the experimental field were collected at random from 0 to 20 cm depth before the experimentation. And a composite sample was drawn, processed and analyzed for properties by adopting the standard procedures and the results are presented in Table 3.2.

The soil was sandy loam in texture, neutral in soil reaction, low in available nitrogen and organic carbon, low in available phosphorus and high in available potassium.

Table 3.2 Properties of soil of the experimental site.

Particulars	Value	Method of analysis
I. Physical characteristics		
Sand (%)	75	Bouyoucos Hydrometer (Piper, 1966)
Silt (%)	10	
Clay (%)	15	
Soil texture	Sandy loam	
II. Chemical characteristics		
Soil reaction (pH) (1: 2.5 soil water suspension)	7.56	Glass electrode pH meter (Jackson, 1967)
Electrical conductivity ($dS\ m^{-1}$) (1: 2.5 soil water suspension)	0.26	Conductivity meter (Jackson, 1967)
Organic carbon (%)	0.87	Walkley and Black's modified method (Walkley and Black, 1934)
Available N ($kg\ ha^{-1}$)	166.80	Alkaline potassium permanganate method (Subbiah and Asija, 1956) Kelplus-Classic Dx
Available P_2O_5 ($kg\ ha^{-1}$)	22.11	Olsen's extractant method (Olsen *et al*., 1954)
Available K_2O ($kg\ ha^{-1}$)	376.50	Neutral normal ammonium acetate method using flame photometer (Jackson, 1967)
Bulk density ($Mg\ m^{-3}$)	1.20	Keen and Raczkowski, 1921
Particle density ($Mg\ m^{-3}$)	2.49	
Pore space (%)	51.20	
Water holding capacity (%)	28.00	

3.4 CROPPING HISTORY OF EXPERIMENTAL PLOT

The cropping history of the experimental site before commencement of experiment are given in Table 3.3.

Table 3.3. Cropping history of the experimental plot

Year	***Kharif***	***Rabi***	***Summer***
2016-2017	Cotton	Fallow	Fallow
2017-2018	Cotton	Fallow	Fallow
2018-2019	Finger millet	Fallow	Fallow

3.5 EXPERIMENTAL DETAILS

3.5.1 Design and Layout

The experiment was laid out in a randomized block design with factorial concept with fourteen treatments each replicated thrice. The lay out plan of experimental plot is depicted in Fig.3.2.

Location	: College Farm, College of Agriculture, Rajendranagar
Season	: *Kharif,* 2019-20
Treatments	: 14
Replications	: 3
Design	: Randomized Block Design (Factorial concept)
Crop	: Foxtail millet (*Setaria italica*)
Spacing	: 30 cm × 10 cm
Varieties	: SiA 3085 SiA 3156
Seed rate	: 5 kg ha^{-1}
Recommended Dose of Fertilizers	: 40-20-20 kg N: P_2O_5: K_2O ha^{-1}

3.5.2 Treatments

The details of the treatments are as follows.

Factor-1: Varieties (2)

C_1 - SiA 3085

C_2 - SiA 3156

Factor-2: Integrated nutrient management

T_1 – Control (100% RDF -40-20-20 kg NPK ha^{-1})

T_2 - 25% RDN through Vermicompost + 75% RDF

T_3 - 25% RDN through Farm Yard Manure + 75% RDF

T_4 - 25% RDN through Sheep Manure + 75% RDF

T_5 - 50% RDN through Vermicompost + 50% RDF

T_6 - 50% RDN through FYM + 50% RDF

T_7 - 50% RDN through Sheep Manure + 50% RDF

Table 3.4. Quantities of organic manures applied

Sl no.	% RDN	N (Kg ha^{-1})	Quantity (t ha^{-1})		
			FYM (1.25%N)	Vermicompost (3.61 %N)	Sheep Manure (2.25 %N)
1	25%	10	0.80	0.27	0.44
2	50%	20	1.60	0.55	0.88

3.5.3 Plot Size

Gross plot size : 4.8 m × 4.0 m

Net plot size : 3.6 m × 3.6 m

3.6 VARIETAL DESCRIPTION

The two varieties of foxtail millet used in this experiment were developed at Regional Agricultural Research Station, Nandyal, Andhra Pradesh.

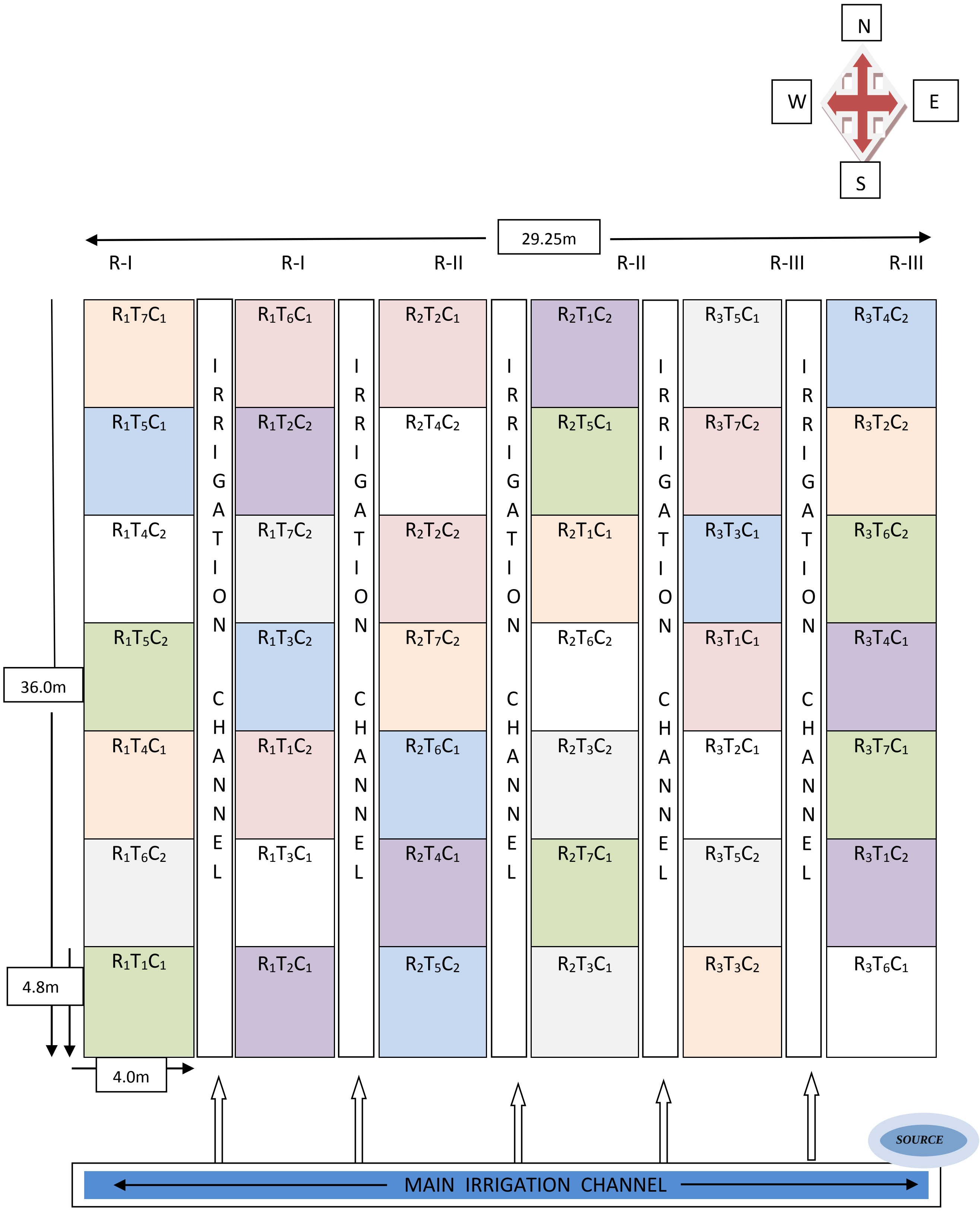

Figure 3.2 Lay-out plan of the experimental field.

3.6.1 SiA 3085 (C_1)

This variety matures in about 80-85 days. It produces semi compact, cylindrical shaped and purple pigmented panicles of 16 - 20 cm long with small to medium sized bristles. The grain is medium bold in size and yellow colour in appearance. This variety has a grain yield potential of 20-30 q ha^{-1}.

3.6.3 SiA 3156 (C_2)

This variety is having duration of about 85-90 days. It produces compact panicles with compact lobes having pigmented bristles. This variety has a grain yield potential of 20-25 q ha^{-1}.

3.7 CULTIVATION DETAILS

3.7.1 Preparatory cultivation

The experimental field was prepared by ploughing twice with a tractor drawn cultivator followed by harrowing with a tractor drawn rotavator in order to obtain a fine tilth. The field was cleared of weeds and stubbles, then finally leveled and the plots were laid out according to the layout plan.

3.7.2 Application of farm yard manure, vermicompost and sheep manure

The required quantities of 25% RDN and 50% RDN through farm yard manure, vermicompost and sheep manure were applied in respective plots as per the treatments and incorporated into soil two weeks before sowing of the crop.

3.7.3 Seeds and Sowing

Clean, healthy and matured seeds of high germination percentage were used for sowing. The seeds were treated with Carbendazim @ 2 g kg^{-1} seed to avoid seed and soil borne diseases of foxtail millet. Seeds @ 5 kg ha^{-1} were sown after mixing with sand thoroughly, in the open furrows made with the help of hand hoe by adopting a spacing of 30 cm x 10 cm. The seeds were dropped to a depth of 2 cm and covered thoroughly with soil.

3.7.4 Gap filling and thinning

After 10 days of sowing, gap filling was done to maintain desired plant population and thinning was carried out one week after gap filling to retain one seedling $hill^{-1}$.

3.7.5 Fertilizer Application

Nitrogen as per N levels (100%, 75% and 50% RD N) was applied through urea in three equal splits *viz*., 1/2 as basal and 1/2 at tillering stage (30 DAS). The entire dose of phosphorous @ 20 kg ha^{-1} as single super phosphate (SSP) and potassium @ 20 kg ha^{-1} as muriate of potash (MOP) were applied as basal dose at the time of sowing. All the fertilizers including the top dressed urea was applied by placement method at 5 cm away from the seed/plant rows at 5 cm depth.

3.7.6 Weed management

Weedicides were not applied but only hand weeding was done once during the crop growth period at 25 DAS both within and between the rows of the crop to keep the crop free from weeds. Afterwards no weeding was done since the crop has smothered the weeds. The predominant weed flora found in the experimental field were *Cyperus rotundus*, *Eclipta alba*, *Phyllanthus niruri*, *Celosia argentia* and *Parthenium hysterophorus.*

3.7.7 Irrigation

Foxtail millet was grown as a rainfed crop but only one irrigation was given immediately after sowing of the crop for better germination and establishment of the crop. Afterwards no irrigation was given as the rainfall was sufficient to raise the crop.

3.7.8 Plant protection

Tricyclazole (@ 0.6 g a.i. lit^{-1} of water) was sprayed once for the control of blast in foxtail millet at 35 DAS.

3.7.9 Bird scaring

Manual bird scaring were done off to avoid bird damage when the crop was at matured stage.

3.7.10 Harvesting

The crop was harvested at maturity when the entire plant turned yellow and grains turned brown. Border rows were harvested first leaving the net plot. Later harvesting done in net plot after separating the plants designated for recording biometric observations. The spikes and stover of each treatment were sun dried thoroughly. After drying, the spikes were threshed manually to separate the grains. Then grains were dried and cleaned.

3.8 BIOMETRIC OBSERVATIONS

Five plants were selected randomly and tagged in each treatmental plot for recording of the non-destructive sampling parameters like plant height, number of tillers etc. Likewise, five plants for destructive sampling were uprooted from two rows on either side between border and net plots earmarked for the purpose at each sampling interval.

3.8.1 Plant population

Number of plants were counted in ten rows of 3 m row length during initial (10 DAS) and final stages (60 DAS) and was expressed in plants ha^{-1}.

3.8.2 Plant height

Plant height was measured from the ground level to the growing tip of the top most leaf at 30 DAS and to the tip of the panicle at 60 DAS and at harvest. Observations were taken from five earmarked plants and mean value was expressed in cm**.**

3.8.3 Number of tillers m^{-2}

In the net plot, plants in one square metre area was demarcated with tags for recording the number of tillers. Number of tillers was recorded at 30, 60 DAS and at harvest and expressed as number of tillers m^{-2}.

3.8.4 Leaf area

Leaf area (cm^2) of five plants was measured with the help of leaf area meter (LICOR-3100 automatic leaf area meter) at 30, 60 DAS and at harvest.

After computing the leaf area, the leaf area index (LAI) was calculated by using the following formula as suggested by Watson (1952).

$$LAI = \frac{\text{Leaf area}}{\text{Land area}}$$

3.8.5 Dry matter production

Five plants at random from the border rows (leaving the extreme outer row) were destructively sampled at 30, 60 DAS and at harvest. The plant samples were shade dried initially and later dried in hot air oven at 60 °C until a constant weight was recorded and expressed as kg ha^{-1}.

3.8.6 Number of productive tillers m^{-2}

In each plot, one square metre area was demarcated. The number of productive tillers per square meter were counted at harvest.

3.8.7 Days to 50 per cent flowering

Days to 50 per cent flowering was recorded by visual observation. Number of days taken for flowering of 50% plants was recorded and presented as days to 50% flowering.

3.9 YIELD ATTRIBUTES AND YIELD

3.9.1 Number of panicles m^{-2}

Number of panicles were counted from one square metre area of the net plot in each treatment before the harvest and expressed as number of panicles m^{-2}.

3.9.2 Length of panicle

The length of the panicles obtained from the randomly selected five sample plants were measured from the base of the panicle to the tip of the panicle and the mean length was calculated and expressed as cm.

3.9.3 Number of grains panicle^{-1}

The number of grains per panicle from randomly selected five plants was counted and mean was recorded.

3.9.4 Number of filled grains panicle^{-1}

Number of filled grains from the panicles of the five randomly selected plants were counted, averaged and expressed as number of filled grains panicle^{-1}.

3.9.5 Test weight

Samples of 1000 grains were drawn from the net plot yield of each treatment and weight of these samples was recorded separately, averaged and expressed as 1000-grain weight or test weight in grams (g).

3.9.6 Grain yield

The harvested spikes from the net plot area were dried to constant weight, threshed and winnowed and again the grains were thoroughly sun dried, weighed as per the treatment and expressed as kg ha^{-1}.

3.9.7 Straw yield

The straw obtained from the net plot area after harvesting of the spikes were weighed after sun drying to a constant weight and expressed as kg ha^{-1}.

3.9.8 Harvest index

It is the ratio of economic yield to the total biological yield. It was calculated by using the following formula and expressed in percentage.

$$\text{Harvest Index (HI)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.10 UPTAKE ANALYSIS

For estimating nitrogen, phosphorus and potassium content in plants, the dried plant samples collected from each plot for dry matter estimation at maturity were oven dried, powdered and used for chemical analysis.

3.10.1 Nitrogen Uptake

Nitrogen content in dry matter was estimated after digesting the powdered plant sample with H_2SO_4 and H_2O_2 by Micro Kjeldahl method (Piper, 1966). The nitrogen uptake was calculated by multiplying the content of nitrogen with respective dry matter production and expressed in kg ha^{-1}.

3.10.2 Phosphorus Uptake

The di-acid digested plant samples were analyzed for phosphorus content by vanado – molybdo phosphoric acid method (Jackson, 1967). The intensity of yellow colour developed was measured using spectrophotometer at 470 nm wavelength. The phosphorus uptake was calculated by multiplying the phosphorus content with the respective dry matter production and expressed as kg ha^{-1}.

3.10.3 Potassium Uptake

Potassium content of di-acid digested plant sample was determined using flame photometer and uptake of potassium was estimated by multiplying the potassium content with the respective dry matter production and presented in kg ha^{-1}.

3.11 SOIL ANALYSIS

Soil samples were drawn from 0-15 cm depth both before and after harvesting of foxtail millet varieties, from each treatment plot separately. Dried in shade, pounded, sieved and analyzed to find out the pre and post-harvest physico-chemical properties of the soil, as detailed below:

3.11.1 Available Nitrogen

The available nitrogen in soil was analysed by alkaline permanganate method as detailed by Subbiah and Asija (1956).

3.11.2 Available Phosphorus

The available phosphorus status in soil was estimated by Olsen's method (Olsen *et al*., 1954).

