PLANTING DENSITY AND INM INTERVENTIONS IN SESAME PRODUCTION

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B.Sc. (Ag.)

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B.Sc. (Ag.)

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DECLARATION

I, RAYAVARAPU SAI KUMAR hereby declare that the thesis entitled "**PLANTING DENSITY AND INM INTERVENTIONS IN SESAME PRODUCTION"** submitted to the **Acharya N.G. Ranga 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.

Place: **Bapatla** (**R. SAI KUMAR**)
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CERTIFICATE

Mr. R. SAI KUMAR has satisfactorily prosecuted the course of research and that thesis entitled "**PLANTING DENSITY AND INM INTERVENTIONS IN SESAME PRODUCTION**" 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 there of has been previously submitted by him for a degree of any University.

Date:
Place: **Bapatla**

(P. V. N. PRASAD)
Chairperson

CERTIFICATE

This is to certify that the thesis entitled "**PLANTING DENSITY AND INM INTERVENTIONS IN SESAME PRODUCTION**" submitted in partial fulfilment of the requirements for the degree of **'Master of Science in Agriculture'** of the Acharya N.G. Ranga Agricultural University, Guntur is a record of the bonafide original research work carried out by **Mr. R. Sai Kumar** 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 the assistance received during the course of the investigations have been duly acknowledged by the author of the thesis.

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Place : Bapatla

Date : ***(Rayavarapu Saikumar)***

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LIST OF SYMBOLS AND ABBREVIATIONS

At the rate	:	@
Benefit cost ratio	:	B: C
Centimetre	:	cm
%	:	Per cent
T	:	Treatment
CD	:	Critical difference
cm	:	centimetre
d.f.	:	Degree of freedom
et al.	:	Et alli (and other)
Farmyard manure	:	FYM
Gram	:	g
Gross monetary return	:	GMR
Harvest Index	:	HI
Hectare	:	ha
ha.	:	Hectare
Kg	:	Kilogram
SEm±	:	Standard error of mean
viz.,	:	Videlicet (namely)
i.e	:	that is
DAS	:	Days after sowing
Fig	:	Figure
No.	:	Number
ºC	:	Degree centigrade
N	:	Nitrogen
Recommended dose of fertilizer	:	RDF
Non significant	:	NS
Per hectare	:	ha-1
Per cent	:	%
Maximum	:	Max.
Meterological standard week	:	MSW
Milimetre	:	mm
Minimum	:	Min.
P_2O_5	:	Phosphorous
PM	:	Poultry manure
K_2O	:	Potassium

ABSTRACT

Name of the Author	:	**RAYAVARAPU SAIKUMAR**
Title of the thesis	:	**PLANTING DENSITY AND INM INTERVENTIONS IN SESAME PRODUCTION**
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A field experiment entitled **"**Planting Density and INM Interventions in Sesame Production" was conducted at Agricultural College Farm, in sandy loam soil of Bapatla during *rabi* 2017-18. The treatments comprised combination of two planting densities *viz.*, S_1(2.22 lakh plants ha^{-1}), S_2(3.33 lakh plants ha^{-1}) and five nutrient treatments F_1(100%RDF (60, 40, 60 NPK ha^{-1}), F_2(75% RDF + 5t FYM ha^{-1}), F_3(75% RDF + 0.75 t PM ha^{-1}), F_4(75% RDF + 1.3t Sun hemp Green manuring ha^{-1}) , F_5(25% RDF + FYM 5t ha^{-1} + PM 0.75 t ha^{-1} + Sun hemp Green manuring 1.3t ha^{-1}). The experiment was laid out in Factorial Randomized Block Design with three replications.

Numerically taller plants were produced at higher planting density of 3.33 lakh plants ha^{-1} than lower planting density (2.22 lakh plants ha^{-1})at 30, 60 DAS but significantly taller plants (77.3 cm)was recorded at maturity. Significantly the highest plant height (34.4cm, 64.9cm, and 79.5cm) at 30, 60 DAS and maturity respectively was recorded with the application of treatment F_5 and the lowest plant height was observed with treatment $F_{3.}$

Drymatter accumulation (193 kg ha^{-1}, 1348 kg ha^{-1} and 2548 kg ha^{-1}) was significantly higher in plant densities of 3.33 lakh plants ha^{-1} at all the stages of crop growth (30, 60 DAS and at maturity). Treatment F_5 produced significantly higher drymatter (187, 1659, 2704 kg $ha^{-1)}$ at 30, 60 DAS and maturity respectively and the lowest drymatter production was recorded in treatment F_3.

Number of capsules $plant^{-1}$(35) was recorded significantly higher in plant density (2.22 lakh ha $^{-1}$) with a spacing of 45cm X 10cm. Application of treatment F_5 has recorded significantly higher number of capsules per plant (37.0). However lower number of capsules per plant (31.1) was noticed with treatment F_3.

Numerically the highest test weight (2.49 g) was recorded with the spacing of 30 cm X 10 cm. Among the treatments the test weight of 2.56 g was recorded numerically higher weight with the treatment F_5.

The highest seed yield and stalk yield (713.5 kg ha^{-1}, 1604 kg ha^{-1}) was produced in higher planting density (3.33lakh ha^{-1}) with the spacing of 30cm X 10cm. significantly the highest seed yield (794 kg ha^{-1}) was recorded under F_5 treatment. Application of treatment F_5 has recorded the highest stalk yield (1795 kg ha^{-1}) and it was on par with treatment F_2. The lowest seed and stalk yields (619 kg ha^{-1}, 1362.5 kg ha^{-1}) was recorded with the treatment F_3.

Numerically the highest harvest index (30.8 %) was observed in 30cm X 10cm planting density as compared to 45cm X 10 cm planting density. Application of treatment F_5 recorded numerically higher harvest index (31.5%) and lowest harvest index (29.5 %) was registered with treatment F_3

Oil content of 48.24 % was observed in plant density of 3.33lakh plant ha^{-1}, which was numerically higher than plant density of 2.22 lakh plant ha^{-1}.Among the nutrient treatments the oil content of 48.8 % the maximum was recorded under the treatment F_5.

Protein content of 23.47 % was observed in plant density of 3.33lakh plant ha^{-1}, which was numerically higher than protein content in plant density of 2.22 lakh plant ha^{-1}. Application of treatment F_5 the highest recorded protein content (24.41%)

Numerically higher nitrogen content in seed and stalk (3.74%, 1.74 %) was noticed in 30cm X 10 cm spacing Significantly the highest nitrogen content in seed and stalk (3.91 %, 1.88 %) were recorded with treatment F_5.

Numerically higher phosphorus content in seed and stalk (1.35%, 0.39 %) was noticed in 30cm X 10 cm spacing. Among the treatments, numerically higher P content of 1.36 % in seed, was noticed however P content of stalk (0.43%) was significantly higher in treatment F_5.

Numerically higher potassium content in seed and stalk (1.93%, 1.40 %), was noticed in 30cm X 10 cm spacing. Among the treatments numerically higher K content of 1.94 %, in seed, was exhibited however the K content of stalk (1.54 %) was significantly higher in treatment F_5.

Significantly the highest total nitrogen, phosphorus and potassium uptake (69.5 kg ha^{-1}, 19.5 kg ha^{-1}, 49.5kg ha^{-1}) of sesame was recorded with 30 cm X 10 cm. Among the nutrient treatments, maximum total uptake of nitrogen, phosphorus and potassium (81.6 kg ha^{-1}, 22.3 kg ha^{-1}, 57.0 kg ha^{-1}) in sesame was recorded with treatment F_5. The lowest total uptake of nitrogen recorded with treatment F_3.

Significantly the highest available nitrogen (183 kg ha^{-1}), phosphorus (10.5 kg ha^{-1}) and potassium (268 kg ha^{-1}) in soil after harvest of sesame in 45cm X 10cm spacing (2.22 lakh plant ha^{-1}).

The highest gross returns (Rs.42091 ha^{-1}), net returns (Rs. 17926 ha^{-1}) and returns per rupee investment (1.74) were recorded with application of 25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp Green manuring ha^{-1} over all other treatment combinations, followed by treatment F_2.

Chapter – I

Introduction

Chapter - I

INTRODUCTION

Sesame (*Sesamum indicum* L.) is an ancient oilseed crop. It is recognized by various names like gingely, til, simsim, gergelim and biniseed *etc*, it has earned a poetic label "Queen of Oilseeds" because the seeds have high quality poly- unsaturated stable fatty acids which offer resistance to rancidity. Moreover, its seed is a rich source of edible oil (48-55%) and protein (20-28%) (Taware *et al.,* 2006) consisting of both methionine and tryptophane, vitamin (niacine) and minerals (Ca and P). Seed contains two lignans *viz*., sesamin and sesmolin. After roasting sesame seeds, sesamolin is converted to sesamol. Sesamol has been found to have anti-oxidative effects and induce growth arrest and apoptosis in cancer cells (Elleuch *et al*., 2011). Because of its excellent quality characters, sesame oil is also sometimes referred to as "poor man's substitute for ghee".

It is also known for its insecticidal and medicinal properties as well as for its cosmetic values. Sesame oil has anti-bacterial, anti-fungal, anti-viral and anti-inflammatory properties due to presence of linoleic acid (40%). About 73 percent of sesame produced in the country is used for oil extraction, 20 per cent for domestic use including preparation of sweet candies, as condiments, culinary and confectionary purposes, 2-3 per cent for hydrogenations and 4.2 per cent used for industrial purposes in manufacturing of paints, perfumed oils, pharmaceuticals and insecticides. Sesame oil stimulates antibody production and enhances immunity. Lower grade oil is used in soap industries. Sesame oil has excellent nutritional, medicinal, cosmetic and cooking qualities for which, it is known as 'the queen of oilseeds'. Due to the presence of potent antioxidants, sesame seeds are called as 'the seeds of immortality' and auspicious.

In Indian economy, oilseeds occupy an important place and contribute to about 13 per cent of the gross cropped area and account for nearly 3 per cent of gross national product and 10 per cent value of all agricultural commodities

(Anonymous, 2017). This sector has recorded annual growth rate of area, production and yield at the rate 2.44, 5.47 and 2.96 per cent, respectively (Anonymous, 2016-17). India is the largest producer and acreage holder (26 per cent) of sesame in the world after China.

Oilseeds play a vital role in agricultural and industrial economics in the world. Oilseeds are the main source of fats and protein particularly for vegetarians. Sesame is one of the most ancient crops grown for its oil rich seeds. It is a crop of tropical and subtropical areas. Bulk of the sesame in the world is grown in the semi arid region with little rainfall which is an indication that sesame is drought tolerant crop. China is the world's highest producer of sesame followed by India and Myanmar. Sudan, Uganda and Nigeria ranked 4th 5th and 6th in that order (Dey, 2016).

Globally, India is the largest producer, consumer and exporter of sesame with an area of 19.81 lakh hectares with a production of 8.87 lakh tonnes during 2015-16 (SEAI). The major states producing sesame are West Bengal, Madhya Pradesh, Rajasthan and Gujarat. These states represent more than 70 per cent production of total country. The other sesame producing states are Uttar Pradesh, Andhra Pradesh, Maharashtra, Tamil Nadu, Karnataka and Odisha. In Andhra Pradesh, it is grown in an area of 85 lakh ha with a production of 2.8 M t and productivity of about 329 kg ha^{-1} (*www.indiastat.com*, 2014-15).

Among various agronomic techniques, time of sowing as non monetary practice, plays an important role for increasing the crop productivity. Particularly in the country like India with widely varying agro-climatic conditions. Generally, crops grown in summer, yield almost one and half to double as compared to *kharif* due to high photosynthetic efficiency and less disease and pest problems.

For total exploitation of the yield potential of the summer sesame, it is important to maintain optimum plant population. Proper spacing is necessary for interception of sunlight to each strata of leaves. This will promote the rate of photosynthesis and consequently the dry matter production. Sesame is a C_3 plant subjected to photorespiration. Photorespiration can be minimized by following proper plant geometry which ultimately increases the crop yield. In term of modern technology, spacing has connotation in relation to plant population, which generally depends upon the soil fertility status and moisture level of the field.

Integrated nutrient management in sesame improves its quantity and quality of produce and reduces the incidence of diseases, pests and cost of cultivation. Thus the concurrent application of organic manures and bio-fertilizers are frequently recommended for improving biological, physical and chemical properties of soil and to get agricultural products with good quality and free pollutants (Chapman and Pratt, 1978). Integrated nutrient management continues to gain importance to maintain soil health for sustainable production of good quality sesame (Duhoon *et al.*, 2009). In order to increase the productivity, adoption of nutrient management practices is one of the crucial factors. Now-a-days there is a huge demand for organic sesame in the global market. India has greater scope to produce sesame as it is traditionally grown without much chemical fertilizer and plant protection.

Among organic sources, we have many options for plant nutrition mainly, FYM and Poultry manure. Poultry manure has been recognized as the most desirable organic manures for sesame. It improves soil fertility by adding nitrogen and phosphorous as well as micronutrients and thus improves moisture and nutrient retention (Farhad *et al.*, 2009).

In order to increase the productivity, adoption of improved nutrient supply is also one of the crucial factors. However, farmers growing sesame in north coastal zone of Andhra Pradesh confine the sesame crop under residual fertility after rice, with least external nutrient supply. This is a key impediment to sustainable production. Though there is a huge demand for organic sesame in the global markets, approaches based purely on organic inputs cannot provide the required increase in agricultural production (Tandon, 1992). An efficient use of organic sesame supplemented with mineral fertilizers has proved to be a sound soil fertility management to enhance crop yields on one hand and maintain a greater beneficial residual effect on soil fertility on the other (Makinde and Ayoola, 2008). The superior effect of integrated use of organic and inorganic nutrients as opposed to their sole application has been reported by several workers in sesame in the past. However, studies on response of sesame crop with varied density, under inorganic fertilizer in general and INM practices in particular are scanty. Therefore a study is proposed to be conducted to determine the optimum nutrition to sesame with sole and complementary application of poultry manure, farmyard manure, green manure with inorganic N, P, K fertilizers.

In light of the above, the following field study has been formulated with the following objectives.

1. To evaluate growth and yield potential of Sesame under varied plant density and nutrient management

2. To find out the possibility of reducing the quantity of inorganic fertilizer application through use of organic sources

3. To work out the economics

Chapter – II

Review of Literature

Chapter II

REVIEW OF LITERATURE

A field experiment entitled **“Planting Density and INM Interventions in Sesame Production”** was conducted at the Agricultural College Farm, Bapatla. Importance of oilseeds in agriculture needs no further emphasis, as they are valuable items of human nutrition. Among several management practices, proper and balanced supply of nutrients is one of the key factors for realization of higher productivity levels. The information available exclusively on sesame with respect to inorganic, organic fertilizers are reviewed in this chapter and presented under the following heads.

2.1 Effect of planting geometry on growth and yield.

2.2 Effect of organic and inorganic fertilizers on growth and yield parameters of crop

2.3 Effect of planting geometry and fertilization on nutrient quality, concentration and uptake.

2.4 Economics

2.1 EFFECT OF PLANTING GEOMETRY ON GROWTH AND YIELD

The study was conducted to evaluate the effect of sowing dates and row spacing on growth and yield of sesame under summer condition during the period from February to May of 2009, 2011 and 2012 at Agricultural Research Station, Amreli, Gujarat. From the results, Monpara and Vaghasia (2016) found that row spacing of 30 cm x 10 cm recorded significantly the highest seed yield (1,050 kg ha^{-1}), number of capsules $plant^{-1}$, and 1000-seed weight were significantly the highest at the S_2 (30 cm x 10 cm) spacing.

A field experiment was conducted during summer season of 2010 to 2012 on clayey soil of Junagadh (Gujarat) to ascertain proper time of sowing (3rd week of January, 2nd week of February and 4th week of February) and spacing

(30 cm x 10 cm, 45 cm x 10 cm and broadcast) in relation to growth and yield of sesame (*Sesamum indicum* L.). Shekh *et al.* (2014) noticed that significantly the highest plant height, branches plant^{-1}, capsules plant^{-1} and test weight was recorded with 45 cm x 10 cm spacing however, it remained at par with 30 cm x 10 cm spacing in case of number of capsules per plant. Further, it was observed that 30 cm x 10 cm spacing gave higher seed yield (1.782 t ha^{-1}) and stalk yield (2.016 t ha^{-1}) as compared to 45 cm x 10 cm and broadcast treatments.