3.11.3 Available Potassium

The available potassium content in soil was determined by Flame Photometry (Jackson, 1967).

3.11.4 Physical properties

The physical properties of soil *viz*., bulk density, particle density, porosity and water holding capacity were determined by using Keen's cup method (Keen and Raczkowski, 1921).

3.12 ECONOMICS

3.12.1 Gross returns (Rs. ha^{-1})

The total cost of cultivation ha^{-1} was calculated for each treatment on the basis of input cost. Gross returns ha^{-1} were computed by considering the prevailing market price of the output.

$$\text{Gross returns} = \text{Grain yield (kg ha}^{-1}\text{) x Price (Rs. kg}^{-1}\text{)}$$

3.12.2 Net returns (Rs. ha^{-1})

Net returns ha^{-1} were calculated by deducting the cost of cultivation of respective treatments from gross monetary returns for the corresponding treatments.

$$\text{Net returns} = \text{Gross return (Rs. ha}^{-1}\text{)} - \text{Cost of cultivation (Rs. ha}^{-1}\text{)}$$

3.12.3 Benefit-Cost ratio (B:C)

Benefit-cost ratio (Rupees income per rupee investment) was worked out for each treatment by dividing gross returns from each treatment with cost of cultivation using the following formula.

$$\text{Benefit cost ratio} = \frac{\text{Gross returns (Rs.)}}{\text{Cost of cultivation (Rs.)}}$$

3.13 STATISTICAL ANALYSIS

The data recorded on various parameters of crop during the course of investigation were statistically analyzed following the analysis of variance for randomized block design with factorial concept as suggested by Gomez and Gomez (1984). OPSTAT software was used for statistical analysis of data. The statisticial significance was tested with F-test value at 0.05 level of probability and wherever the F value was found significant, critical difference (CD) was worked out to test the significance and if the treatmental difference was non-significant (NS) and was indicated by “NS”. If the difference between two treatments was more than critical difference, the value was indicated for comparison by treatment means.

Chapter IV

RESULTS AND DISCUSSION

A field experiment entitled "Response of foxtail millet (*Setaria italica*) varieties to integrated nutrient management" was carried out during *kharif*, 2019 at College farm, College of Agriculture, Rajendranagar, Hyderabad. The experimental results pertaining to biometric observations, yield attributes, yield, nutrient uptake, economics of foxtail millet and post-harvest soil nutrient status as influenced by different varieties and integrated nutrient management are presented in this chapter and also illustrated graphically to provide better understanding of important trends, wherever, felt necessary.

4.1 BIOMETRIC OBSERVATIONS

4.1.1 Plant population

Table 4.1 Initial and final plant population ha^{-1} of foxtail millet as influenced by varieties and INM.

Treatments	Initial plant population ha^{-1} (in Lakhs)	Final plant population ha^{-1} (in Lakhs)
Varieties		
C_1: SiA 3085	3.3	3.2
C_2: SiA 3156	3.3	3.2
SEm±	0.4	0.4
CD (P=0.05)	NS	NS
Integrated nutrient management		
T_1 Control(100% RDF)	3.1	3.1
T_2 25% RDN Vermicompost + 75% RDF	3.4	3.4
T_3 25% RDN FYM + 75% RDF	3.3	3.2
T_4 25% RDN Sheep manure + 75% RDF	3.3	3.2
T_5 50% RDN Vermicompost + 50% RDF	3.3	3.3
T_6 50% RDN FYM + 50% RDF	3.3	3.3
T_7 50% RDN Sheep manure + 50% RDF	3.2	3.2
SEm±	0.7	0.7
CD (P=0.05)	NS	NS
Interaction		
SEm±	0.9	0.9
CD (P=0.05)	NS	NS
C.V.	5.1	5.1

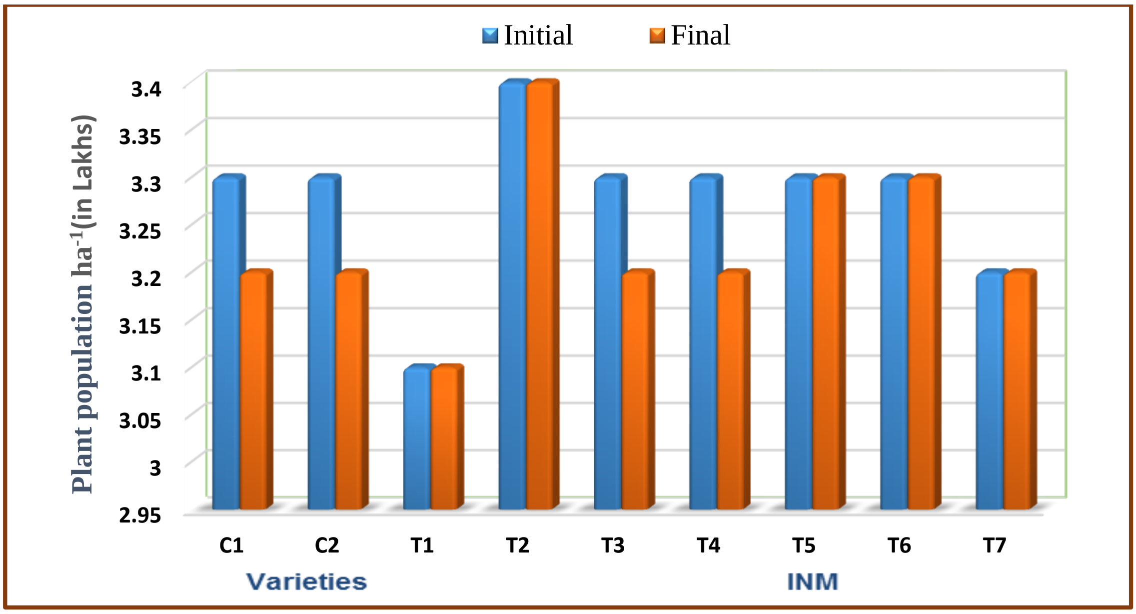

Fig. 4.1 Initial and final plant population ha^{-1} of foxtail millet as influenced by varieties and INM.

Data presented in table 4.1 and Fig. 4.1 showed that influence of the different varieties, application of integrated nutrient management and their interaction had no significant effect on plant stand both at initial stage and at harvest. Thus plant population was almost uniform in all the treated plots.

4.1.2 Plant height (cm)

Data on plant height revealed that, with advancement of crop growth, plant height increased progressively up to harvest stage irrespective of the treatments (Table 4.2 and Fig. 4.2). Plant height measured at different growth stages *viz*., 30 DAS, 60 DAS and at harvest was significantly influenced by integrated nutrient management. The plant height (cm) was not influenced significantly with the varieties from 30 DAS to harvest of the crop and the interaction between varieties and integrated nutrient management was also found to be non-significant.

4.1.2.1 Plant height at 30 DAS

Data inscribed in table 4.2 on plant height at 30 DAS as influenced by integrated nutrient management revealed that maximum plant height was observed with the application of 25% RDN through Vermicompost + 75% RDF (T_2) (59.4 cm) which was on par with application of 50% RDN through Vermicompost + 50% RDF (T_5) (56.0 cm) and recorded significantly taller plants than other combinations of organic and inorganic treatments. The lowest plant height was produced with control *viz.*, 100% RDF (T_1) (45.6 cm).

4.1.2.2 Plant height at 60 DAS

A perusal of data (Table 4.2) revealed that application of 25% RDN through Vermicompost + 75% RDF (T_2) recorded the maximum plant height of 138.5 cm at 60 DAS. It was significantly superior to other combinations of organic and inorganic treatments except 50% RDN through Vermicompost + 50% RDF (T_5) (135.2 cm) which remained at par with 25% RDN through Vermicompost + 75% RDF. The next best treatments were 25% RDN FYM + 75% RDF (T_3) and 25% RDN Sheep manure + 75% RDF (T_4). Lowest plant height recorded with control (100% RDF).

4.1.2.3 Plant height at harvest

Plant height at maturity was significantly influenced by integrated nutrient management. When compared to 60DAS and thereafter marginal increase were noticed at harvest stage. Among the integrated nutrient management treatments, the application of 25% RDN through Vermicompost + 75% RDF (T_2) (142.6 cm) recorded significantly highest plant height over control (T_1), and other combinations of organic and inorganic treatments being at par with 50% RDN through Vermicompost + 50% RDF (T_5) (138.8 cm). 25% RDN through Sheep manure + 75% RDF (T_4) recorded similar plant height (134.0 cm) with the treatment where in combination of 50% RDN through organics + 50% RDF through inorganic and 25% RDN FYM + 75% RDF (T_3) (135.0 cm).

At all the stages of observation, taller plants were produced with the application of 25% RDN through Vermicompost + 75% RDF (T_2) and 50% RDN through Vermicompost + 50% RDF (T_5), while the plants were of the shortest stature with no organic manure application. This might be due to the gradual release and maintained a high level of availability of nutrients throughout the crop growth period by vermicompost. The growth of plant is greatly influenced by soil environment. Here the treatment with integration of chemical and organic sources provided enough amounts of nutrients and organic matter which ultimately influenced the soil environment in positive ways for plant growth. The favourable soil condition finally resulted into higher values of plant height under these two treatments.

Nitrogen being a constituent of the plant cell influenced different physiological processes such as a cell division, cell elongation and chlorophyll production which ultimately resulted in better growth attributes. These findings are in close agreement with those reported by Thesiya *et al.* (2019), Umesh *et al*. (2006), Thimmaiah *et al*. (2016) and Shubhashree *et al.* (2017).

Table 4.2 Plant height (cm) of foxtail millet at different growth stages as influenced by varieties and INM.

Treatments	30 DAS	60 DAS	At Harvest
Varieties			
C_1: SiA 3085	51.0	129.1	133.5
C_2: SiA 3156	52.5	130.8	134.5
SEm±	0.8	0.9	1.0
CD (P=0.05)	NS	NS	NS
Integrated nutrient management			
T_1 Control(100% RDF)	45.6	124.9	127.1
T_2 25% RDN Vermicompost + 75% RDF	59.4	138.5	142.6
T_3 25% RDN FYM + 75% RDF	52.1	132.2	135.0
T_4 25% RDN Sheep manure + 75% RDF	51.5	130.7	134.0
T_5 50% RDN Vermicompost + 50% RDF	56.0	135.2	138.8
T_6 50% RDN FYM + 50% RDF	49.1	127.9	131.6
T_7 50% RDN Sheep manure + 50% RDF	48.4	126.7	129.0
SEm±	1.7	1.8	1.9
CD (P=0.05)	4.8	5.1	5.5
Interaction			
SEm±	2.4	2.5	2.7
CD (P=0.05)	NS	NS	NS
C.V.	7.9	5.1	5.3

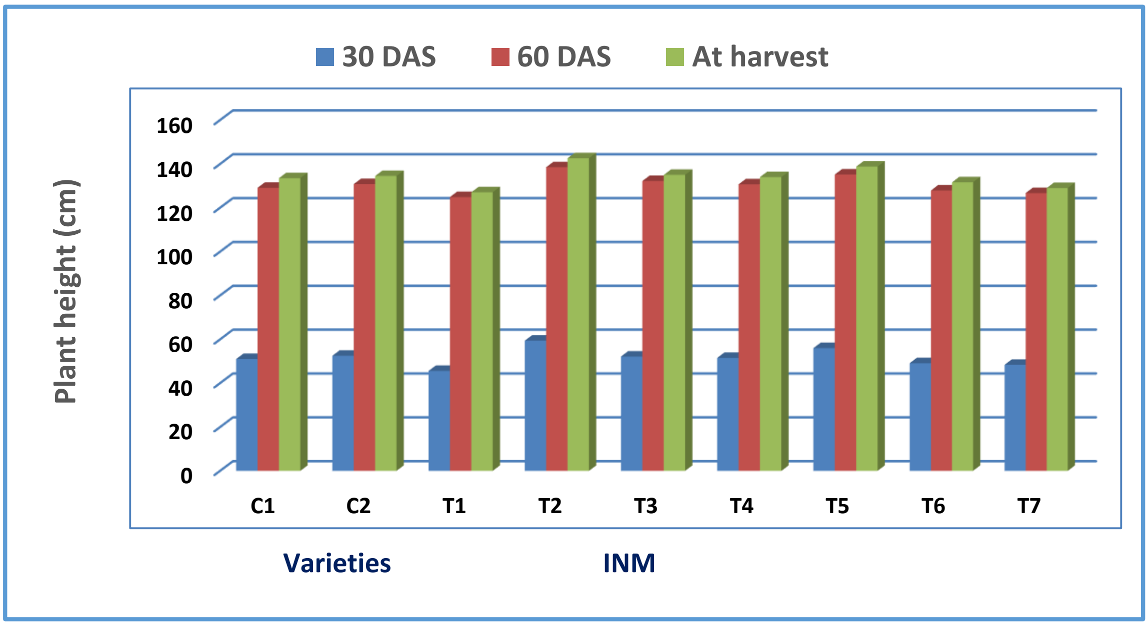

Fig. 4.2 Plant height (cm) of foxtail millet at different growth stages as influenced by varieties and INM.

4.1.3 Leaf Area Index

Leaf area index of foxtail millet was significantly influenced by varieties and integrated nutrient management at all stages of sampling (Table 4.3 and Fig. 4.3), whereas the interaction effect between them was statistically not traceable. The LAI of foxtail millet tended to increase progressively with advance in the age of the crop up to 60 DAS and decline thereafter.

4.1.3.1 Leaf area index at 30 DAS

Among the varieties tested, the highest leaf area index at 30DAS was recorded with the variety SiA 3085 (C_1) (0.29) which was significantly superior to that of variety SiA 3156 (C_2) (0.25).

Among the INM treatments, application of 25% RDN through Vermicompost + 75% RDF (T_2) had shown significantly higher leaf area index (0.34) and was statistically on par with the application of 50% RDN through Vermicompost + 50% RDF (T_5) (0.31). While 25% RDN through FYM + 75% RDF (T_3) produced LAI of 0.29 which was at par with 25% RDN through Sheep manure + 75% RDF (T_4) (0.26). These treatments were followed by 50% RDN through FYM + 50% RDF (T_6) (0.24) and 50% RDN through Sheep manure + 50% RDF (T_7) (0.24). The lowest LAI was with the application of 100% RDF (T_1) (0.23).

4.1.3.2 Leaf area index at 60 DAS

The highest leaf area index at 60 DAS was recorded with SiA 3085 (C_1) (1.53) which was having significantly higher leaf area index than SiA 3156 (C_2) (1.45).

Among the integrated nutrient management treatments, 25% RDN through Vermicompost + 75% RDF (T_2) had resulted in higher leaf area index (1.67), which was statistically on par with 50% RDN through Vermicompost + 50% RDF (T_5) having leaf area index (1.53). These two treatments were significantly superior to rest of the treatments. The lowest leaf area index of 1.38 was observed with application of 100% RDF.

4.1.3.3 Leaf area index at harvest

Among the varieties higher leaf area index at harvest was found to be with SiA 3085 (C_1) (1.36), as compared to SiA 3156 (C_2) (1.28).

The data on leaf area index as influenced by integrated nutrient management treatments revealed that higher leaf area index was observed with 25% RDN through Vermicompost + 75% RDF (T_2) (1.47) which was significantly superior over other combinations of organic and inorganic treatments and was statistically on par with 50% RDN through Vermicompost + 50% RDF (T_5) having leaf area index (1.37). While lowest leaf area index was recorded with control (100% RDF) (T_1) (1.23).

Table 4.3 Leaf area index of foxtail millet at different growth stages as influenced by varieties and INM.

Treatments	30 DAS	60 DAS	At Harvest
Varieties			
C_1: SiA 3085	0.29	1.53	1.36
C_2: SiA 3156	0.25	1.45	1.28
SEm±	0.01	0.03	0.02
CD (P=0.05)	0.02	0.07	0.06
Integrated nutrient management			
T_1 Control(100% RDF)	0.23	1.38	1.23
T_2 25% RDN Vermicompost + 75% RDF	0.34	1.67	1.47
T_3 25% RDN FYM + 75% RDF	0.29	1.50	1.36
T_4 25% RDN Sheep manure + 75% RDF	0.26	1.47	1.33
T_5 50% RDN Vermicompost + 50% RDF	0.31	1.53	1.37
T_6 50% RDN FYM + 50% RDF	0.24	1.45	1.26
T_7 50% RDN Sheep manure + 50% RDF	0.24	1.42	1.25
SEm±	0.02	0.05	0.04
CD (P=0.05)	0.04	0.14	0.10
Interaction			
SEm±	0.02	0.07	0.05
CD (P=0.05)	NS	NS	NS
C.V.	13.20	11.61	11.90

Leaf area represents a measure of photosynthetic efficiency. At all the stages of observation, SiA 3085 (C_1) produced higher LAI compared to the other variety *viz.*, SiA 3156 (C_2). This might be due to higher plant height, varietal difference in leaf area and delayed senescence of leaves. These results are in agreement with the findings of Hanumantha Rao *et al*. (1987) and Saini and Negi (1996).