Kumara *et al.* (2014) conducted a field experiment during *kharif* 2007 at the Main Agricultural Research Station, Dharwad to study the response of sesame genotypes to levels of fertilizer and planting geometry. They reported that seed weight plant^{-1}, number of capsules plant^{-1}, and 1000-seed weight were higher with wider spacing of 45cm x 20 cm as compared to 30 cm x 10 cm. However, seed yield recorded was significantly higher under 30 cm x 10 cm as compared to rest of the treatments, while stalk yield and harvest index remain at par with 45 cm x 10 cm spacing.

Sivagamy and Rammohan (2013) carried a field experiment on sesame during summer season of 2006 in a sandy loam soil at Masipattam. They reported that the wider spacing of 45 cm x 15 cm recorded significantly higher seed yield of 908 kg ha^{-1} during 2006 was followed by normal spacing of 30 cm x 30 cm with 800 kg ha^{-1}.

Ngala *et al.* (2013) conducted field trials during 2006 and 2007 rainy seasons at Maiduguri, Nigeria on sesame. They opined that among the row spacings growing of sesame at 50 cm x 25 cm recorded the highest seed yield (135.2, 459.0 kg ha^{-1} respectively during 2006, 2007) over other row spacings.

Shinde *et al.,* (2011) on an experiment during summer 2008 at Agriculture College, Pune (Maharashtra) noticed that the plant height, plant spread, number of branches, number of capsules, and 1000 seed weight and dry matter accumulation plant^{-1} in sesame were significantly higher with the spacing of 45 cm x 10 cm.

Kumar *et al.* (2011) conducted a field experiment at Allahabad during spring 2004-05 in sunflower and reported that significantly higher seed yield and straw yield of sesame.

Roy *et al.* (2009) conducted a field experiment at Khulna University, Khulna, Bangladesh in *kharif* season 2007 using three row spacings (15, 30 and 45 cm). They found that 30 cm row spacing was significantly superior to 45 cm row spacing in respect of seed yield of sesame.

The results of a field experiment laid out during summer season of 2000 and 2001 at Beldanga, Murshidabad, West Bengal on sesame showed that growing of crop at 45 cm x 30 cm recorded significantly higher number of capsules^{-1}, but plant height and seed yield recorded was significantly the highest in 30 cm x 10 cm spacing (Duary and Ghosh, 2009).

Paraye *et al.* (2009) conducted a field experiment in Raigarh, Chhattisgarh, India, during the winter of 2001-02 and 2002-03 to study the effect of nutrient management practices and plant spacing on the growth, yield attributes and yield of Indian mustard (*B. juncea*) in sandy clay loam soils. They tried plant spacing treatments (30 × 15 cm, 45 × 15 cm, and broadcasting) and reported that significantly higher seed and straw yield was obtained with spacing 45 cm x 15 cm.

A field experiment was conducted during *kharif* 2007 at the Main Agricultural Research Station, Dharwad to study the response of sesame genotypes to levels of fertilizer and planting geometry by Prasannakumara *et al.* (2014). They registered significantly higher seed yield and stalk yield (788 kg ha^{-1}, 2788 kg ha^{-1} respectively) under the spacing of 30 cm x 10 cm.

Yadav *et al.* (2007) conducted a field experiment at AICRP (sesame) centre Mauranipur, Jansi during *kharif* season of 2001 and 2002 on sesame, where 30 cm inter spacing gave significantly higher plant height (96.5 and 94.2 cm), higher seed yield (780 and 481 kg ha^{-1}). While significantly higher capsules plant^{-1} was observed under the 45 cm inter spacing.

Sarkar and Pal (2005) reported that crop geometry of 30 cm × 30 cm proved superior to 45 cm × 20 cm in enhancing growth parameters *viz.*, plant height, drymatter production and yield attributes *viz.*, number of capsules^{-1} resulting in higher seed yield (1.48 t ha^{-1}).

Ahmad *et al.* (2002) reported that planting pattern affected seed yield of sesame significantly. Sesame crop grown with 30 cm row distance produced significantly more seed yield (0.7 t ha^{-1}) and was statistically on par with that grown in the pattern of 45 cm apart rows while minimum seed yield of 0.60 t ha^{-1} was obtained from crop planted in 80 cm apart rows.

Kathiresan (2002) observed from the field experiments during rainy and summer season that closer spacing of 30 cm x 30 cm with the highest level of nutrients recorded the maximum drymatter with significantly higher seed yield over the 30 cm x 40 cm and 30 cm x 45 cm spacings in sesame.

Sarkar and Banik (2002) conducted a field trial during the spring season in West Bengal during 1999 and 2000. They concluded that 45 cm x 15 cm spacing gave the highest seed yield than the 30 cm x 30 cm and 45 cm x 30 cm spacings.

Subrahmaniyan *et al*. (2001) revealed from experiment conducted during summer season at Regional Research Station, Vridhachalam, that spacing of 30 cm x 10 cm significantly recorded the highest seed yield of 622 kg ha^{-1} than the 30 cm x 20 cm and 30 cm x 30 cm spacing.

In Karnataka, on paddy fallows in Tunga Bhadra irrigation command during summer with two sesame cultivars *i.e.*, DS 1 and E 8. Research results revealed that significantly higher seed yield(1736 kg ha^{-1}) was recorded with 6,66,000 plants ha^{-1}(30 cm X 5 cm) than with 3,33,000 ha^{-1} (30 cm X 10 cm, 1621 kg ha^{-1}) (Basavaraj *et al.*, 2000).

Patra and Mishra (2000) conducted three field experiments at Chiplima during rainy season on sandy loam soil from which they concluded that the highest seed yield was obtained with spacing of 30 cm x 10 cm with 3,33,000 plant population ha^{-1} over other treatments of spacing.

Senthilkumar *et al.* (2000) carried out a field experiment at Tamil Nadu to evaluate the intra-row spacing and nitrogen levels on sesame. They reported that yield in both the *khairf* and summer increased with increasing plant density (i.e. from 30 cm x 30 cm, 30 cm x 25 cm to 30 cm x 20 cm spacing).

Hemalatha *et al.* (1999) carried out an experiment during *kharif* on sandy loam soil at Tirupati Campus of ANGRAU. They indicated that plant height and leaf area index were highest with the spacing of 22.5 cm x 10 cm, whereas, the drymatter $plant^{-1}$ and number of capsules $plant^{-1}$ were maximum with spacing of 45 cm x 10 cm than the other spacings in sesame.

While studying the effect of different geometry on summer sesame at Vridhachalam (T. N.) during 1996 and 1997, by Subrahmaniyan and Arulmozhi (1999) the plant height, number of branches $plant^{-1}$ and drymatter production (g $plant^{-1}$) were significantly increased under 30 cm x 30 cm plant geometry compared to 30 cm x 20 cm during both the years.

Jain *et al.* (1999) conducted an experiment at Calcutta (West Bengal) during 1999 and 2000 indicated that the seed yield of sesame was significantly highest with the plant geometry planting geometry of 45 cm × 15 cm, over other planting geometry of 30 cm × 30 cm and 40 cm × 30 cm.

Brar *et al.* (1998) investigated from his field experiment conducted during 1992 and 1993 on loamy sandy soil at Agronomy Farm of PAU, Ludhiana. They concluded that the maximum plant height and dry matter $plant^{-1}$were observed with 22.5 cm x 10 cm spacing and in 45 cm x 10 cm spacing during both the years of study in sarson.

Ramanathan and Chandrashekharan (1998) reported that planting geometry of 45 cm × 15 cm resulted in highest seed yield due to enhanced plant yield attribute characters *viz.*, capsules plant $^{-1}$ and seeds capsule^{-1} which was significantly superior over the other planting geometry (30 cm × 30 cm, 45 cm × 30 cm).

Tiwari and Namdeo (1997) performed a field trial at Madhya Pradesh during *kharif*. They revealed that plant height of sesame was significantly higher under higher plant density (i.e. in 30 cm x 10 cm), whereas, branches plant^{-1} and leaf area were significantly higher under lower plant density (i.e. in 30 cm x 15 cm).

Patil *et al.* (1995) carried out a field experiment in Maharashtra on N level and spacing on yield of sesame. They revealed that mean seed yield of 0.58 t ha^{-1} was the highest at row spacing of 30 cm x 15 cm as compared to other spacings (30 cm x 10 cm and 45 cm x 10 cm).

Nirval *et al.* (1995) conducted a field experiment for three years at Parbhani to study the effect of sowing dates and plant densities on seed yield of sesame varieties under rainfed condition. They reported that the plant density of 2.25 lakh ha^{-1} i.e. 45 cm x 10 cm recorded significantly higher seed yield (469 kg ha $^{-1}$) over the other plant spacings of 45 cm x 15 cm and 45 cm x 20 cm

Mishra *et al.* (1994) conducted a field experiment on sesame in summer season at Chiplima, Orissa on different spacings (25, 30 and 35 cm). They obtained higher seed yield with 30 cm.

Chimanshette and Dhoble (1992) conducted an experiment and he obtained significantly higher seed yield (364 kg ha^{-1}) with 2,22,000 plants ha^{-1} (45 cm X 10 cm) over 1,48, 000 plants ha^{-1} (45 cm X 15 cm, 325 kg ha^{-1}) and 1,11,000 plants ha^{-}1 (45 cm X 20 cm, 278 kg ha^{-1}) on medium black soil during rainy season at Parbhani.

Bindra and Kharwara (1992) conducted an experiment during spring at Palampur. They reported that plant spacing of 45 cm x 20 cm significantly increased the seed yield as compared to 60 cm x 20 cm and 30 cm x 20 cm spacings in sesame.

Ghungarde *et al.* (1992) conducted an experiment at Parbhani (Maharastra), reported maximum number of capsules plant^{-1} under 60 cm but it was statistically at par with 45 cm spacing.

Kadam *et al.* (1989) carried out an investigation during *kharif,* 1986 and revealed that row spacing of 45 cm produced significantly higher yield than the 60 and 30 cm row spacings in sesame.

2.2 EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON GROWTH AND YIELD OF CROP

Thripathy and Bastia (2012) carried a field experiment during summer season of 2010 and 2011 in sandy loam soil of Bhubaneswar and reported that application of 50 % recommended dose of NPK (30:6.6:12.5 NPK, kg ha^{-1}) + FYM 5t ha^{-1} gave significantly higher values of growth and yield attributes.

Haruna *et al.* (2012) reported that application of 2.5 t ha^{-1} of poultry manure produced the highest values for all the yield attributes and yield of sesame.

Gunri and Nath (2012) studied the effect of organic manures and biofertilizer on productivity of groundnut and found that the significantly higher pods per plant and shelling out turn was recorded when recommended dose of fertilizer was applied along with 10 t ha^{-1} FYM or 5 t ha^{-1} poultry manure as compared to other treatment.

Patel *et al.* (2012) studied the effect of integrated nutrient management on soybean on clay soil at Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidhyalaya, Raipur. The result revealed that application of 125 % RDF along with FYM @ 5t ha^{-1} produced significantly higher growth and yield attributes, seed (20.08 q ha^{-1}) and straw (26.24 q ha^{-1}) yields as compared to application of 100% RDF or FYM.

Sridhar *et al.* (2012) fertilized sunflower with 100 % RDF and recorded significantly higher germination percentage, plant height, number of leaves, leaf area index, drymatter production than rest of the treatments. Yield attributes viz., head diameter (10.6 cm) and number of seeds per head were significantly higher with 100 % RDF (35:50:35 $N:P_2O_5:K_2O$ kg ha^{-1}) but on par with in situ sunhemp green manure incorporation @ 2.5 t ha^{-1} + 50 % RDF of nitrogen through urea and in situ sunhemp green manure incorporation @ 5 t ha^{-1}. Seed yield and stalk yield of sunflower were significantly higher with 100 % RDF.

Barik and Fulmali (2011) studied the integrated plant nutrient supply through organic and mineral sources on productivity of summer sesame in a field experiment was conducted during summer season of 2004 and 2005 at Agricultural Farm, Sriniketan, West Bengal on a sandy loam soil. They found the highest plant height (125.0 cm), dry matter accumulation (216.2 g m^{-2}), number of capsule $plant^{-1}$ (53.3), test weight (3.0 g), seed yield (0.9 t ha^{-1}) of sesame with FYM @ 10 t ha^{-1} application. This treatment remains par with the treatment, application of mustard cake @ 1 t ha^{-1}.

Haruna (2011) further reported that application of poultry manure at 5 t ha^{-1}, nitrogen 60 kg ha^{-1} and phosphorous 13.2 kg ha^{-1} were the for increased yield of sesame in the northern Guinea Savanna agro ecological zone.

Ogbonna and Umar-Shaaba (2011) while studying on sesame at Savannah of south eastern Nigeria reported that application of 5 and 10 t ha^{-1} poultry manure significantly increased the seed yield by 33.6 and 76.9 % respectively over control.

Sanaz Shoghi Kalkhoran *et al.* (2010) conducted an experiment to evaluate the effects of organic manure (FYM), biofertilizer (Azotobacter and Azosprillium), green manure, chemical and integrated fertilizer systems on the quantitative traits of sunflower and the results showed that the seed yield in the integrated systems was significantly higher than in the organic and chemical systems.

Deshmukh *et al.* (2010) conducted a field trial in clay soil of Rahuri, Maharashtra on sesame during *summer* season. From the results they reported that growth parameters and yield attributes were significantly superior with the application of 60 kg N + 40 kg P_2O_5 + 20 kg K_2O ha^{-1} + 5 t each of FYM and Vermicompost ha^{-1}.

Javia *et al.* (2010) conducted an experiment at Nana Kandhasar, Gujarat on sandy loam soil to study the effect of nutrient management on the yield of sesame. They concluded that sesame crop should be fertilized with FYM @ 5 t ha^{-1} + recommended dose of fertilizer (25: 25: 0 NPK, kg ha^{-1}) to obtain maximum yield.

Kashved *et al.* (2010) revealed that the growth attributes *viz.*, plant height, and dry matter were increased significantly by integrated application of 75 % recommended dose of nitrogen through urea + 25 % N through FYM than the rest of the treatments in mustard.

Chaurasia *et al.* (2009) conducted the field experiments during *Kharif* of 2006 and 2007 in clay loam soils on sesame cv. JTS-8 at Tikamgarh, Madhya Pradesh. They reported significant increase in seed yield with integrated use of 60 kg N + 40 kg P_2O_5 + 20 kg K_2O ha^{-1} + 2.5 t FYM. The highest productivity and net monetary return was also noted in same treatment.

Shashidhara *et al.* (2009) reported the highest yield of sesame during kharif season with the fertilizer application of 40 kg N+25 kg P_2O_5+25 kg K_2O+5t FYM ha^{-1} in Vertisols of Dharwad, Karnataka.

Shinde *et al.* (2009) in a field experiment on integrated nutrient management in soyabean cv. DS-228, at Phule, Kalyani conducted during *kharif* 2005 on a medium black soil in Pune, Maharashtra, India. recorded the highest number of pods (43.50), 1000-seed weight (182.00) and significantly the highest seed yield of 4464.2 kg ha^{-1} was obtained with T_3 100% RDF + farmyard manure at 5 t ha^{-1}.

Deshumukh and Dhoon 2008 reported maximum seed yield and net monetary returns of sesame *cv.* JTS-8 during *kharif* season with the fertilizer application of 60 kg N + 40 P_2O s + 30 kg K_2O + 20 kg S ha^{-1} in clay loam soils of Jabalpur, Madhya Pradesh.

Maheswari *et al.* (2008) reported the highest seed yield of castor with 50 % N through inorganic and 50 % through compost and 75 % N through inorganic and 25 % through Glyricidia in red sandy loam soil of Anantapur.