The significant effect on LAI, as consequence of vermicompost and chemical fertilizers was attributed to the favourbale nutrient status of soil. That might have accelerated growth of new tissues and development of shoots that have ultimately increased the leaf area index. These findings are in conformity with Raman and Krishnamoorthy (2016). The other positive influence of vermicompost application include alterations in morphology of crop plants such as increased leaf area (Lazcano *et al.*, 2009).

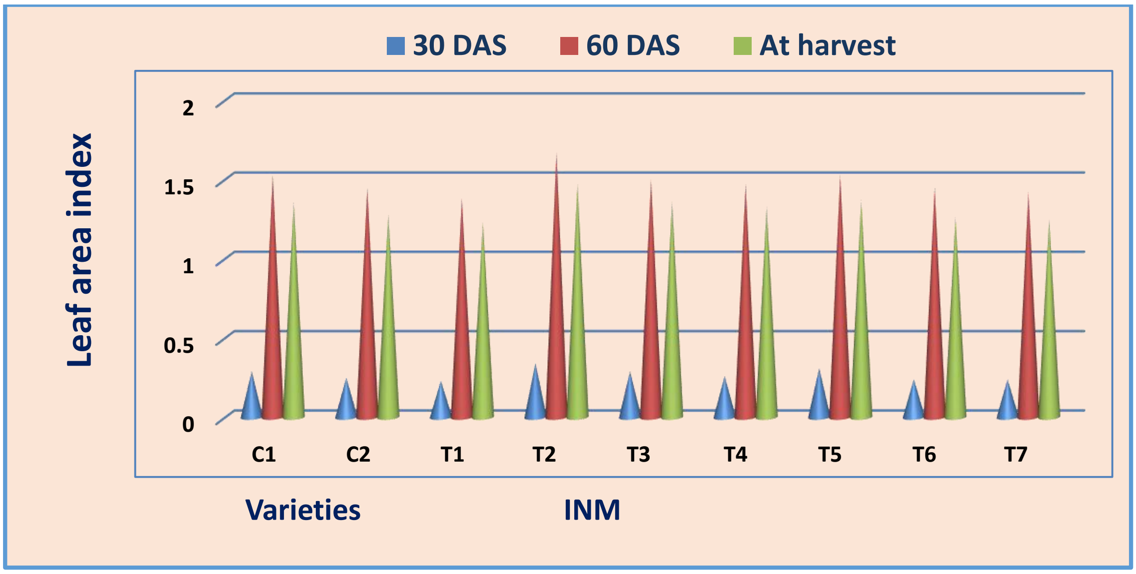

Fig. 4.3 Leaf area index of foxtail millet at different growth stages as influenced by varieties and INM.

4.1.4 Dry matter Production

Data inscribed in table 4.4 and fig. 4.4 pertaining to dry matter accumulation of foxtail millet revealed that dry matter accumulation was significantly influenced by integrated nutrient management at all the stages *viz.*, from 30 DAS up to harvest stage. While the interaction between varieties and integrated nutrient management were found to be non-significant. Dry matter accumulation increased with advancement of crop growth stages and reached to maximum at harvest.

Among the varieties there was no significant difference in dry matter accumulation (g) during the different stages of crop growth recorded from 30 DAS to harvest.

4.1.4.1 Dry matter production at 30 DAS

The data on dry matter accumulation influenced by integrated nutrient management revealed that higher dry matter accumulation was observed with 25% RDN through Vermicompost + 75% RDF (T_2) (855 kg ha^{-1}) which was significantly superior to rest of the treatments and was statistically on par with 50% RDN through Vermicompost + 50% RDF (T_5) (796 kg ha^{-1}). The next best treatments were 25% RDN FYM + 75% RDF (T_3) and 25% RDN Sheep manure + 75% RDF (T_4). The lowest dry matter production was obtained with control *viz.*, 100% RDF.

4.1.4.2 Dry matter production at 60 DAS

With respect to integrated nutrient management treatments, maximum dry matter accumulation was with 25% RDN through Vermicompost + 75% RDF (T_2) (3490 kg ha^{-1}), which was significantly higher to rest of the treatments and was statistically on par with 50% RDN through Vermicompost + 50% RDF (T_5) (3270 kg ha^{-1}). Lowest dry matter accumulation was with control *viz.*, 100% RDF (T_1) (2625 kg ha^{-1}).

4.1.4.3 Dry matter production at harvest

While comparing the integrated nutrient management treatments, 25% RDN through Vermicompost + 75% RDF (T_2) (4442 kg ha^{-1}) had produced maximum dry matter and this treatment was statistically on par with 50% RDN through Vermicompost + 50% RDF (T_5) (4190 kg ha^{-1}). The next best treatments were 25% RDN FYM + 75% RDF (T_3) and 25% RDN Sheep manure + 75% RDF (T_4). Dry matter accumulation was found to be minimum with control at harvest stage (3333 kg ha^{-1}).

Table 4.4 Dry matter production (kg ha^{-1}) of foxtail millet at different growth stages as influenced by varieties and INM.

Treatments	30 DAS	60 DAS	At Harvest
Varieties			
C_1: SiA 3085	762	3054	3876
C_2: SiA 3156	747	2976	3776
SEm±	10.7	47.0	63.5
CD (P=0.05)	NS	NS	NS
Integrated nutrient management			
T_1 Control(100% RDF)	675	2625	3333
T_2 25% RDN Vermicompost + 75% RDF	855	3490	4442
T_3 25% RDN FYM + 75% RDF	763	3098	3884
T_4 25% RDN Sheep manure + 75% RDF	754	3033	3843
T_5 50% RDN Vermicompost + 50% RDF	796	3270	4190
T_6 50% RDN FYM + 50% RDF	724	2819	3610
T_7 50% RDN Sheep manure + 50% RDF	713	2771	3484
SEm±	20.0	88.0	118.8
CD (P=0.05)	59.6	257.1	347.2
Interaction			
SEm±	28.3	124.4	168.0
CD (P=0.05)	NS	NS	NS
C.V.	5.9	9.1	10.8

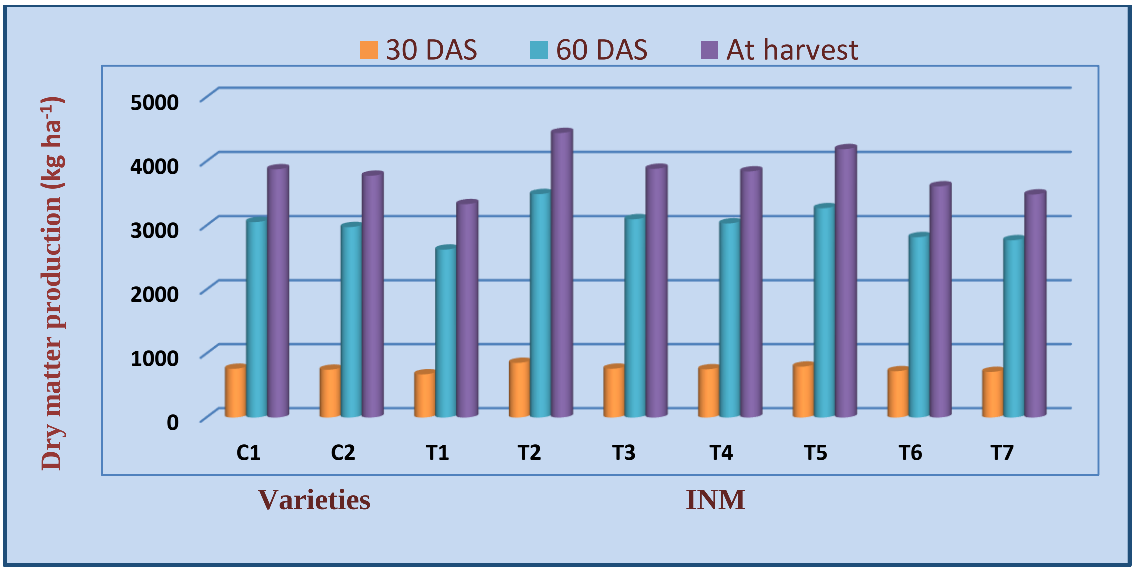

Fig. 4.4 Dry matter production (kg ha^{-1}) of foxtail millet at different growth stages as influenced by varieties and INM.

The higher total dry matter accumulation at all the stages of observation with 25% RDN through Vermicompost + 75% RDF (T_2) and 50% RDN through Vermicompost + 50% RDF (T_5) might be due to the higher availability of nutrients responsible for profuse tillering and higher growth and ultimately increasing the dry matter accumulation. It is the established fact that vermicompost improves the physical and biological properties of soil including supply of almost all the essential plant nutrients for the growth and development of plants. Balanced nutrition due to release of macro and micro nutrients by application of vermicompost under favourable environment might have helped in higher uptake of the nutrients. This accelerated the formation of new tissues and development of new shoots that have ultimately increased the total dry matter accumulation. The results of present investigation are in line with those of Thakral *et al.* (2000) and Yadav and Beniwal (2003) in pearl millet.

4.1.5 Total number of tillers m^{-2}

The total number of tillers m^{-2} recorded at different growth stages of foxtail millet *viz.*, 30, 60 DAS and at harvest was found to be non-significant with the choice of varieties, however it was significantly influenced by integrated nutrient management. The interaction between varieties and integrated nutrient management was found to be non-significant (Table 4.5 and Fig. 4.5).

4.1.5.1 Total number of tillers m^{-2} at 30 DAS

At 30 DAS, significantly higher number of tillers m^{-2} were recorded with 25% RDN through Vermicompost + 75% RDF (T_2) (86.4) and was statistically on par with 50% RDN through Vermicompost + 50% RDF (T_5) (83.2). While the minimum number of tillers m^{-2} were recorded with Control (T_1) (73.3). It ranged from 76.5 to 80.2 with the other integrated nutrient management treatment combinations.

4.1.5.2 Total number of tillers m^{-2} at 60 DAS

At 60 DAS, 25% RDN through Vermicompost + 75% RDF (T_2) (74.3) recorded maximum number of tillers m^{-2} which was significantly superior to other combinations of organic and inorganic treatments, and it was on par with 50% RDN through FYM + 50% RDF (T_5) (71.3). The lowest total number of tillers m^{-2} were recorded with control (T_1) (61.9).

4.1.5.3 Total number of tillers m^{-2} at harvest

The perusal of data on number of tillers m^{-2} of foxtail millet at harvest stage was significantly influenced by integrated nutrient management. Higher number of tillers m^{-2} at harvest were resulted with 25% RDN through Vermicompost + 75% RDF (T_2) (60.9) which was statistically at par with 50% RDN through Vermicompost + 50% RDF (T_5) (57.9). These two treatments were significantly superior over other combinations of organic and inorganic treatments. The less number of tillers m^{-2} at harvest were observed with control (T_1) (48.1).

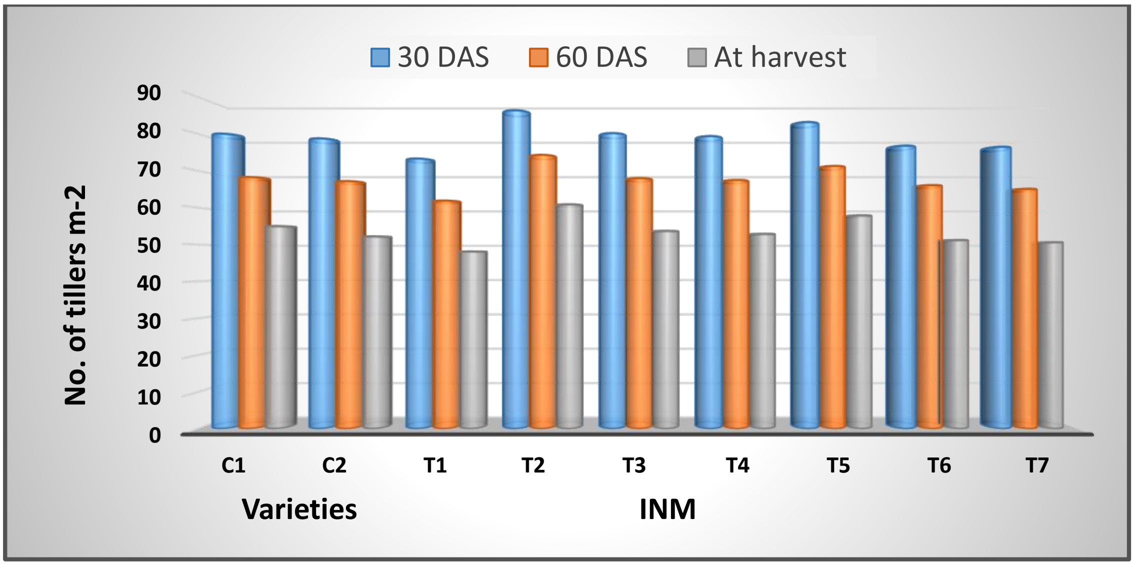

Fig. 4.5 Total number of tillers m^{-2} of foxtail millet at different growth stages as influenced by varieties and INM.

Table 4.5 Total number of tillers m^{-2} of foxtail millet at different growth stages as influenced by varieties and INM.

Treatments	30 DAS	60 DAS	At harvest
Varieties			
C_1: SiA 3085	80.1	68.3	55.0
C_2: SiA 3156	78.8	67.2	52.2
SEm±	1.2	1.1	1.2
CD (P=0.05)	NS	NS	NS
Integrated nutrient management			
T_1 Control(100% RDF)	73.3	61.9	48.1
T_2 25% RDN Vermicompost + 75% RDF	86.4	74.3	60.9
T_3 25% RDN FYM + 75% RDF	80.2	68.0	53.7
T_4 25% RDN Sheep manure + 75% RDF	79.4	67.5	52.9
T_5 50% RDN Vermicompost + 50% RDF	83.2	71.3	57.9
T_6 50% RDN FYM + 50% RDF	76.8	66.1	51.2
T_7 50% RDN Sheep manure + 50% RDF	76.5	65.1	50.6
SEm±	2.2	2.1	2.2
CD (P=0.05)	6.0	6.2	6.4
Interaction			
SEm±	3.1	3.0	3.1
CD (P=0.05)	NS	NS	NS
C.V.	7.8	10.1	13.5

Higher number of tillers m^{-2} of foxtail millet was seen at early stage *viz.*, 30 DAS. As the crop growth advanced from 30 DAS to 60 DAS the number of tillers m^{-2} decreased progressively and found to be lowest at harvest stage irrespective of the treatments. Organic manures had a major role in supply of all vital nutrients required by the plants. N being the growth nutrient is reported to increase the tiller numbers. In the present investigation integrated use of manures and fertilizers was improved the plant growth parameters compared to application manures and fertilizers alone. These results corroborate with the findings of Rakesh *et al*. (2014), Thumar *et al*. (2016), Husain *et al*. (2017) and Monisha *et al.* (2019).

4.1.6 Days to 50% flowering

Days to 50 per cent flowering of foxtail millet remained non-significant in response to integrated nutrient management practices, also among the foxtail millet varieties tested there was no significant difference with days to 50% flowering, and the effect of their interaction was also found to be non-significant (Table 4.6 and Fig. 4.6).

Table 4.6 Days to 50 per cent flowering of foxtail millet as influenced by varieties and INM.

Treatments	Days to 50% Flowering
Varieties	
C_1: SiA 3085	46
C_2: SiA 3156	46
SEm±	0.5
CD (P=0.05)	NS
Integrated nutrient management	
T_1 Control(100% RDF)	47
T_2 25% RDN Vermicompost + 75% RDF	44
T_3 25% RDN FYM + 75% RDF	46
T_4 25% RDN Sheep manure + 75% RDF	46
T_5 50% RDN Vermicompost + 50% RDF	45
T_6 50% RDN FYM + 50% RDF	47
T_7 50% RDN Sheep manure + 50% RDF	47
SEm±	0.9
CD (P=0.05)	NS
Interaction	
SEm±	1.3
CD (P=0.05)	NS
C.V.	5.0

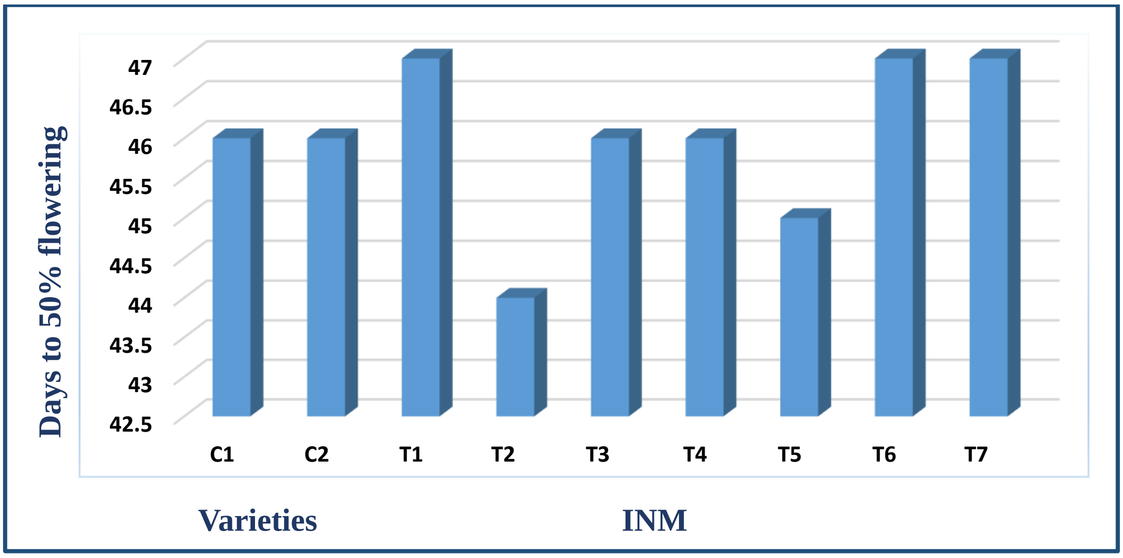

Fig. 4.6 Days to 50 per cent flowering of foxtail millet as influenced by varieties and INM.

Among integrated nutrient management treatment practices days to 50 per cent flowering was earlier with application of 25% RDN through Vermicompost + 75% RDF compared to other treatments. This might be due to the role of vermicompost, which enhances the utility of using the accumulated growing degree days resulting in earlier flowering and maturity of the crop. Earlier maturity due to increased nitrogen and other nutrients availability by vermicompost, may be due to the role of poly amines, the low molecular weight organic nitrogen compounds that are usually involved in cell division, embryogenesis, floral initiation and development within the schedule period of crop ontogeny. This is in line with the findings of Jyothi *et al.* (2016).

4.2 YIELD ATTRIBUTES AND YIELD:

4.2.1 Number of panicles m^{-2}

Number of panicles m^{-2} at harvest were found to be non-significant with choice of varieties. However it was significantly influenced by integrated nutrient management practices. The interaction between varieties and integrated nutrient management was found to be non-significant (Table 4.7 and Fig. 4.7).

Highest number of panicles m^{-2} at harvest were recorded with 25% RDN through Vermicompost + 75% RDF (T_2) (45), which was statistically on par with 50% RDN through Vermicompost + 50% RDF (T_5) (42) and was significantly superior over the other combinations of organic and inorganic treatments. The next best treatment was 25% RDN through FYM + 75% RDF (T_3) and 25% RDN through Sheep manure + 75% RDF (T_4). All the combinations of organic and inorganic treatments were found to be superior over control (100% RDF) (36) that produced the lowest number of panicles m^{-2}. This might be due to improved availability of required quantities of nutrients to produce more number of tillers m^{-2} and then converted to more number of productive tillers m^{-2}. Similar results were reported by Hasan *et al.* (2013).

4.2.2 Length of panicle (cm)

The panicle length of foxtail millet was significantly influenced by different varieties and integrated nutrient management practices, while the interaction effect was non-significant (Table 4.7 and Fig. 4.7).

The variety SiA 3085 (C_1) recorded the highest panicle length of 23.5 cm which was significantly higher than the other variety SiA 3156 (C_2) (21.5 cm). This might be due to the genetic potential of the variety in deciding the length of the panicle and in better partitioning of assimilates from source to sink. Similar results were obtained by Jyothi *et al.* (2016), Hanumantha Rao *et al.* (1987), Intodia (1994) and Saini and Negi (1996).

Application of 25% RDN through Vermicompost + 75% RDF (T_2) (25.4 cm) recorded the significantly highest panicle length than the other integrated nutrient management treatments and was on par with 50% RDN through Vermicompost + 50% RDF (T_5) (23.7 cm), while the shortest panicle length was observed with control (T_1) (20.1 cm). All the combinations of organic and inorganic treatments were found to be superior over control. The length of the panicle in other combinations of organic and inorganic sources ranged from 22.7 cm to 21.8 cm.

This might be due to more vigorous and luxuriant vegetative growth due to application of vermicompost along with inorganic fertilizer, which in turn favoured a better partitioning of assimilates from source to sink. The present results were in accordance with the findings of Subramanian and Ganesaraja (1992) and Hasan *et al.* (2013).

4.2.4 Number of grains panicle^{-1}

Data inscribed in table 4.7 and fig. 4.8 pertaining to number of grains panicle^{-1} of foxtail millet revealed that number of grains panicle^{-1} were significantly influenced by varieties and integrated nutrient management, whereas the interaction effect between them was statistically not traceable.

The higher number of grains panicle^{-1} were recorded with SiA 3085 (C_1) (2155) which was having significantly higher than SiA 3156 (C_2) (2022).

Among the integrated nutrient management treatments, 25% RDN through Vermicompost + 75% RDF (T_2) had resulted in highest number of grains panicle^{-1} (2611), which was statistically on par with 50% RDN through Vermicompost + 50% RDF (T_5) (2182) and was significantly superior over other combinations of organic and inorganic treatments. The lowest number of grains panicle^{-1} of 1928 was observed with application of 100% RDF.

This might be associated with the increased growth of the crop in terms of plant height, dry matter accumulation and higher number of tillers recorded under these treatments due to greater availability of most of the macro and micro nutrients in appropriate amounts by organic manures and balanced proportion that led to higher uptake of the nutrients. The increased growth provided greater site for photosynthesis and diversion of photosynthates towards sink (panicle and grain). Synergistic effect shown by the inorganic and organic nutrients might be also the reason for enhanced physiological activity of the plants showing better partition and translocation of photosynthates to the sink. These findings are in consonance with Divya *et al.* (2017) in pearl millet and Roy *et al.* (2018) in finger millet.

4.2.4 Number of filled grains panicle^{-1}

Number of filled grains panicle^{-1} were found to be significantly influenced by different varieties and integrated nutrient management practices tested, while the interaction effect was not statistically traceable (Table 4.7and Fig. 4.8).

Among varieties tested, the highest number of filled grains panicle^{-1} were obtained with the variety SiA 3085 (C_1) (2029), which was significantly superior over the variety SiA 3156 (C_2) (1905). Higher number of filled grains panicle^{-1} with SiA 3085 (C_1), might be due to efficient translocation of photosynthates from source to the sink and also the genetic potential of variety. This is in the accordance with the results reported by Gurunadha Rao *et al.* (1990), Divya and Maurya (2013), Jyothi *et al.* (2016).

The highest number of filled grains per panicle at harvest (2200) were recorded with 25% RDN through Vermicompost + 75% RDF (T_2) which was significantly superior to rest of the treatments and was statistically on par with 50% RDN through Vermicompost + 50% RDF (T_5) (2058). The lowest number of filled grains per panicle (1812) were obtained with control. All the treatments having combined application of organic and inorganic fertilizers were superior over control in having higher number of filled grains per panicle, which ranged from 1971 to 1886.

The beneficial effect on yield attribute *viz*., number of filled grains per panicle might be due to the increased supply of all the essential nutrients by vermicompost resulted in higher manufacture of food and its subsequent partitioning towards sink, for the same reason the chaffy grains were less resulting in higher number of filled grains per panicle. The findings of present investigation are supported by Verma (1996) and Khan *et al.* (2000) in pearl millet.

4.2.5 Test weight (g)

The perusal of data on thousand grain weight of foxtail millet at harvest stage was significantly influenced by integrated nutrient management practices, whereas the effect of varieties and the interaction effect between varieties and integrated nutrient management were not statistically traceable (Table. 4.7 and Fig. 4.9).

Data revealed that application of 25% RDN through Vermicompost + 75% RDF (T_2) registered higher test weight of 3.26 g which was on par with 50% RDN through Vermicompost + 50% RDF(T_5) (3.15 g) and significantly superior to rest of the treatments. The lowest test weight was recorded with control (100% RDF) (T_1) (2.90 g). The data on integrated nutrient management treatment combinations ranged from 3.11 g to 3.03 g.

Table 4.7 No. of panicles m^{-2}, length of the panicle (cm), no. of grains panicles^{-1}, no. of filled grains panicles^{-1}, test weight (g) of foxtail millet as influenced by varieties and INM.

Treatments	No. of panicles m^{-2}	Length of the panicle (cm)	No. of grains panicle^{-1}	No. of filled grains panicle^{-1}	Test weight (g)
Varieties					
C_1: SiA 3085	40	23.5	2155	2029	3.10
C_2: SiA 3156	39	21.5	2022	1905	3.08
SEm±	0.8	0.5	41.8	37.4	0.02
CD (P=0.05)	NS	1.5	122.2	109.4	NS
Integrated nutrient management					
T_1 Control(100% RDF)	36	20.1	1928	1812	2.90
T_2 25% RDN Vermicompost + 75% RDF	45	25.4	2327	2200	3.26
T_3 25% RDN FYM + 75% RDF	41	22.7	2098	1971	3.11
T_4 25% RDN Sheep manure + 75% RDF	40	22.3	2096	1950	3.09
T_5 50% RDN Vermicompost + 50% RDF	42	23.7	2182	2058	3.15
T_6 50% RDN FYM + 50% RDF	38	21.7	2019	1895	3.06
T_7 50% RDN Sheep manure + 50% RDF	37	21.8	1969	1886	3.03
SEm±	1.4	0.9	78.2	70.0	0.04
CD (P=0.05)	4.2	2.7	228.6	204.6	0.11
Interaction					
SEm±	2.0	1.3	110.6	99.1	0.05
CD (P=0.05)	NS	NS	NS	NS	NS
C.V.	9.1	5.1	5.1	5.1	7.2

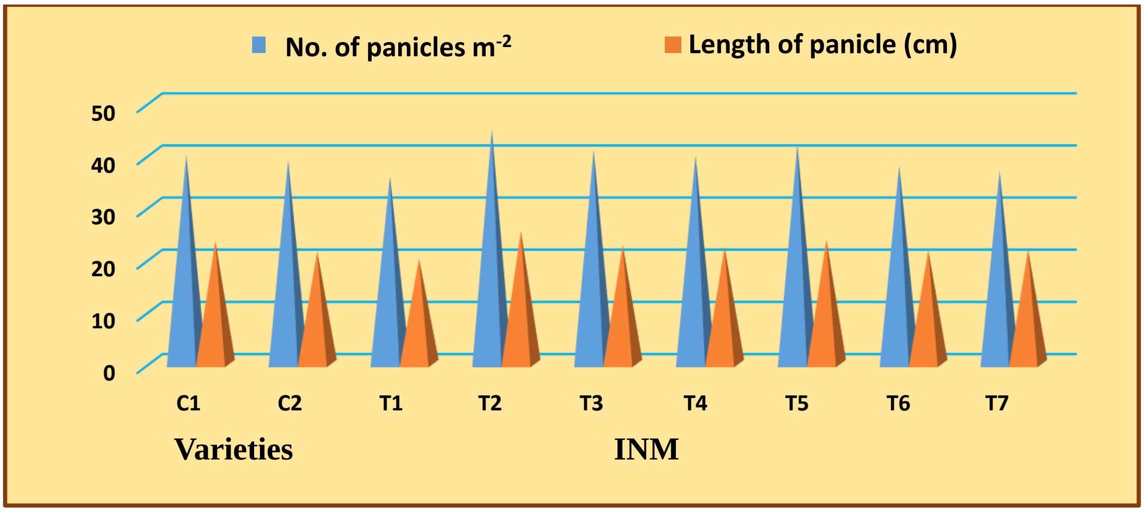

Fig. 4.7 No. of panicles m^{-2} and length of panicle (cm) of foxtail millet as influenced by varieties and INM.

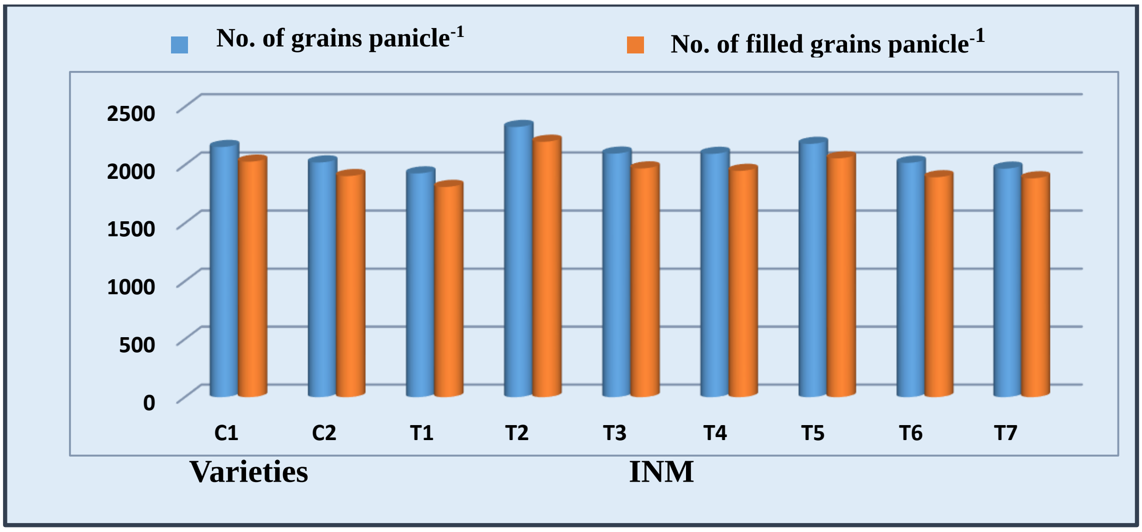

Fig. 4.8 No. of grains $panicle^{-1}$ and no. of filled grains $panicle^{-1}$ foxtail millet as influenced by varieties and INM.

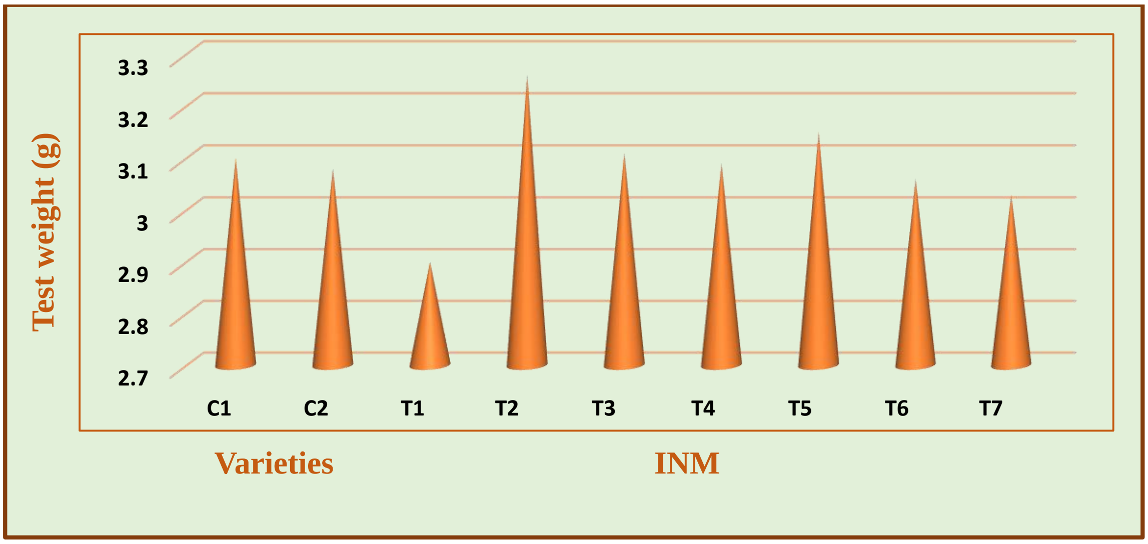

Fig. 4.9 Test weight foxtail millet as influenced by varieties and INM.