More *et al.* (2008) conducted a field experiment at Agriculture College farm, Nagpur Maharashtra, India during *kharif* 2006-2007 to study the influence of nutrient management treatment on growth and yield attributes and yield of soybean. The studies revealed that the growth attributes *viz.*, plant height, number of branches $plant^{-1}$ and drymatter accumulation were maximum in 30:75:00 kg NPK ha^{-1} (RDF) followed by 75% RDF + 5 t FYM ha^{-1}.

Tripathi and Rajput 2007 recorded the highest seed yield and net monetary returns of sesame *cv.* JTS-8 during *kharif* with the fertilizer application of 60 kg N + 30 kg P_2O_5 + 15 kg K_2O ha^{-1} in sandy loam soils of Tikamgarh, Madhya Pradesh.

Thakur and Umat (2007) reported maximum seed yield and economic returns of niger *cv.* Ootacmund with the application of 10 kg N + 2 t FYM ha^{-1} mainly due to superiority in growth parameters (plant height and branches $plant^{-1}$) and yield attributes (number of capsules $plant^{-1}$ and seeds $capsule^{-1}$) in sandy loam soils of Chhindwara, Madhya Pradesh.

Reddy *et al.* (2007) conducted an experiment at Rajendranagar, Hyderabad during *kharif* season of 2005 to study the productivity and nutrient uptake of sunflower as influenced by site specific integrated nutrient management on alfisols. They reported that the 50 % NPK + 50% N (25 % N – Green manure + 25 % N – Poultry manure) significantly increased the leaves per plant and seed yield of sunflower.

Mali and Gokhle (2007) conducted an experiment on influence of integrated nutrient management on yield and quality of soybean and pigeonpea intercropping system in clayey and slightly alkaline soil at Agronomy Farm, College of Agriculture, Latur, Maharashtra during *kharif* 2004-2005. They revealed that the higher soybean and pegionpea seed equivalent yield of 3483 and 3020 kg ha^{-1}, respectively were observed due to application of 100 % RDF through FYM than 100% RDF of main crop to entire system.

Thorave (2006) conducted a field experiment on summer groundnut and reported that application of 75 % N through inorganic fertilizer + 25% N through FYM has significant improvement over 50:50 and 25:75 combination of inorganic fertilizer and FYM respectively. It enhanced all the growth attributes *viz*., plant height, number of branches, number of functional leaves, leaf area and total drymatter $plant^{-1}$ of groundnut.

Chaturvedi and Chandel (2005) at Pantnagar found the maximum values of yield contributing characters (pods per plant and 100- seed weight), harvest index and seed yield of soyabean with the application of 100 per cent recommended NPK + FYM 10 t ha^{-1}.

Paneerselvam and Bheemaiah (2005) reported the highest yield of sunflower with subabul green leaf manure @ 5 t ha^{-1} + 30 kg N ha^{-1} in sandy loam soil of Hyderabad.

Aruna and Mohammad (2005) while testing the residual effect of nutrients in rice sunflower sequence reported that highest plant height of sunflower was recorded with 75 % of N through fertilizer and 25 % N through sunnhemp on sandy loam soil of Hyderabad.

Vanaja and Raju (2004) reported that green manuring with cowpea or pillipesara resulted in significantly higher seed yield of sunflower compared to no green manuring in all treatments over control in a sandy loam soil of Hyderabad.

Parihar (2004) revealed that sunflower seed yield obtained with 80 kg N ha^{-1} (50 % through green manure + 50 % through urea) were comparable to 80 kg N ha^{-1} (50 % through FYM + 50 % through urea) both were significantly higher than 80 kg N through urea alone.

Paradkar and Deshmukh (2004) reported maximum seed yield of soybean *cv.* JS-335 during *kharif* season with the application of 20 kg N + 60 kg P_2O_5 + 20 kg K_2O + 10 t FYM ha^{-1} in sandy clay loam soils of Chhindwara, Madhya Pradesh.

In a study on cropping systems and integrated nutrient management practice, Vani and Bheemaiah (2003) at Hyderabad reported higher seed yield of castor with *Leucaena* green leaf manuring @ 5 t ha^{-1} which was at par with *Albizia* green leaf manuring @ 5 t ha^{-1}at Hyderabad.

Kathiresan (2002) conducted an experiment in sandy loam soil of Tamilnadu with sesame *cv.* TMV-4 during rainy season and reported that application of 52 kg N + 35 kg P_2O_5 + 35 kg K_2O ha^{-1} gave highest seed yield.

Deshmukh *et al.* (2002) recorded the highest seed yield of sesame *cv.* TKG-22 at Jabalpur, Madhya Pradesh with the integrated use of 50% N through urea + 50% N through FYM. It was mainly due to improvement in plant height, capsules $plant^{-1}$ and test weight. The integrated nutrient management also fetched higher net monetary return and benefit-cost ratio over other nutrient management.

Prasad and Satyanarayana (2002) studied the integrated use of organic and chemical fertilizers to improve crop productivity and sustain soil health and fertility. Their result showed that maximum seed of rice was obtained by application of 120:26:37 kg NPK ha^{-1} in combination with green manures. Whereas maximum pod yield of groundnut was obtained by residual effect of green manure applied to rice and application of 30: 26: 33 kg NPK ha^{-1} in combination with gypsum applied to groundnut crop.

According to Narkhede *et al.* (2001) application of castor cake one t ha^{-1} or farm yard manure (FYM) 5 t ha^{-1} + RDF (50 kg N ha^{-1}) in two equal splits (50% as basal + 50% at 30 DAS) was the most effective integrated nutrient management strategy to maximize the productivity of sesame *cv.* Padma during *kharif* season in medium black soil of Jalgaon, Maharashtra.

From the results of a multilocation study on integrated use of fertilizers and FYM in sesame for two consecutive years, Duhoon *et al.* (2001) recorded the highest seed yield with the use of 50% N through urea + 50% N through FYM + 50% P (through single superphosphate) + 100% K (through muriate of potash). Thus, there was saving of 50% each of N and P fertilizer besides improvement in soil-health and increased seed yield due to integrated use of FYM and other fertilizers.

Bhal and Pasricha (2000) observed a residual effect of green manuring on the following sunflower crop and resulted in an average 317 kg ha^{-1} higher yield as compared to the treatments without any residual green manure.

Kathmale *et al.* (2000) studied on integrated nutrient management in groundnut and found that significantly higher dry pod (2751 kg ha^{-1}) and haulm yields (5119 kg ha^{-1}) of *kharif* groundnut were observed due to application of 2.5 t FYM ha^{-1} + 75% RDF which was 57% higher than that of control and 31% higher than farmers practice. However, this treatment was closely followed by application of 10 t wheat straw + 50% recommended fertilizer dose.

Abolel and Abo (1996) reported the highest seed yield (14.0 q ha^{-1}) of sesame cv. B-67 during *summer* season with the application of 75% NPK + 10 t FYM ha^{-1} in sandy loam soil of West Bengal, India.

Sharnapa and Shivraj (1995) studied the influence of pre-season green manure crop on the performance of rice sunflower sequence on sandy loam soil at Bangalore. They recorded that seed yield of rice was significantly higher with *S. rostrata* green manure (4.47 t ha^{-1}) which was followed by sunhemp green manure (4.37 t ha^{-1}) compared to non-green manured plot. Similarly, the seed yield of sunflower was significantly higher in *S. rostratra* rice followed by sunhemp-rice (0.78 and 0.71 t ha^{-1}, respectively).

Mondal *et al.* (1993) found maximum seed yield of sesame cv. B-67 with the application of 75% NPK (RDF) + 5 t FYM ha^{-1} in sandy loam soils of Sriniketan, West Bengal.

2.2.1 Negative Effects of Poultry Manure

Unlike inorganic N, poultry litter contains high levels of organic N and slow mineralization rates leads to less N available for crops at the time of poultry litter application.On the average, only 55% of the organic N from poultry litter is mineralized and 75 % of total N was available during the first year after application (Moore *et al.*, 1998). Therefore, in a long-term study with multiple years of poultry litter application, plenty of organic N accumulates in the field and mineralizes to inorganic form and becomes available for plant growth.