Though test weight is a genetic character, but due to good management, weight of foxtail millet grain increased with combination of inorganic fertilizers and vermicompost. Vermicompost contain sufficient amount of vitamins, amino acids, antibiotics, enzymes and hormones that are helpful in growth and development of plants (Anil *et al*., 2018). While vermicomopst supplied essential nutrients for plant growth and development, that may be due to efficient dry matter partitioning and better translocation to the sink, leading to the formation of large sized grains due to adequate availability of nutrients at the time of grain filling. This ultimately resulted in higher test weight. This is in the accordance with the results reported by Rani *et al*. (2017), Ullasa *et al*. (2017) in finger millet, Divya *et al*. (2017) and Patel *et al*. (2014) in pearl millet.

4.2.5 Grain yield (Kg ha^{-1})

The grain yield of foxtail millet was significantly influenced by the integrated nutrient management practices, while the choice of varieties and the interaction between varieties and integrated nutrient management were not statistically significant.

It was inferred from the data (Table 4.8 and Fig. 4.10) that grain yield of foxtail millet was significantly increased in all the treatments in comparison to 100% RDF (1725 kg ha^{-1}). Regarding integrated nutrient management practices, application of 25% RDN through Vermicompost + 75% RDF (T_2) (2324 kg ha^{-1}) recorded the highest grain yield which was significantly superior to rest of the treatments and was statistically on par with application of 50% RDN through Vermicompost + 50% RDF (T_5) (2187 kg ha^{-1}). The grain yield ranged from 1903 kg ha^{-1} to 2089 kg ha^{-1}with all the other integrated nutrient management practices. The grain yield increased by 34.70% with application of 25% RDN through Vermicompost + 75% RDF (T_2) over control.

Grain yield is directly related with the growth and yield attributes. All the growth and yield attributes were higher with application of 25% RDN through Vermicompost + 75% RDF (T_2) and 50% RDN through Vermicompost + 50% RDF (T_5). The increased grain yield can be ascribed to the effect of adequate availability of NPK in soil solution, may cause increase in root growth, thereby increasing uptake of nutrients. Actually, addition of vermicompost in soil before sowing has immediate benefit as it contain nutrients in plant available form and these nutrients can be directly absorbed by the crop plants, referred by Anil *et al*. (2018). Higher yield due to combined application of chemical fertilizers and organic manures might have attributed to sustained nutrient supply and also as a result of better utilization of applied nutrients through improved micro environmental conditions, especially the activities of soil microorganisms involved in nutrient transformation and fixation. These findings are in close agreement with those reported by Senapati *et al.* (2007), Basavaraju and Purushotha (2009), Chaudhari *et al.* (2011) in finger millet.

4.2.5 Straw yield (Kg ha^{-1})

Data obtained on straw yield was significantly influenced by integrated nutrient management treatments while the straw yield was found to be non-significant with the choice of varieties. The result obtained (Table. 4.8 and Fig. 4.10) also revealed that the interaction between varieties and integrated nutrient management treatments was not found to be significant.

Perusal of data revealed that significantly higher straw yield of 4353 kg ha^{-1} was noticed with 25% RDN through Vermicompost + 75% RDF (T_2), which was statistically on par with application of 50% RDN through Vermicompost + 50% RDF (T_5) (4144 kg ha^{-1}). The next best treatments were 25% RDN through FYM + 75% RDF (T_3) (3987 kg ha^{-1}), 25% RDN through Sheep manure + 75% RDF (T_4) (3917 kg ha^{-1}), 50% RDN through FYM + 50% RDF (T_6) (3720 kg ha^{-1}), 50% RDN through Sheep manure + 50% RDF (T_7) (3651 kg ha^{-1}) respectively. The lowest straw yield 3353 kg ha^{-1} was obtained with control (T_1) which was significantly inferior to rest of the treatments. The straw yield increased by 29.8% with application of 25% RDN through Vermicompost + 75% RDF (T_2) over control.

This could be attributed to the higher availability of NPK during crop growth period which improved the plant height, number of tillers and eventually increased the straw yield. These findings are in close agreement with Hasan *et al*. (2013), who observed that in foxtail millet straw yield improved up to higher availability of NPK supply. The conjunctive use of organic and inorganic sources has beneficial effect on physiological process of plant metabolism and growth thereby leading to higher grain and straw yields. The easy availability of nitrogen due to mineralization of organics influences the shoot and root growth favouring absorption of other nutrients. Similar results were obtained by Yakadri and Reddy (2009), Umesh *et al*., (2006) and Basavaraju and Purushotham (2009), Thesiya *et al*., (2019).

4.2.5 Harvest index (%)

The harvest index remained non-significant with respect to varieties, integrated nutrient management practices as well as their interaction. (Table 4.8 and Fig. 4.11).

Table 4.8 Grain yield, straw yield (kg ha^{-1}) and harvest index (%) of foxtail millet as influenced by varieties and INM.

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
Varieties			
C_1: SiA 3085	2048	3929	34.23
C_2: SiA 3156	2011	3820	34.42
SEm±	43.4	46.5	0.55
CD (P=0.05)	NS	NS	NS
Integrated nutrient management			
T_1 Control(100% RDF)	1725	3353	33.97
T_2 25% RDN Vermicompost + 75% RDF	2324	4353	34.78
T_3 25% RDN FYM + 75% RDF	2087	3987	34.35
T_4 25% RDN Sheep manure + 75% RDF	2058	3917	34.28
T_5 50% RDN Vermicompost + 50% RDF	2187	4144	34.60
T_6 50% RDN FYM + 50% RDF	1923	3720	34.08
T_7 50% RDN Sheep manure + 50% RDF	1903	3651	34.22
SEm±	81.1	87.1	1.03
CD (P=0.05)	236.0	254.5	NS
Interaction			
SEm±	114.7	123.1	1.45
CD (P=0.05)	NS	NS	NS
C.V.	10.9	7.5	7.5

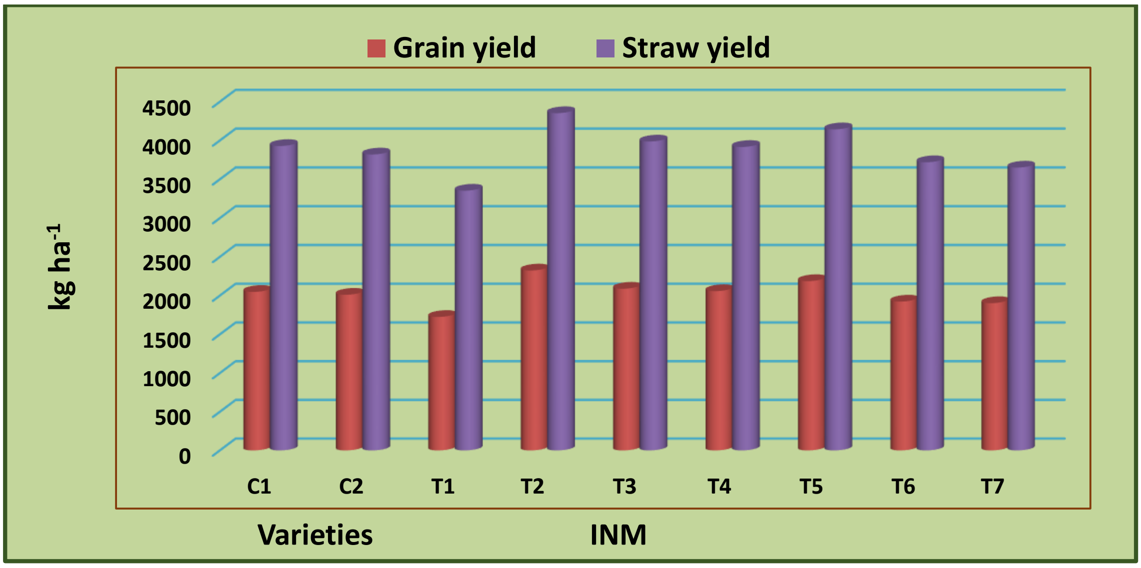

Fig. 4.10 Grain and straw yield (kg ha^{-1}) of foxtail millet as influenced by varieties and INM.

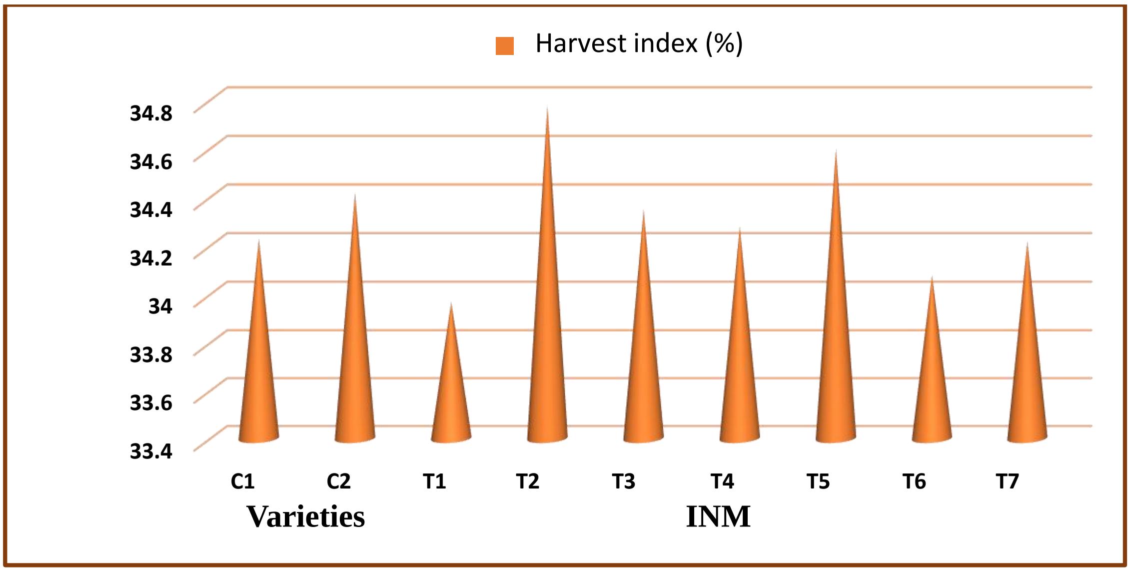

Fig. 4.11 Harvest index (%) of foxtail millet as influenced by varieties and INM.

The effect of integration of chemicals and organics on harvest index *i.e.*, partitioning of photosynthates between vegetative and reproductive organs was non-significant indicating proportionate partitioning with increasing and decreasing supply of nitrogen. These findings are in agreement with Senapati *et al.* (2007) and Thesiya *et al.* (2019).

4.4. Uptake analysis

4.4.1 Nitrogen uptake

The critical examination of the data revealed that nitrogen uptake by foxtail millet was significantly influenced by integrated nutrient management practices, while the effect of varieties and interaction between varieties and integrated nutrient management were not significant (Table. 4.9 and Fig. 4.12).

At 30 DAS with respect to integrated nutrient management practices, significantly higher nitrogen uptake of 20.52 kg ha^{-1} was noticed with 25% RDN through Vermicompost + 75% RDF (T_2), which was statistically on par with 50% RDN through Vermicompost + 50% RDF (T_5) (18.45 kg ha^{-1}). The lowest nitrogen uptake of 14.02 kg ha^{-1} was recorded with Control (100% RDF) (T_1). It ranged from 15.15 to 17.20 kg ha^{-1} with other combinations of organic and inorganic sources.

At 60 DAS maximum nitrogen uptake of 50.07 kg ha^{-1} was noticed when foxtail millet crop was imposed with 25% RDN through Vermicompost + 75% RDF (T_2), which was statistically on par with 50% RDN through Vermicompost + 50% RDF (T_5) (45.42 kg ha^{-1}). The lowest content of nitrogen uptake 31.90 kg ha^{-1} was observed with Control

(100% RDF) (T_1) which was on par with 50% RDN through FYM + 50% RDF (T_6) (36.50 kg ha^{-1}) and 50% RDN through Sheep manure + 50% RDF (T_7) (35.05 kg ha^{-1}).

Perusal of data on nitrogen uptake by straw revealed that significantly higher nitrogen uptake was found with 25% RDN through Vermicompost + 75% RDF (T_2) (36.34 kg ha^{-1}), which was significantly superior to rest of the treatments and on par with 50% RDN through Vermicompost + 50% RDF (T_5) (33.54 kg ha^{-1}). Among the integrated nutrient management treatments lowest nitrogen uptake by straw was recorded with Control (100% RDF) (T_1) (25.60 kg ha^{-1}). It ranged from 28.82 to 25.69 kg ha^{-1} with other combinations of organic and inorganic sources.

Nitrogen uptake by grain was significantly higher with 25% RDN through Vermicompost + 75% RDF (T_2) (25.32 kg ha^{-1}) and was statistically at par with the application of 50% RDN through Vermicompost + 50% RDF (T_5) (24.67 kg ha^{-1}). The lowest nitrogen uptake by grain recorded with Control (100% RDF) (T_1) (17.17 kg ha^{-1}).

It is clear from the data (Table 4.8) that application of 25% RDN through Vermicompost + 75% RDF (T_2) recorded significantly highest total nitrogen uptake at harvest (61.66 kg ha^{-1}) among all the treatments and statistically at par with the application of 50% RDN through Vermicompost + 50% RDF (T_5) (58.21 kg ha^{-1}). The lowest total nitrogen uptake at harvest was observed with Control (100% RDF) (T_1) (42.23 kg ha^{-1}), which was inferior to other organic and inorganic treatment combinations. It ranged from 51.81 to 44.40 kg ha^{-1} with other combinations of organic and inorganic sources.

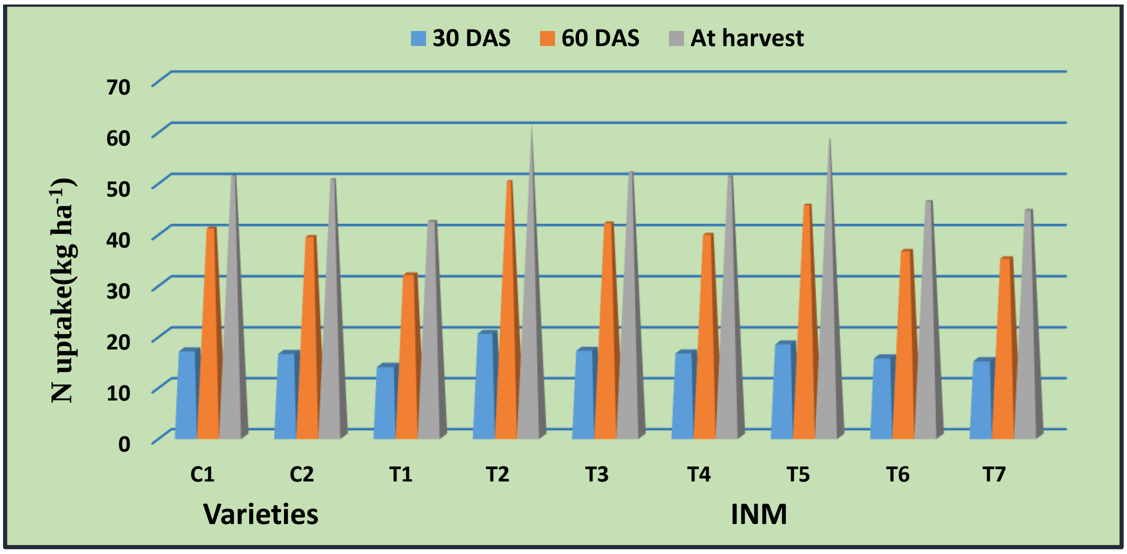

Fig. 4.12 Nitrogen uptake (kg ha^{-1}) of foxtail millet as influenced by varieties and INM.

The increase in dry matter yield together with increased levels of nitrogen by addition of vermicompost had led to the higher uptake of nitrogen by plants. The present investigation confirms the documented evidence of Naik *et al.* (1995), Basavarajappa *et al.* (2002), Jyothi *et al.* (2016) and Negi (2017).

Table 4.9 Nitrogen uptake (kg ha^{-1}) of foxtail millet as influenced by varieties and INM at 30 and 60 DAS and at harvest.