Various studies found that greater CEC is associated with greater soil organic matter (SOM) contents, due to a higher degree of oxidation of SOM and a higher surface area for cation adsorption sites. Electrical conductivity was slightly higher (P = 0.0752) in litter applied soils compared to inorganic fertilizer applications, which was consistent with previous long-term studies (He *et al*., 2008). Poultry litter added to the soil mineralizes and release the nutrients and salts to the soil leading to an increase of soil EC and salt content. Increasing soil pH is due to respiration by microbes from the poultry litter treatments which could increase the carbonate content of soil, hence increasing the soil pH (Azeez and Van Averbeke, 2012) are some of the possible reasons for low availability of ‘N’ of the crop.

2.2.2 Remedy Measures

Generally, management of crop nutrients and soil fertility mainly depend upon a complex long-term integrated approach rather than a short-term one. Differences in crop yield maybe different depending on whether poultry litter is applied only one year or for multiple years. Our analysis showed a positive effect for experimental duration on crop productivity crop yield increased (5.05 ± 3.95 %) when PL was applied for multiple years (6 – 13 years). Similarly, Diacono and Montemurro (2010) reviewed long-term studies (3 – 60 years) on the effects of organic amendments and found crop yield increased up to 250% with long-term applications of high rates of municipal solid waste compost.

2.3. EFFECT ON QUALITY, NUTRIENT CONCENTRATION AND UPTAKE

Choudhary *et al*. (2017) in a field experiment was conducted during kharif season of 2015 at Agronomy Farm, S.K.N. College of Agriculture, Jaipur (Rajasthan) with groundnut variety RG-382 (Durga) on loamy sand alkaline soil under irrigated condition revealed that application of poultry manure @ 5 t ha^{-1} recorded the highest values of protein content (25.30%), oil content (48.39%), and NPK concentration and uptake.

Hanumanthappa *et al*. (2016) was carried out an experiment during *kharif*, 2014 at Zonal Agricultural & Horticultural Research Station, Brahmavar, Udupi, Karnataka, India, to study the residual effect of different organic sources of nutrients in paddy-groundnut cropping sequence and reported that the highest nutrient uptake and availability (142.38, 12.63, 58.24 and 210, 130, 78 kg ha^{-1} NPK and N, P_2O_5 and K_2O), respectively in Poultry manure (1.0 t ha^{-1}) + Cow urine equivalent to 75 kg N ha^{-1} in 4 splits.

Moinuddin *et al*. (2016) carried out an experiment during *kharif* 2009-2010 at the Crop Research Farm, Department of Agronomy, Sam Higginbottom Institute of Agriculture, Technology & Sciences, and concluded that the highest oil content and protein content were recorded with the application of 25 % RDN through FYM + 25 % RDN through vermicompost + 25 % RDN through poultry manure + 25 % RDN through neem cake.

Kumara *et al*. (2014) at the Main Agricultural Research Station, Dharwad indicated that oil content did not differ significantly with different spacings in sesamum. However, spacing of 30 cm x 10 cm recorded significantly higher oil yield (354 kg ha^{-1}) than 45 cm x 20 cm spacing (269 kg ha^{-1}), but spacing of 45 cm x 10 cm was comparable with that of 30 cm x 10 cm.

Sheetal *et al*. (2014) observed that the highest nutrient content and uptake was recorded in 150% RDF (37.5:75:37.5 kg ha^{-1}) and found at par with 5t FYM ha^{-1} +50% RDF + neem cake 500 kg ha^{-1} + biofertilizers in pod and haulm in groundnut, respectively.

Nayek *et al*. (2014) at Nadia, West Bengal observed that the maximum oil content (%), nitrogen, phosphorous and potassium uptake (kg ha^{-1}) were significantly the highest with application of 40 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1} along with 5.0 t FYM ha^{-1} as compared to sole application of chemical fertilizers.

Gunri and Nath (2012) revealed that the integrated use of organic and inorganic sources of fertilizer had a positive influence to increase the groundnut pod yield than sole application of recommended dose of inorganic fertilizer. The application of biofertilizer and /or bio-pesticide along with organic manure to groundnut had the significant influence to increase the groundnut yield. The results revealed that the pod yield of groundnut increased when both the organic manures (farm yard manure and poultry manure) were applied along with biofertilizer than application of either only farm yard manure or poultry manure alone.

Rao and Shaktawat. (2005). Conducted a field experiment for two years (1997 to 1999) at the Agronomy farm of Rajasthan College of Agriculture, Udaipur in a sandy clay loam soil to study the effect of organic manure, phosphorus and gypsum on groundnut and concluded that concentration and uptake of nitrogen and phosphorus were high with the application of farmyard manure at 10 t ha^{-1}+ poultry manure at 5t ha^{-1}+ 40 kg $P_2O_5^{-1}$ + gypsum at 250 kg ha^{-1}.

Srinivasarao *et al.* (2004) observed the highest number of total and filled pods per plant, shelling per cent, 100 kernel weight, pod, oil and protein yield of groundnut with the application of 100% RDF + FYM 5t ha^{-1}

Vaiyapuri *et al.* (2003) conducted an experiment to determine the effects of Sulphur (0, 15, 30 and 45 kg ha^{-1}) and organic amendments (10 t ha^{-1} each of farmyard manure, poultry manure and press mud) on the seed quality and nutrient uptake of sesame cv. TMV 3 and observed that application of poultry manure resulted in the highest oil content, oil yield and crude protein in sesame.

A Field experiment was conducted during the summer of 2002 and 2003 at University of Agricultural Sciences, Bangalore to study the effect of Nutrient Uptake and Agronomic efficiency of groundnut as influenced by different organic manures. and reported that the highest NPK uptake of groundnut recorded with the application of RDF + 10 t FYM ha^{-1}. (Seshadri. R *et al.* 2003).

Patil *et al*. (2003) conducted a field experiment at Maharashtra, during the *kharif* 1999 and observed that Protein and oil content increased with increasing rates of FYM and NPK fertilizers to sesame.

Majumdar *et al.* (2002) conducted a field experiment during *kharif* 1999 and 2000 to investigate the effects of rock phosphate (RP), superphosphate (SSP) and farmyard manure (FYM) on the performance of soybean grown on a P-deficient Ultic Hapludalf in Meghalaya. Fourteen treatments consisting of different combinations of RP, SSP and FYM and the control were used. SSP at 60 kg ha^{-1} + FYM at 5 t ha^{-1} recorded the highest protein (42.5%) and oil content (20.5%), protein (9.60 q ha^{-1}) and oil yield (4.60 q ha^{-1}).

A study was undertaken to determine effect of different row spacing on growth and yield attributes of two varieties of sesame at the Agronomy Research Area, University of Agriculture, Faisalabad, during 1999. In their research Ahamd *et al.* (2002) specified that seed oil content of sesame was not affected significantly by the various row spacing (30, 45, 60 cm) under study.

Kachot *et al.* (2001) carried out a field experiment Junagdh, Gujarat during the rainy season. They found that pod yield, protein content, protein yield, oil yield in groundnut were the highest with of 100% recommended dose of fertilizer along with 20 t of FYM ha^{-1} and seed dressing with *Azotobacter* .

Patel and Shelke (2000) studied the effect of organic and inorganic fertilizers on yield of mustard at Parbhani and reported that application of FYM @ 5 t ha^{-1} along with inorganic fertilizer significantly increased the mean oil and protein yield and nutrient content in mustard over only inorganic fertilizer.

Dasani *et al*. (1999) reported that the significant increase in protein content (26.24%), oil content (47.30%) and oil yield (7.81q ha^{-1}) of ground nut due to the integrated use of fertilizers and manures.

Babalad (1999) noticed significantly increased uptake of N, P and K in soybean cotton system with application of RDF + FYM @ 5 t per ha or RDF + vermicompost @ 2.5 t per ha as compared to RDF alone.

A field experiment was conducted by Tiwari and Namdeo (1997) during *kharif* seasons of the year 1990-91 at, Tikamgarh, Madhya Pradesh and noted that plant density have no significant influence on oil content, but oil yield was significantly higher in sesamum variety TKG 21 with 30 cm × 10 cm over rest of variety and spacing treatments.

Ramamurthy and Shivashankar (1996) reported that the uptake of major nutrients increased significantly with the increasing levels of organic matter application to soybean. The maximum values for uptake of N, P and K (225.1, 23.4 and 86.5 kg ha^{-1}, respectively) were recorded with the application of 10 t organic matter per ha and this was significantly higher over 5 t per ha and no organic matter application.