Treatments	30 DAS	60 DAS	At harvest		
			Straw	Grain	Total
Varieties					
C_1: SiA 3085	17.06	40.91	29.48	21.50	51.08
C_2: SiA 3156	16.57	39.24	29.15	21.24	50.47
SEm±	0.34	0.97	0.93	0.52	1.22
CD (P=0.05)	NS	NS	NS	NS	NS
Integrated nutrient management					
T_1 Control(100% RDF)	14.02	31.90	25.60	17.17	42.23
T_2 25% RDN Vermicompost + 75% RDF	20.52	50.07	36.34	25.32	61.66
T_3 25% RDN FYM + 75% RDF	17.20	41.93	28.82	22.00	51.81
T_4 25% RDN Sheep manure + 75% RDF	16.67	39.68	29.25	21.73	50.98
T_5 50% RDN Vermicompost + 50% RDF	18.45	45.42	33.54	24.67	58.21
T_6 50% RDN FYM + 50% RDF	15.70	36.50	26.53	19.60	46.12
T_7 50% RDN Sheep manure + 50% RDF	15.15	35.05	25.69	18.71	44.40
SEm±	0.63	1.82	1.75	0.98	2.28
CD (P=0.05)	1.80	5.31	5.10	2.91	6.68
Interaction					
SEm±	0.89	2.57	2.47	1.39	3.23
CD (P=0.05)	NS	NS	NS	NS	NS
C.V.	8.61	8.12	13.80	13.11	10.13

4.4.2 Phosphorous uptake

Phosphorous uptake was found to be significantly influenced by integrated nutrient management practices, while the effect of varieties and the interaction between varieties and integrated nutrient management were found to be non-significant. (Table 4.10 and Fig. 4.13)

Significantly higher uptake of phosphorous at 30 DAS was observed with the application of 25% RDN through Vermicompost + 75% RDF (T_2) (5.19 kg ha^{-1}), which was statistically at par with 50% RDN through Vermicompost + 50% RDF (T_5) (4.61 kg ha^{-1}) and was significantly superior to rest of the treatments in phosphorous uptake. The lowest phosphorous uptake was recorded with Control (100% RDF) (T_1) (3.05 kg ha^{-1}). It ranged from 4.25 to 3.40 kg ha^{-1} with other combinations of organic and inorganic treatments.

Perusal of data on phosphorous uptake at 60 DAS revealed that higher phosphorous uptake was found with 25% RDN through Vermicompost + 75% RDF (T_2) (17.58 kg ha^{-1}), which was statistically at par with 50% RDN through Vermicompost + 50% RDF (T_5) (16.07 kg ha^{-1}) and was significantly superior to other integrated nutrient management treatments. Among all the treatments the lowest phosphorous uptake was recorded with Control (100% RDF) (T_1) (10.02 kg ha^{-1}).

It is clear from the data (Table 4.10) that application of 25% RDN through Vermicompost + 75% RDF (T_2) recorded the significantly highest phosphorus uptake by straw (21.45 kg ha^{-1}) among all the treatments and was statistically at par with 50% RDN through Vermicompost + 50% RDF (T_5) (19.95 kg ha^{-1}). It was followed by 25% RDN FYM + 75% RDF (T_3) and 25% RDN Sheep manure + 75% RDF (T_4). The lowest phosphorous uptake by straw was observed with Control (100% RDF) (T_1) (12.46 kg ha^{-1}).

Highest phosphorus uptake by grain was recorded with application of 25% RDN through Vermicompost + 75% RDF (T_2) (10.68 kg ha^{-1}) which was significantly superior over all the treatments except 50% RDN through Vermicompost + 50% RDF (T_5) (9.58 kg ha^{-1}), which was at par with it. The next best treatments were 25% RDN FYM + 75% RDF (T_3) and 25% RDN Sheep manure + 75% RDF (T_4). The lowest phosphorous uptake by grain recorded with Control (100% RDF) (T_1) (6.71 kg ha^{-1}). It ranged from 7.54 to 9.22 kg ha^{-1} with other INM combinations.

Further reference to data revealed that the maximum concentration of total phosphorus uptake at harvest by straw and grain was recorded with 25% RDN through Vermicompost + 75% RDF (T_2) (32.13 kg ha^{-1}) which was significantly superior among all the treatments, and was statistically at par with 50% RDN through Vermicompost + 50% RDF (T_5) (29.53 kg ha^{-1}). The lowest total phosphorous uptake at harvest was seen in Control (100% RDF) (T_1) (19.18 kg ha^{-1}) and was inferior to all the combinations of organic and inorganic treatments.

Table 4.10 Phosphorous uptake (kg ha^{-1}) of foxtail millet as influenced by varieties and INM at 30 and 60 DAS and at harvest.

Treatments	30 DAS	60 DAS	At harvest		
			Straw	Grain	Total
Varieties					
C_1: SiA 3085	4.14	13.99	16.95	8.78	25.73
C_2: SiA 3156	3.92	12.99	16.21	8.31	24.52
SEm±	0.13	0.43	0.48	0.27	0.63
CD (P=0.05)	NS	NS	NS	NS	NS
Integrated nutrient management					
T_1 Control(100% RDF)	3.05	10.02	12.46	6.71	19.18
T_2 25% RDN Vermicompost + 75% RDF	5.19	17.58	21.45	10.68	32.13
T_3 25% RDN FYM + 75% RDF	4.25	14.27	16.50	9.22	25.72
T_4 25% RDN Sheep manure + 75% RDF	4.06	13.88	16.23	8.44	24.67
T_5 50% RDN Vermicompost + 50% RDF	4.61	16.07	19.95	9.58	29.53
T_6 50% RDN FYM + 50% RDF	3.66	12.22	15.02	7.66	22.68
T_7 50% RDN Sheep manure + 50% RDF	3.40	10.39	14.43	7.54	21.97
SEm±	0.24	0.80	0.89	0.49	1.17
CD (P=0.05)	0.69	2.34	2.60	1.43	3.43
Interaction					
SEm±	0.33	1.13	1.26	0.69	1.66
CD (P=0.05)	NS	NS	NS	NS	NS
C.V.	13.31	17.60	14.02	17.68	13.41

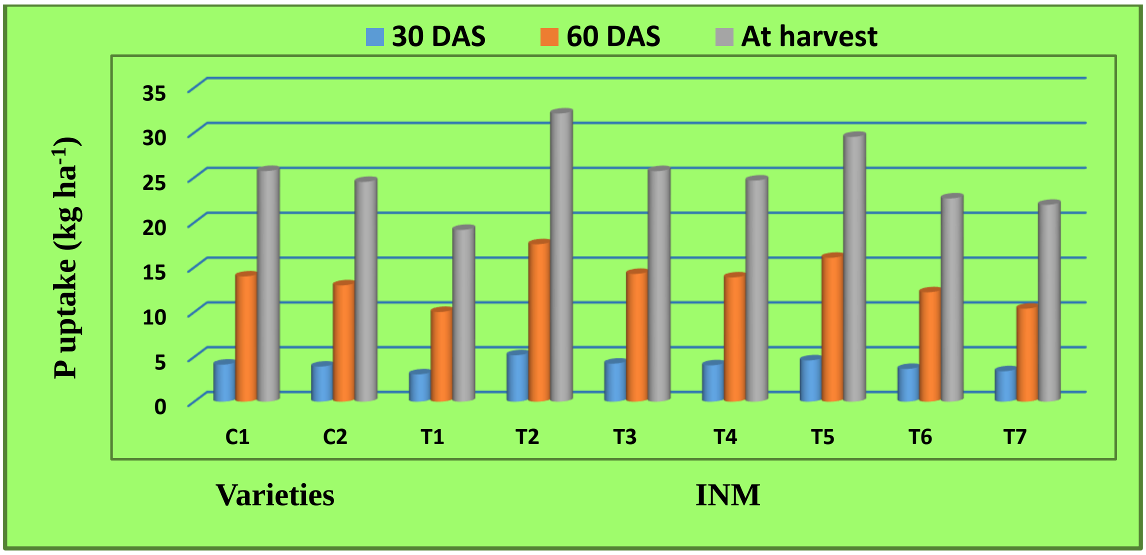

Fig. 4.13 Phosphorous uptake (kg ha^{-1}) of foxtail millet as influenced by varieties and INM.

Phosphorus uptake is vital in enhancing yield and nutrient content of crop. Considerable increase in either nutrient content or in yield may increase the uptake. Phosphorus uptake coincide with higher nutrient contents and yields. Uptake of any nutrient is the function of its content and dry matter production by the crop. Higher nutrient content in the produce and higher biomass production of foxtail millet might be the pertinent reason for higher uptake of phosphorus. These findings were in close agreement with the results reported by Mehta *et al*. (2005), Singh *et al.* (2011).

4.4.3 Potassium uptake

Potassium uptake was found to be significantly influenced by different integrated nutrient management practices while effect of varieties was non-significant. Experimental results revealed that interaction effect between varieties and integrated nutrient management practices was found to be non-significant (Table 4.11 and Fig. 4.14).

At 30 DAS application of 25% RDN through Vermicompost + 75% RDF (T_2) recorded the highest potassium uptake of 30.24 kg ha^{-1}, which was significantly superior among all the treatments and was statistically at par with 50% RDN through Vermicompost + 50% RDF (T_5) (28.85 kg ha^{-1}). The lowest total phosphorous uptake at harvest was seen in Control (100% RDF) (T_1) (21.95 kg ha^{-1}), which was significantly inferior to all other treatments. It ranged from 26.44 to 23.93 kg ha^{-1} with other INM combinations.

Potassium uptake at 60 DAS was highest with application of 25% RDN through Vermicompost + 75% RDF (T_2) (78.67 kg ha^{-1}) which was significantly superior to rest of the treatments and was statistically at par with 50% RDN through Vermicompost + 50% RDF (T_5) (74.07 kg ha^{-1}). The lowest potassium uptake at 60DAS recorded with Control (100% RDF) (T_1) (57.14 kg ha^{-1}). The uptake of potassium ranged from 70.56 to 60.68 kg ha^{-1} with other INM combinations.

Higher uptake of potassium by straw *viz.*, 79.91 kg ha^{-1} was observed with the application of 25% RDN through Vermicompost + 75% RDF (T_2), which was at par with 50% RDN through Vermicompost + 50% RDF (T_5) (76.44 kg ha^{-1}) and significantly superior over all other treatments. The least uptake of potassium by straw was observed with Control (100% RDF) (T_1) (60.21 kg ha^{-1}). It ranged from 73.72 to 63.57 kg ha^{-1} with other INM combinations.

Perusal of data on potassium uptake by grain revealed that highest potassium uptake was found with 25% RDN through Vermicompost + 75% RDF (T_2) (10.89 kg ha^{-1}), which was significantly superior to rest of the treatments and was on par with 50% RDN through Vermicompost + 50% RDF (T_5) (10.00 kg ha^{-1}). Among the integrated nutrient management treatments lowest uptake of potassium by grain was recorded with Control (100% RDF) (T_1) (7.48 kg ha^{-1}). It ranged from 9.35 to 8.16 kg ha^{-1} with other INM combinations.

Data revealed that application of 25% RDN through Vermicompost + 75% RDF (T_2) registered highest total uptake of potassium at harvest *viz.*, 89.24 kg ha^{-1} which was statistically on par with 50% RDN through Vermicompost + 50% RDF (T_5) (88.76 kg ha^{-1}) and significantly superior to rest of the treatments. The lowest total potassium uptake at harvest was recorded with control (100% RDF) (T_1) (67.00 kg ha^{-1}). It ranged from 82.08 to 71.25 kg ha^{-1} with other INM combinations.

The higher K uptake with higher nitrogen availability might be due to the synergistic effect of nitrogen and potassium due to increased availability of nitrogen which in turn increased the K concentration in turn increased the K concentration in grain and straw and finally led to increased K uptake. The results in line with Negi (2017).

Combined application of organic and inorganic fertilizers created favourable nutritional environment to the plant rhizosphere which enhanced the photosynthetic activity and translocation of nutrients thus increasing the grain yield and nutrient uptake by plant at all growth stages and at harvest. Vermicompost is a good quality manure that contain several essential nutrients needed by the crops such as nitrogen, phosphorus, potassium, calcium, magnesium and micronutrients *viz.,* iron, zinc, copper, manganese in sufficient quantity that increase the productivity and quality of crops (Anil *et al*., 2018). Higher NPK concentration in vermicompost coupled with higher availability of nutrients in simple form over the entire cropping season could have resulted in higher yields and nutrient uptake than FYM, sheep manure and inorganic fertilizers. Increased uptake by the crop can also be ascribed to higher dry matter production, increased availability of nutrients from soil reservoir and through solubilization coupled with additional nutrient supply by vermicompost. The results were in accordance with those of Patil *et al*. (2015), Pallavi *et al*. (2016).

Table 4.11 Potassium uptake (kg ha^{-1}) of foxtail millet as influenced by varieties and INM at 30 and 60 DAS and at harvest.

Treatments	30 DAS	60 DAS	At harvest		
			Straw	Grain	Total
Varieties					
C_1: SiA 3085	26.15	68.51	70.34	9.24	80.59
C_2: SiA 3156	25.52	66.29	69.74	8.87	78.09
SEm±	0.38	1.03	1.12	0.26	1.29
CD (P=0.05)	NS	NS	NS	NS	NS
Integrated nutrient management					
T_1 Control(100% RDF)	21.95	57.14	60.21	7.48	67.00
T_2 25% RDN Vermicompost +75% RDF	30.24	78.67	79.91	10.89	89.24
T_3 25% RDN FYM + 75% RDF	26.44	70.56	73.72	9.35	82.08
T_4 25% RDN Sheep manure + 75% RDF	25.90	68.24	71.14	9.28	81.30
T_5 50% RDN Vermicompost + 50% RDF	28.85	74.07	76.44	10.00	88.76
T_6 50% RDN FYM + 50% RDF	24.54	62.45	65.31	8.24	73.76
T_7 50% RDN Sheep manure + 50% RDF	23.93	60.68	63.57	8.16	71.25
SEm±	0.70	1.94	2.10	0.48	2.40
CD (P=0.05)	2.04	5.68	6.10	1.40	7.02
Interaction					
SEm±	1.00	2.74	2.97	0.68	3.40
CD (P=0.05)	NS	NS	NS	NS	NS
C.V.	6.49	6.61	7.28	8.60	7.11

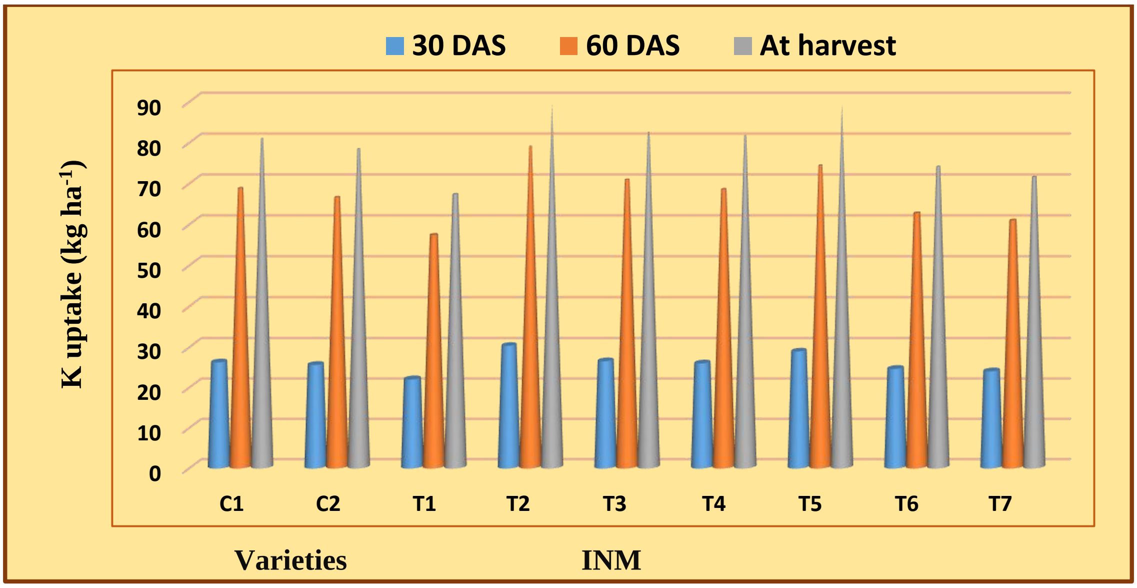

Fig. 4.14 Potassium uptake (kg ha^{-1}) of foxtail millet as influenced by varieties and INM.

4.5 Economics

4.5.1 Gross returns (Rs. ha^{-1})

Data pertaining to gross returns of foxtail millet showed that it was influenced by integrated nutrient management practices and varieties. (Table 4.12 and Fig. 4.15).

Gross returns were maximum with variety SiA 3085 (33080 Rs. ha^{-1}), this was mainly due to higher grain yield. Variety SiA 3156 recorded gross return of 32459 Rs. ha^{-1}, however the difference in gross return of the two varieties was very less.

With regard to the integrated nutrient management, application of 25% RDN through Vermicompost + 75% RDF (T_2) (37467 Rs. ha^{-1}) resulted in the highest gross returns among all the combinations of organic and inorganic treatments. The next best treatment was 50% RDN through Vermicompost + 50% RDF (T_5) having gross returns of 35291 Rs. ha^{-1}. The lowest gross returns were recorded with control (100% RDF) (T_1) (27879 Rs. ha^{-1}). The gross returns ranged from 33732 Rs. ha^{-1} to 30728 Rs. ha^{-1} with other combinations of organic and inorganic treatments. There was 34.40% higher gross returns obtained with 25% RDN through Vermicompost + 75% RDF (T_2) over control. This might be due to the higher grain yield and straw yield recorded in these treatments compared to control.

4.5.2 Net returns (Rs. ha^{-1})

Net returns of foxtail millet were influenced by both integrated nutrient management practices and varieties. (Table. 4.12 and Fig. 4.15).

Net returns was higher with variety SiA 3085 (17696 Rs. ha^{-1}) compared to SiA 3156 (17075 Rs. ha^{-1}), however the difference was very less as both the varieties performed almost equally in response to integrated nutrient management practices.

The higher net returns were realized with 25% RDN through Vermicompost + 75% RDF (T_2) (22345 Rs. ha^{-1}), which was found to be higher among all other combinations of organic and inorganic treatments and control. The next best treatment was 25% RDN through FYM + 50% RDF (T_3) (18826 Rs. ha^{-1}) and the net return was recorded least with control (100% RDF) (T_1) (14853 Rs. ha^{-1}). The net return ranged from 18826 Rs. ha^{-1} to 14288 Rs. ha^{-1} with other combinations of organic and inorganic treatments. There was 33.53% higher net return obtained with 25% RDN through Vermicompost + 75% RDF (T_2) over control.

Higher net returns were obtained by the way of cutting down the expenditure on inorganic fertilizer, lesser cost of cultivation and also due to lower cost of organic manures *viz.*, vermicompost compared to inorganic fertilizers. Present investigation confirms the results reported by Munirathnam *et al*. (2006) and Thimmaiah *et al.* (2016).

4.5.3 Benefit-Cost Ratio

Data pertaining to economics of foxtail millet (Table 4.12) showed that B:C ratio was influenced by both integrated nutrient management practices and the effect of varieties.

B:C ratio was higher with variety SiA 3085 (2.16) compared to SiA 3156 (2.12), however the difference was very less as both the varieties performed almost equally in response to integrated nutrient management practices.

Table 4.12 Economics of foxtail millet cultivation as influenced by varieties and INM.

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
Varieties				
C_1: SiA 3085	14966	33080	17696	2.16
C_2: SiA 3156	14966	32459	17075	2.12
Integrated nutrient management				
T_1 Control(100% RDF)	13026	27879	14853	2.14
T_2 25% RDN Vermicompost + 75% RDF	15122	37467	22345	2.48
T_3 25% RDN FYM + 75% RDF	14906	33732	18826	2.26
T_4 25% RDN Sheep manure + 75% RDF	14551	33214	18663	2.28
T_5 50% RDN Vermicompost + 50% RDF	17218	35291	18073	2.05
T_6 50% RDN FYM + 50% RDF	16786	31075	14288	1.85
T_7 50% RDN Sheep manure + 50% RDF	16075	30728	14653	1.91

Among the all integrated nutrient management treatments, maximum benefit-cost ratio of 2.48 was recorded with 25% RDN through Vermicompost + 75% RDF (T_2). The next higher benefit-cost ratio of 2.28 was recorded with 25% RDN sheep manure + 75% RDF (T_4) and the least benefit-cost ratio recorded with 50% RDN FYM + 50 % RDF (T_6). These results are in line with findings of Hussain *et al.* (2017) in pearl millet.

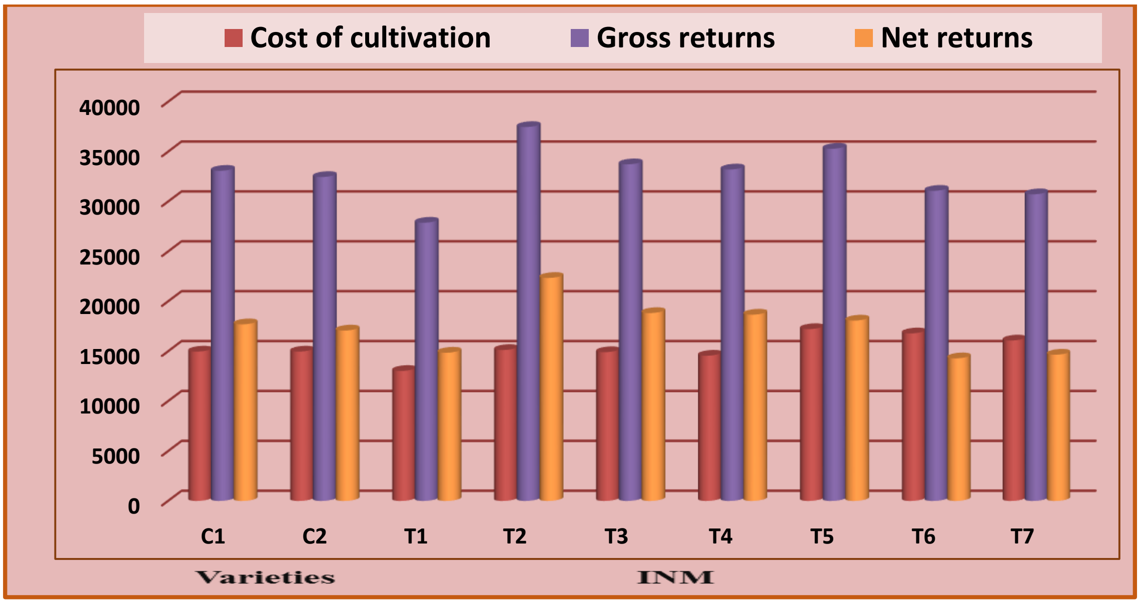

Fig. 4.15 Economics of foxtail millet cultivation as influenced by varieties and INM.

The higher level of biomass accumulation and efficient translocation to the reproductive parts due to supply of adequate nutrients by vermicompost might be responsible for the production of elevated yield attributes, which resulted in higher monetary returns and B:C ratio. Similar results were also reported by Reddy and Reddy (2010), Patil *et al*. (2015) and Pallavi *et al*. (2016), Harika *et al.* (2019) in finger millet.

4.8 Post-harvest soil analysis

4.8.1 Physical properties

The data presented in Table 4.13 indicates that the physical properties of soil *viz*., bulk density (g cm^{-3}), particle density (g cm^{-3}), pore space (%), water holding capacity (%) in soil, after the harvest of foxtail millet crop were not significantly altered by varieties, integrated nutrient management practices and their interaction. This might be attributed to the shorter duration of the crop and usually these basic physical properties of the soil will not alter by application of low quantities of manures and fertilizers. Though not significantly but the physical properties *viz.*, bulk density, particle density of surface soil after harvest decreased positively with the increasing use of organic manure over initial value , while pore space (%) and water holding capacity (%) had increased in all the combinations of organic and inorganic treatments other than control. Similar results were revealed by the studies of Siddika *et al.* (2017) in sorghum.

Table 4.13 Bulk density (g cm^{-3}), Particle density (g cm^{-3}), Pore space (%), and WHC (%) after harvest of foxtail millet as influenced by varieties and INM.

Treatments	BD (g cm^{-3})	PD (g cm^{-3})	Pore space (%)	WHC (%)
Varieties				
C_1: SiA 3085	1.18	2.45	51.63	31.43
C_2: SiA 3156	1.18	2.44	51.71	31.37
SEm±	0.02	0.03	0.46	0.61
CD (P=0.05)	NS	NS	NS	NS
Integrated nutrient management				
T_1 Control(100% RDF)	1.22	2.50	51.20	28.17
T_2 25% RDN Vermicompost + 75% RDF	1.18	2.44	51.66	31.82
T_3 25% RDN FYM + 75% RDF	1.19	2.46	51.54	31.13
T_4 25% RDN Sheep manure + 75% RDF	1.20	2.47	51.32	30.62
T_5 50% RDN Vermicompost + 50% RDF	1.14	2.40	52.45	33.10
T_6 50% RDN FYM + 50% RDF	1.16	2.41	51.79	32.77
T_7 50% RDN Sheep manure + 50% RDF	1.17	2.42	51.75	32.20
SEm±	0.03	0.05	0.85	1.14
CD (P=0.05)	NS	NS	NS	NS
Interaction				
SEm±	0.04	0.07	1.21	1.61
CD (P=0.05)	NS	NS	NS	NS
C.V.	5.80	5.12	4.11	8.88
Initial	1.22	2.49	51.20	28.20

4.8.2 Chemical properties

4.8.2.1 pH and EC

The data presented in Table 4.13 indicates that pH and EC in soil, after the harvest of foxtail millet crop were not significantly altered by varieties, integrated nutrient management practices and their interaction. pH and EC of surface soil at harvest did not differ significantly over initial values. As the duration of the crop is less the basic properties like pH and EC will not change by application of low quantities of manures and fertilizers. These results are in line with the findings of Arbad *et al*. (2008) in sweet sorghum and Divya *et al.* (2017) in pearl millet.

4.8.2.2 Soil organic carbon (%)

Post-harvest soil organic carbon status was significantly influenced by nutrient management practices in foxtail millet, while effect of varieties was non-significant.

Experimental results also revealed that interaction effect between the varieties and integrated nutrient management practices was found to be non-significant (Table 4.14).

Significantly highest organic carbon (1.06%) was recorded with 50% RDN through Vermicompost + 50% RDF (T_5) which was statistically similar to 50% RDN through FYM + 50% RDF (T_6), 50% RDN through Sheep manure + 50% RDF (T_7) and 25% RDN through Vermicompost + 75% RDF (T_2). All the INM treatments were found significant superior over initial soil organic carbon status except control. The lowest organic carbon content was recorded with control (100% RDF) (0.84) due to high leaching losses in inorganic fertilizers, where no nutrients remain up to harvest stage. Hence, the root growth, spread and decomposition was low which led to less addition of organic matter to soil.

Vermicomopst has a great potential to increase the soil organic carbon in the soil. It has much higher content of soil organic carbon and nutrients than the other organic sources (Lee., 1985). The studies undertaken by Maheswarappa *et al.* (1999) also revealed that vermicompost addition in soil enhanced organic carbon status of the soil.

Slight built up of organic carbon was found by conjoint use of organic and inorganic nutrient combinations over control. This might be due to enhanced root growth and production of more crop residues leading to the accumulation of more organic residues in soil. Organic carbon in the soil acts as energy substrate for proliferating microorganisms enhancing nutrient availability. These results were in conformity with findings of Madhuvani (2004), Pallavi *et al*. (2016) and Negi (2017).

4.8.2.3 Soil available nitrogen

Different integrated nutrient management practices exerted significant influence on the post-harvest available nitrogen status of the soil, while effect of varieties was non-significant. Experimental results also revealed that interaction effect between the varieties and integrated nutrient management practices was found to be non-significant (Table 4.14 and Fig. 4.16).

The maximum soil available nitrogen (222.8 kg ha^{-1}) was recorded with 50% RDN through Vermicompost + 50% RDF (T_5) followed by 100% RDF, 50% RDN through FYM + 50% RDF (T_6), 50% RDN through Sheep manure + 50% RDF (T_7) and 25% RDN through Vermicompost + 75% RDF (T_2). All these treatments were at par with each other but significantly superior over other combinations of organic and inorganic treatments. The least soil available nitrogen (172.7 kg ha^{-1}) was recorded with 25% RDN through Sheep manure + 75% RDF (T_4). Soil available nitrogen recorded in all the treatments were superior over initial soil available nitrogen status (166.8 kg ha^{-1}).

This might be attributed due to higher amount of N and OC content present in vermicompost which might have hastened the process of mineralization during crop growth period. Higher availability of N might be due to the addition of mineral fertilizer N along with organic sources which have contributed to the reduction of C:N ratio and thus increased the rate of decomposition resulting in faster availability of nutrients from manures. Similar findings were reported by Rajamani (2009), Pallavi *et al.* (2016) and Negi (2017).

4.8.2.4 Soil available phosphrous

Post-harvest soil available phosphorus was significantly influenced by nutrient management practices are presented in table 4.14 and fig. 4.16. While the effect of varieties and the interaction between varieties and integrated nutrient management were found to be non-significant.

The highest quantity of soil available phosphorus (30.2 kg ha^{-1}) was noticed with 50% RDN through Vermicompost + 50% RDF (T_5), which was on a par with 50% RDN through FYM + 50% RDF (T_6), 50% RDN through Sheep manure + 50% RDF (T_7) and 25% RDN through Vermicompost + 75% RDF (T_2). The soil available phosphorus was lowest with Control (100% RDF) (T_1) (21.7 kg ha^{-1}).

Vermicompost treated soils were rich in water soluble phosphate and inorganic nitrogen as due to increased solubility of phosphate by phosphatase enzyme activity the availability of phosphorus increases in the soil.

The higher available phosphorus might be due to the release of organic acids during microbial decomposition of organic matter which helped in the solubility of native phosphates thus increasing available phosphorus. The applied organic matter might have led to formation of coating on the sesquioxide clay minerals, because of which the phosphate fixing capacity of soil was reduced in manure treated plots. Similar results were observed by Gupta *et al*. (2000), Varalakshmi (2005) and Pallavi *et al.* (2016).

4.8.2.5 Soil available potassium

Post-harvest soil available potassium was significantly influenced by nutrient management practices while effect of varieties was non-significant. Experimental results revealed that interaction effect between varieties and integrated nutrient management practices was found to be non-significant (Table 4.14 and Fig. 4.16).

Maximum value of available potassium (398.3 kg ha^{-1}) was observed with 50% RDN through Vermicompost + 50% RDF (T_5), which was on par with 50% RDN through FYM + 50% RDF (T_6), 50% RDN through Sheep manure + 50% RDF (T_7) and 25% RDN through Vermicompost + 75% RDF (T_2). These treatments were significantly superior over other combination of organic and inorganic treatments. The lowest soil available potassium (367.0 kg ha^{-1}) resulted with Control (100% RDF) (T_1).

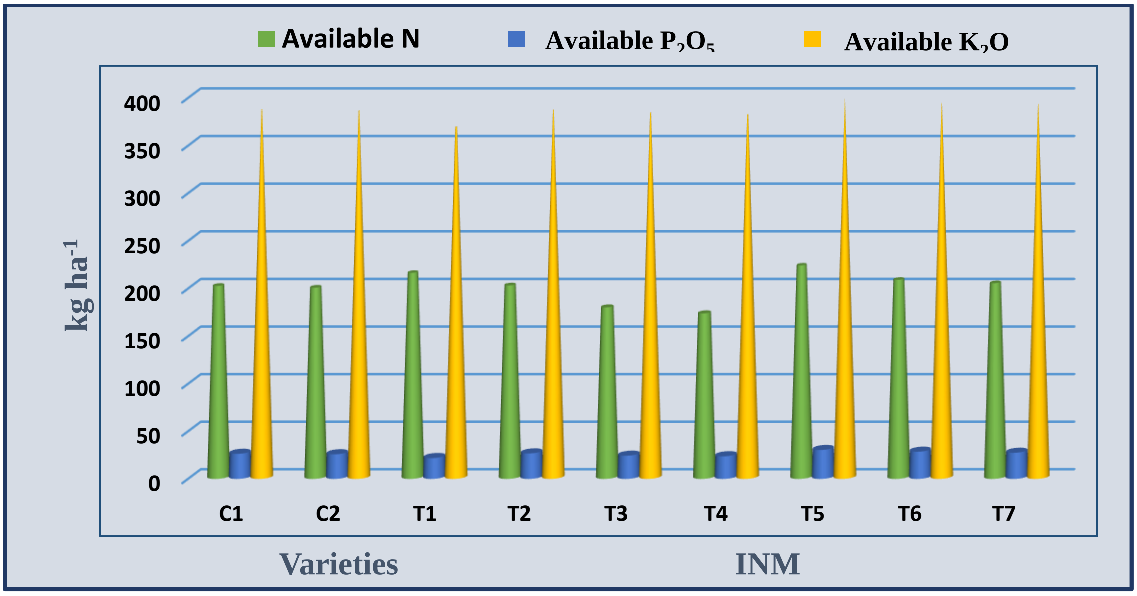

Fig. 4.16 Soil available N, P_2O_5 and K_2O (kg ha^{-1}) after harvest of foxtail millet as influenced by varieties and INM.