Ghosh and Patra (1994) carried out an experiment at the Agricultural Research Farm, Institute of Agriculture, Visav-Bharati, Sriniketan, West Bengal during summer season of 1989 and 1990. This results revealed that variation in oil content was not observed due to plant density during both years, however, oil yield recorded was the maximum at higher plant density (3,33,000 plant ha^{-1}) and it was significantly superior to medium (2,22,000 plant ha^{-1}) and low plant densities (1,67,000 plant ha^{-1}) at sandy-loam lateritic acid tract of West Bengal.

2.4. ECONOMICS OF NUTRIENT MANAGEMENT

Prasannakumara *et al.* (2014) conducted a field experiment during *kharif* 2007 at Dharwad in sesame and reported that the 30 cm x10 cm spacing gave maximum gross return (29,790 Rs. ha^{-1}), net return (18,592 Rs. ha^{-1}) and B: C ratios (2.66) were observed.

Shekh *et al*. (2014) in their experiment conducted at Junagadh, Gujarat observed that 30 cm x 10 cm spacing gave higher net returns (36279 ha^{-1}) and B:C ratio (2.98) over 45 cm x 10 cm and broadcast sowing in sesame crop.

An experiment was conducted at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushingar Dantiwada Agricultural University, S. K. nagar during 2011 on response of summer sesame (*Sesame indicum* L.) to different spacing and levels of nitrogen under North Gujarat condition by Patel *et al*. (2014). The results revealed that the highest net realization of Rs. 35096 ha^{-1} was recorded under 60 cm spacing which was 38.1 and 18.1 per cent higher than 30 and 45 cm spacing, respectively.

Results of an experiment carried out during the *kharif* season of 2007 at Main Agriculture Research Station, Dharwad by Kumara *et al*. (2014). Indicated that maximum gross return, net return and B:C ratio were obtained with 30 cm x 10 cm spacing pattern in sesame.

A field experiment was carried out by Sivagamy and Rammohan (2013) on sesame during summer season of 2006 in Masipattam and reported that the wider spacing 45 cm x 15 cm as an ideal agronomic practice for improving the sesame productivity, maximum gross income, net income and B: C ratio on Cauvery delta zone of Karaikal.

Kumar *et al.* (2012) reported that the maximum gross return (22704, 22720 Rs. ha^{-1}), net return (9,802, 9,818 Rs. ha^{-1}) and benefit cost ratio (1.75, 1.76) was obtained with medium spacing of 45 cm x 30 cm during 2004 and 2005 years respectively as compared to closer spacing of 30 cm x 30 cm and wider spacing of 60 cm x 30 cm of sunflower.

Barik and Fulmali (2011) studied the integrated plant nutrient supply through organic and mineral sources on productivity of summer sesame. A field experiment was conducted during summer season 2004 and 2005 at Agricultural Farm, Palli Siksha Bhavan, Vishva-Bharti on sandy loam soil. They noticed that the highest gross return (14,961 Rs ha^{-1}), net return (4,742 Rs ha^{-1}) and BCR (1:1.5) in sesame were recorded in treatment FYM @ 10 t ha^{-1}, which was significantly higher than control but at par with treatment mustard cake @ 1t ha^{-1}.

The highest net monetary return and profitability of sesame was obtained with application of 5 t FYM ha^{-1}, before 15 days of sowing (DOR, 2010).

Sutaria *et al.* (2010) noted the highest net return and benefit:cost ratio from groundnut *cv* GG-5 with integrated application of 50 % N through urea + 50 % N through FYM during *kharif* season in non saline soils of Dhari (Gujarat) .

Duary and Ghosh (2009) conducted field experiment during two consecutive summer seasons 2000 and 2001 at Pulse and Oilseeds Research Sub-station, Beldanga, Murshidabad, West Bengal on effect of nipping on growth, productivity and economics under varying levels of plant density. They tried four levels of spacing for plant density *viz.*, 30 cm x 10 cm, 45 cm x 15 cm, 30 cm x 30 cm and 45 cm x 30 cm in their experiment. The result showed that the sesame crop sown at a spacing of 30 cm x 10 cm (3.33 lakhs plant ha^{-1}) fetched higher net return and benefit cost ratio.

Deshmukh and Duhoon (2008) reported higher net monetary returns of *cv.* JTS-8 during *kharif* season with the fertilizer application of 60 kg N + 40 kg P_2O_5 + 30 kg K_2O + 20 kg S ha^{-1} in clay loam soil of Jabalpur (Madhya Pradesh).

Tripathi and Rajput (2007) at Tikamgarh (M. P.) observed that the maximum seed yield, higher net return and Cost Benefit Ratio OF sesame were recorded with the higher fertility level (60:30:15) N: P: K kg ha^{-1}.

Thorave (2006) conducted a field experiment on summer groundnut and reported that application of 75 % N through inorganic fertilizer + 25 % N through FYM recorded the higher gross and net monetary returns and benefit: cost ratio over rest of the integrated nitrogen management the treatments.

Deshmukh *et. al*. (2005) conducted a field experiment during *kharif* 2000 at Kaymore Plateau and Satpura Hills, Madhya Pradesh, India, to evaluate the response of integrated use of inorganic fertilizers, farmyard manure (FYM) and Phosphorus Solubilizing Bacteria (PSB) alone and in combination on nutrient availability, seed, energy and protein yields and economic feasibility of soybean. Results revealed that application of recommended dose of NPK (20:40:20 kg ha^{-1}) along with FYM (2.5 t ha^{-1}) recorded the maximum gross return (11,466 ha^{-1}) and net return (4,066 ha^{-1}), while the best benefit: cost ratio was obtained in treatment where only RDF was added (1:1.60).

Paneerselvam and Bheemaiah (2005) in a study on integrated nutrient management practices in agroforestry systems, reported that highest net returns and B:C ratio of sunflower were recorded with recommended dose of nitrogen (60 kg ha^{-1}) and subabul green leaf manure @ 5 t ha^{-1} + 30 kg N ha^{-1} in sandy loam soil of Hyderabad.

Sharma (2005) at Guna, (M.P) found that the application of N, P and K fertilizers (60 kg N + 40 kg P_2O_5+20 kg K_2O ha^{-1}) resulted in significantly higher seed yield, number of capsules $plant^{-1}$ and benefits cost ratio (2.10) in sesame.

Deshmukh, *et. al.* (2005) reported the highest net monetary return from soybean crop with the application of 2.5t FYM + 40 kg N + 30 kg P_20 5 + 20 kg K_20 ha^{-1} during *kharif* season in mixed red and black soil of Rewa (Madhya Pradesh) .

Deshmukh *et. al.* (2002) noted the higher net monetary returns and benefit : cost ratio from sesame *cv.* TKG-22 with the integrated use of 50% N through urea + 50% N through FYM in clay loam soil of Jabalpur, Madhya Pradesh.

Narkhede *et. al.* (2001) kg ha^{-1}) reported higher monetary returns and benefit cost ratio with application of one t ha^{-1} FYM + 40 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1} from sesame crop during *kharif* on medium black soils of Jalgaon, Maharashtra. .

Halepyati (2001) conducted a field experiment at Karnataka, during the *rabi*/summer of 1997-98 to determine the effect of farmyard manure (FYM), vermicompost and 100% recommended NPK rates, alone and their combination, on groundnut cv. S-206. The highest net return (16038 ha^{-1}) was recorded with the application of FYM at 6 t ha^{-1} + RDF.

Bajpai (2000) at Tikamgarh (M.P.) reported that the 100 percent recommended dose of N, P and K (60 N, 40 P_2O_5 and 20 K_2O kg ha^{-1}) resulted in significantly higher yield (398kg ha^{-1}) and maximum net return (Rs. 3502 ha^{-1}) in sesame crop.

Basavaraj *et. al.* (2000) at Karnataka observed that the highest seed yield (1777 kg ha^{-1}), net return (Rs 19,517 ha^{-1}) and benefit cost ratio (3.12) were obtained under 60:75:40 kg NPK ha^{-1} fertilizer treatment.