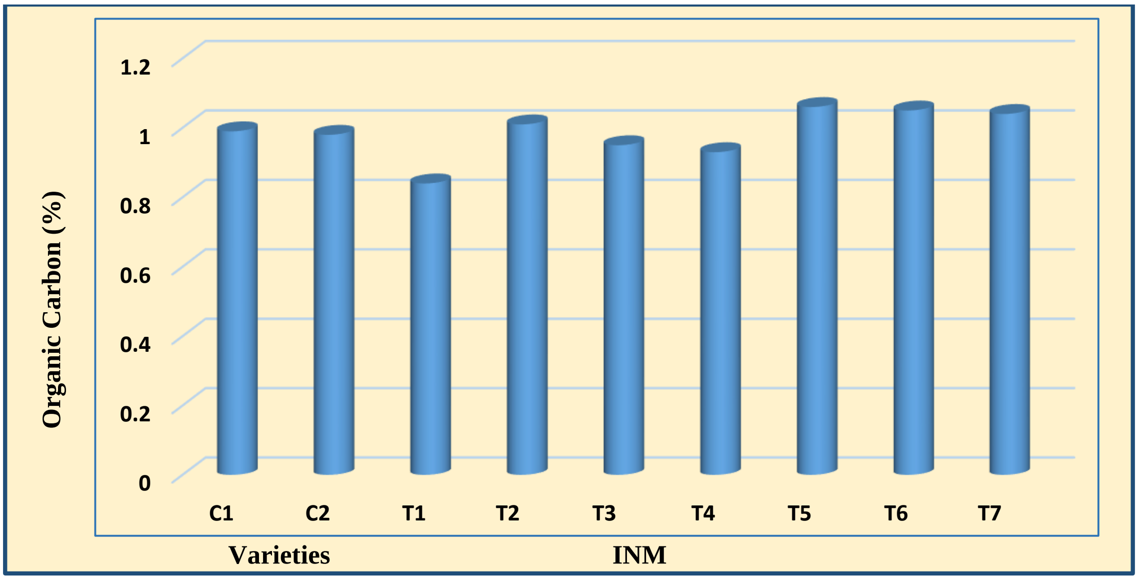

Fig. 4.17 Soil organic carbon (%) after harvest of foxtail millet as influenced by varieties and INM.

Vermicompost contains good amount of potassium. The availability of potassium is more in the vermicompost as the fixation of potassium is much lower in vermicompost as compared to mineral soil. The distribution of K between non exchangeable to exchangeable forms is such that which maintain availability of potassium during growth period. The beneficial effect of organics on available potassium might be ascribed to the reduction of K fixation and release of potassium due to the interaction of organic matter with clay minerals besides the direct potassium addition to the potassium pool of the soil. Similar beneficial effect of organics on available K was also reported in case of poultry manure by Pallavi *et al.* (2016) and Negi (2017) in finger milet.

Table 4.14 Soil pH, EC (dSm^{-1}), OC (%), available N, P_2O_5 and K_2O ($kg\ ha^{-1}$) after harvest of foxtail millet as influenced by varieties and INM.

Treatments	pH	EC	OC (%)	Available ($kg\ ha^{-1}$)		
				N	P_2O_5	K_2O
Varieties						
C_1: SiA 3085	7.45	0.18	0.99	201.4	26.2	385.6
C_2: SiA 3156	7.46	0.18	0.98	199.5	25.7	384.4
SEm±	0.04	0.01	0.02	4.1	0.5	3.3
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Integrated nutrient management						
T_1 Control(100% RDF)	7.57	0.22	0.84	215.0	21.7	367.0
T_2 25% RDN Vermicompost + 75% RDF	7.45	0.18	1.01	201.9	26.6	384.9
T_3 25% RDN FYM + 75% RDF	7.47	0.19	0.95	179.0	24.2	382.1
T_4 25% RDN Sheep manure + 75% RDF	7.49	0.20	0.93	172.7	23.6	380.3
T_5 50% RDN Vermicompost + 50% RDF	7.37	0.16	1.06	222.8	30.2	398.3
T_6 50% RDN FYM + 50% RDF	7.39	0.16	1.05	207.7	28.4	391.8
T_7 50% RDN Sheep manure + 50% RDF	7.42	0.17	1.04	204.2	27.3	390.9
SEm±	0.07	0.01	0.03	7.7	0.9	6.2
CD (P=0.05)	NS	NS	0.09	22.4	2.7	18.2
Interaction						
SEm±	0.09	0.02	0.04	10.83	1.3	8.8
CD (P=0.05)	NS	NS	NS	NS	NS	NS
C.V.	2.22	10.01	7.40	9.43	9.1	5.0
Initial	7.56	0.26	0.87	166.8	22.1	376.5

Chapter V

SUMMARY AND CONCLUSIONS

5.1 SUMMARY

The present study entitled "Response of foxtail millet (*Setaria italica*) varieties to integrated nutrient management" was conducted during *kharif,* 2019 at College farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad. The soil was sandy loam in texture, neutral in soil reaction, low in available nitrogen and organic carbon, low in available phosphorus and high in available potassium. Experiment was carried out with two varieties *viz.,* SiA 3085 (C_1) and SiA 3156 (C_2) as first factor and seven integrated nutrient management practices *viz.,* Control (100% RDF -40-20-20 kg NPK ha^{-1}) (T_1), 25% RDN through Vermicompost + 75% RDF (T_2), 25% RDN through Farm Yard Manure + 75% RDF (T_3), 25% RDN through Sheep Manure + 75% RDF (T_4), 50% RDN through Vermicompost + 50% RDF (T_5), 50% RDN through FYM + 50% RDF (T_6), 50% RDN through Sheep Manure + 50% RDF (T_7) as second factor comprising fourteen treatment combinations, laid out in randomized block design with factorial concept, replicated thrice. The salient findings of the experiment are summarized below.

The observations on growth parameters *viz.,* initial and final plant population, plant height, leaf area index, number of tillers m^{-2}, dry matter production at 30, 60 DAS and at harvest and days to 50% flowering were recorded. Data on yield attributes *viz.,* number of panicles m^{-2}, panicle length, number of grains panicle^{-1}, number of filled grains panicle^{-1}, test weight and grain yield, straw yield and harvest index were recorded at harvest stage. Nutrient uptake (N, P, K) at 30, 60 DAS and at harvest (grain and straw), available soil nutrient status (N, P and K), soil pH, EC, organic carbon, bulk density, particle density, porosity and water holding capacity were estimated at initial and harvest stage of foxtail millet. Economics including gross returns, net returns and B:C ratio were calculated.

Salient features of the experimental findings are summarized below

- Growth parameters *viz.,* plant height, leaf area index, number of tillers m^{-2}, dry matter production were significantly influenced by integrated nutrient management at all growth stages, however these were found to be non-significant with the choice of varieties. Influence of the different varieties, application of integrated nutrient management and their interaction had no significant on plant population and days to 50% flowering, whereas leaf area index was significantly influenced by both varieties and integrated nutrient management at all the stages of sampling.

- Among the varieties, at all the stages of observation, SiA 3085 (C_1) (1.36) produced significantly higher LAI compared to the other variety *viz.*, SiA 3156 (C_2). With respect to integrated nutrient management, 25% RDN through Vermicompost + 75% RDF (T_2) had shown significantly higher plant height (142.6 cm), leaf area index (1.47), number of productive tillers m^{-2} (60.9) and dry matter production (4442 kg ha^{-1}) compared to all other combinations of organic and inorganic treatments as well as control (100% RDF) and was statistically at par with 50% RDN through Vermicompost + 50% RDF (T_5).
- Yield attributes *viz.*, length of the panicle, number of grains $panicle^{-1}$, number of filled grains $panicle^{-1}$ were significantly influenced by varieties and integrated nutrient management, whereas the number of panicles m^{-2} and test weight were significantly influenced by integrated nutrient management only and the choice of varieties had no effect on them.
- Among the two varieties, higher length of the panicle (23.5 cm), number of grains/ panicle (2155), number of filled grains $panicle^{-1}$ (2029) were obtained with the variety SiA 3085 (C_1), which was superior over the other variety *viz.*, SiA 3156 (C_2). Among the integrated nutrient management treatments, 25% RDN through Vermicompost + 75% RDF (T_2) had resulted in significantly higher number of panicles m^{-2} (45.0), length of the panicle (25.4 cm), number of grains $panicle^{-1}$ (2327), number of filled grains/panicle (2220), test weight (3.26 g) over other combinations of organic and inorganic treatments and control, however it was statistically at par with 50% RDN through Vermicompost + 50% RDF (T_5).
- The highest grain and straw yields were produced by the variety SiA 3085 (C_1) (2048 kg ha^{-1}) which was however comparable with that of SiA 3156 (C_2), thus grain and straw yields were non-significant with the choice of varieties. Regarding integrated nutrient management practices, application of 25% RDN through Vermicompost + 75% RDF (T_2) recorded significantly higher grain yield of 2324 kg ha^{-1} and straw yield of 4353 kg ha^{-1} compare to all other combinations of integrated nutrient management and control (100% RDF) and was statistically

at par with 50% RDN through Vermicompost + 75% RDF (T_2). Harvest index remained non-significant in response to both varieties and integrated nutrient management practices.

- Application of 25% RDN through Vermicompost + 75% RDF recorded significantly higher nitrogen, phosphorous and potassium uptake at 30, 60 DAS and at harvest (grain and straw) over all other combinations of integrated nutrient management and was on par with 50% RDN through Vermicompost + 50% RDF (T_5). Among the varieties tested there was no significant difference with respect to nitrogen, phosphorous and potassium uptake at 30, 60 DAS and at harvest (grain and straw).
- The pH and EC of soil, after the harvest of foxtail millet crop were not significantly altered by varieties, integrated nutrient management practices and their interaction. While 50% RDN through Vermicompost + 50% RDF (T_5) (1.06) superseded all the treatments in respect of organic carbon content in soil after crop harvest and was on par with other combinations of 50% inorganic + 50% organic treatments and 25% RDN through Vermicompost + 75% RDF (T_2), although there was no effect of varieties on organic carbon content in soil after harvest of foxtail millet.
- Different integrated nutrient management practices exerted significant influence on the post-harvest available nitrogen, phosphorus and potassium status of the soil, while effect of varieties was non-significant.
- Application of 50% RDN through Vermicompost + 50% RDF (T_5) being at par with 100% RDF, 50% RDN through FYM + 50% RDF (T_6), 50% RDN through Sheep manure + 50% RDF (T_7) and 25% RDN through Vermicompost + 75% RDF (T_2) significantly increased the available nitrogen (222.8 kg ha^{-1}) in soil after harvest of foxtail millet crop. Maximum value of available phosphorus (30.2 kg ha^{-1}) and potassium (398.3 kg ha^{-1}) were observed with 50% RDN through Vermicompost + 50% RDF (T_5). However, both available phosphorus and potassium were found to be at par with other combinations of 50% inorganic + 50% organic treatments and 25% RDN through Vermicompost + 75% RDF (T_2).
- Physical properties of soil *viz*., bulk density (g cm^{-3}), particle density (g cm^{-3}), pore space (%), water holding capacity (%) in soil, after the harvest of foxtail millet crop were not significantly altered by varieties, integrated nutrient management practices and their interaction.

- Higher values of gross returns, net returns and benefit cost (B:C) ratio were obtained with application of 25% RDN through Vermicompost + 75% RDF (T_2) and with variety SiA 3085 (C_1). Fetching the net returns of 22345 Rs. ha^{-1} application of 25% RDN through Vermicompost + 75% RDF (T_2) proved to be the most remunerative treatment.

5.2 CONCLUSIONS

Based on the foregoing discussion, the following conclusions could be drawn.

- Among the two varieties (SiA 3085 and SiA 3156) tested, there was no significant difference in growth, yield and uptake of nutrients in foxtail millet. Both the varieties performed equally with different organic and inorganic sources of nutrients and found to be equally effective and remunerative.
- Among the integrated nutrient management treatments, 25% RDN through Vermicompost + 75% RDF (T_2) had significantly increased growth, yield and uptake of foxtail millet varieties and was on par with 50% RDN through Vermicompost + 50% RDF (T_5). These two treatments were found out to be the optimal combination of organic and inorganic sources of nutrients for foxtail millet varieties.
- Higher economic returns of foxtail millet varieties in relation to integrated nutrient management, were obtained with variety SiA 3085 and 25% RDN through Vermicompost + 75% RDF (T_2).

5.3 FUTURE LINE OF WORK

- Research on promising foxtail millet varieties can be studied under different agro climatic conditions, so that suitability of a specific variety to specific climatic condition can be determined.
- There is need to test the importance of other organics in increasing productivity of foxtail millet.
- Research on nanofertilizers with the newly promising foxtail millet varieties may be carried out.

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APPENDIX – A

CALENDAR OF OPERATIONS

S. No.	Date	Operation
1	25.06.2019	Field preparation with tractor drawn plough
2	26.06.2019	Removal of stubbles
3	29.06.2019	Second ploughing, harrowing and leveling of the field
4	01.07.2019	Layout of the experimental plot
5	02.07.2019	Application of organic manures *viz.*, vermicompost, FYM, sheep manure
6	16.07.2019	Sowing of seeds and basal dose of fertilizer application
7	16.07.2019	Irrigation
8	26.07.2019	Thinning and gap filling
9	10.08.2019	Hand weeding
10	14.08.2019	Data collection
11	15.08.2019	Urea split application
12	19.08.2019	Spraying of Tricyclazole @ 1.6 ml l^{-1}
13	13.09.2019	Data collection
14	15.10.2019	Harvest
15	17.10.2019	Threshing

APPENDIX - B

COMMON COST OF CULTIVATION (Rs. ha^{-1})

S. No.	Particulars	Cost (Rs. ha^{-1})
1	Land preparation	3000
2	Seeds and sowing	1600
3	Gap filling and thinning	1100
4	Weeding	2000
5	Irrigation	400
6	Plant protection	800
7	Harvesting, threshing and cleaning	2500
	Total	11,400

APPENDIX - C

TOTAL COST OF CULTIVATION (Rs. ha^{-1})

Treatment	Cost of cultivation (Rs ha^{-1})					Total cost of cultivation (Rs. ha^{-1})
	Field operation	Fertilizer	Vermicompost	FYM	Sheep manure	
T_1C_1	11400	1626	-	-	-	13026
T_1C_2	11400	1626	-	-	-	13026
T_2C_1	11400	1506	2216	-	-	15122
T_2C_2	11400	1506	2216	-	-	15122
T_3C_1	11400	1506	-	2000	-	14906
T_3C_2	11400	1506	-	2000	-	14906
T_4C_1	11400	1506	-	-	1644	14551
T_4C_2	11400	1506	-	-	1644	14551
T_5C_1	11400	1386	4432	-	-	17218
T_5C_2	11400	1386	4432	-	-	17218
T_6C_1	11400	1386	-	4000	-	16786
T_6C_2	11400	1386	-	4000	-	16786
T_7C_1	11400	1386	-	-	3289	16075
T_7C_2	11400	1386	-	-	3289	16075

APPENDIX – D

COST OF INPUT AND OUTPUT (Rs.)

S.No.	Input/output	Cost (Rs. Kg^{-1})
1	Urea	5.52
2	SSP	7.24
3	MOP	15.7
4	Vermicompost	8.00
5	Farm Yard Manure	2.50
6	Sheep Manure	3.70
7	Carbendazim	170
8	Tricyclazole	700
9	One man day^{-1}	220
10	Foxtail millet grains	15.00
11	Foxtail millet straw	0.60

PLATES

Plate -1: Land preparation

Plate -2: Lay out of the experimental plot

Plate-3: Application of organic manures before sowing

Plate-4: Application of fertilizers

Plate-5: Sowing of foxtail millet

Plate-6: Thinning and gap filling

Plate-7: Hand weeding at 30 DAS

Plate-8: Overall view of foxtail millet at different stages

Plate-9: Harvesting of foxtail millet

Plate-10: Threshing and winnowing of harvested foxtail millet

Plate-11: Comparison between best treatment and control