Ramanathan and Chandrashekharan (1998) conducted a field experiment during three consecutive summer seasons to find out the effect of nipping, plant geometry and fertilizer on summer sesame. From the results, they observed that wider spacing (45 cm x 10 cm) recorded higher net return of Rs. 6,301 ha^{-1} with benefit: cost ratio of 2.41 as compared to rest of spacing treatment *i.e.* 30 cm x 30 cm and 45 cm x 30 cm.

Dixit *et al.* (1997) studied the effect of various plant densities on economics of sesame at Hoshangabad (M. P.). They noticed that higher net profit was secured under 30 cm x 5 cm plant density compared to 30 cm x 10 cm and 30 cm x 7.5 cm.

Field experiment was conducted at Tikamgarh, Madhya Pradesh during 1990-91 by Tiwari and Namdeo (1997). They observed that sesame variety TKG 21 sown with 30 cm x 15 cm spacing gave higher net income and benefit cost ratio as compared to rest of the treatments.

Patil *et al.* (1995) conducted an experiment on sesame during *kharif* season at Jalgaon (Maharashtra). On the basis of three years results, they concluded that significantly higher monetary return was secured under 30 cm x 15 cm, but it was followed by 45 cm x 10 cm spacing. Both these spacings were significantly superior to 30 cm x 10 cm and 45 cm x 15 cm spacing.

Chapter – III

Material and Methods

Chapter III

MATERIAL AND METHODS

The present investigation entitled **"Planting Density and INM Interventions in Sesame Production"** was conducted during *rabi*-2017-18 at the Agricultural College Farm, Bapatla. The details regarding material used and methods followed during the course of investigation are presented in this chapter.

3.1 LOCATION OF THE EXPERIMENTAL SITE

The experiment was conducted at Agricultural College Farm, Bapatla. It is located in coastal region of Krishna Agro climatic Zone of Andhra Pradesh. It is situated at 15º 54' N latitude and 80º 25' E longitude with an altitude of 5.49 meters above the mean sea level (MSL) and about 8 km away from the Bay of Bengal.

3.2 WEATHER

Weather data recorded during crop growth period, (10-01-2018 to 04-4-2018) is presented in Table 3.1 and depicted in Figure 3.1. The crop was sown in the 2nd week of January (2nd standard meteorological week). The weekly mean maximum temperatures ranged from 25.6^{0}C to 34.7^{0}C with an average of 31.51^{0}C. The weekly mean minimum temperatures ranged from 14.2^{0}C to 25^{0}C with an average of 19.45^{0}C. During the corresponding period, mean relative humidity ranged from 40.6 to 77.9 per cent with an average of 69.51 per cent. The total amount of 15 mm of rainfall was received during the entire crop growth period.

3.3 EXPERIMENTAL SOIL

The experiment was laid out in Southern block of Agricultural College Farm, Bapatla. Initial soil samples were collected at random from 0 to 30 cm depth from the experiment field, and a composite sample was drawn and analyzed for physical and physico - chemical properties by following standard methods (Table 3.2).

Table 3.1: Weekly meteorological data recorded at Agricultural College Farm, Bapatla during the crop growth period (10-01-2018 to 04-04-2018)

Standard meteorological Week	Date and month	2017-18				
		Mean temp (^{0}C)		Mean RH	Rainfall (mm)	Rainy days
		Max.	Min.	(%)		
2	08th Jan - 14th Jan	30.1	18.1	68.2	0	0
3	15th Jan - 21st Jan	29.9	17.4	74.3	0	0
4	22 Jan - 28th Jan	25.6	14.2	64.5	0	0
5	29th Jan - 04th Feb	31.1	16.5	64.3	0	0
6	05th Feb - 11th Feb	30.6	19.3	75.4	0	0
7	12th Feb - 18th Feb	31.2	18.9	73.4	0	0
8	19th Feb - 25th Feb	31	17.8	68.4	0	0
9	26th Feb - 04th Mar	34.7	17.9	40.6	0	0
10	05th Mar -11th Mar	32.8	19	71.5	0	0
11	12th Mar -18th Mar	32.6	21.8	73.8	0	0
12	19th Mar -25th Mar	33.8	22.9	76.6	0	0
13	26th Mar -01stApr	33	25	77.9	1.2	0
14	02nd Apr -08th Apr	33.2	24	74.7	13.8	1
Total		-	-	-	**15**	
Mean		**31.51**	**19.45**	**69.51**	**-**	**-**

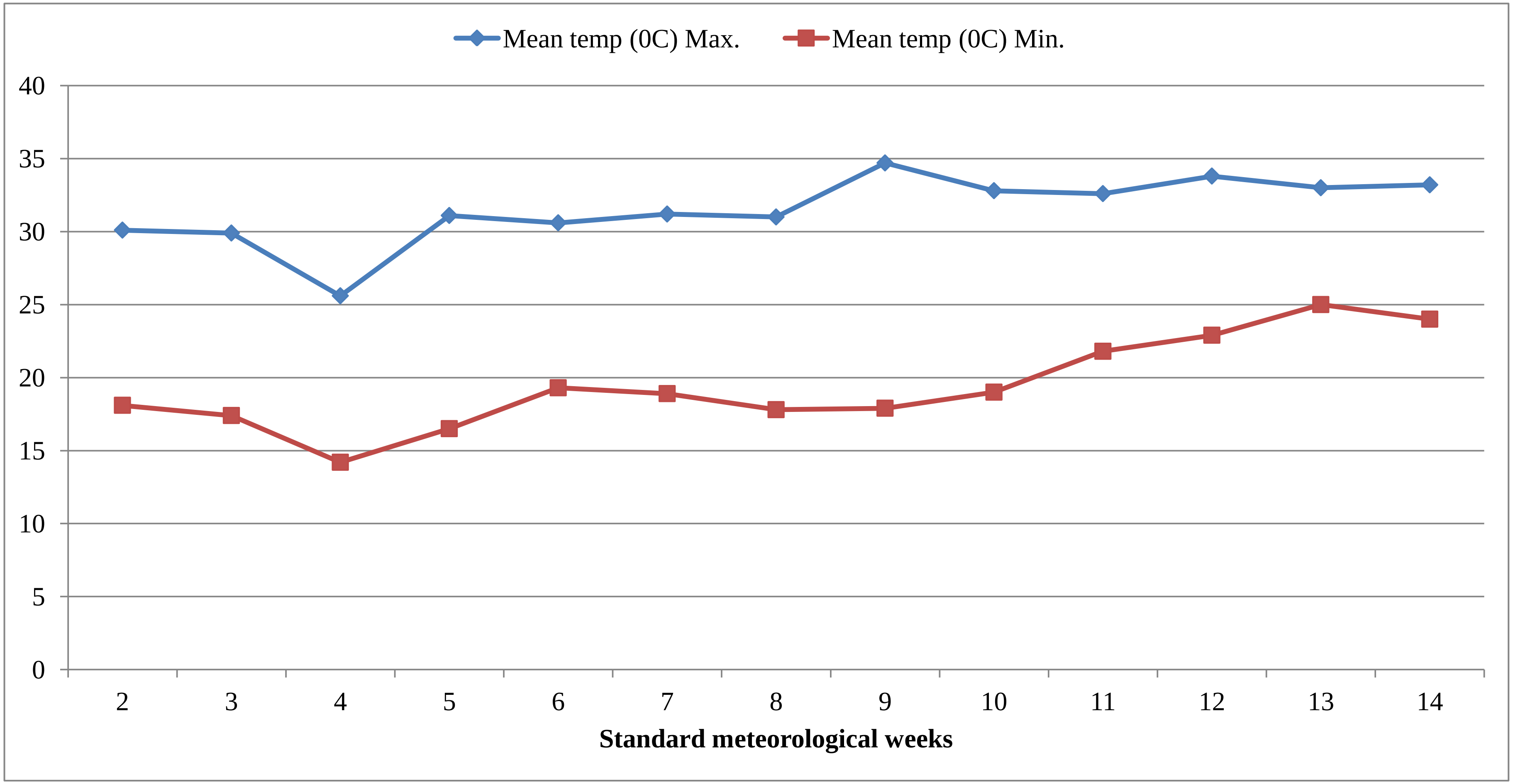


Fig. 3.1 weekly mean minimum and maximum temperatures recorded during the crop period

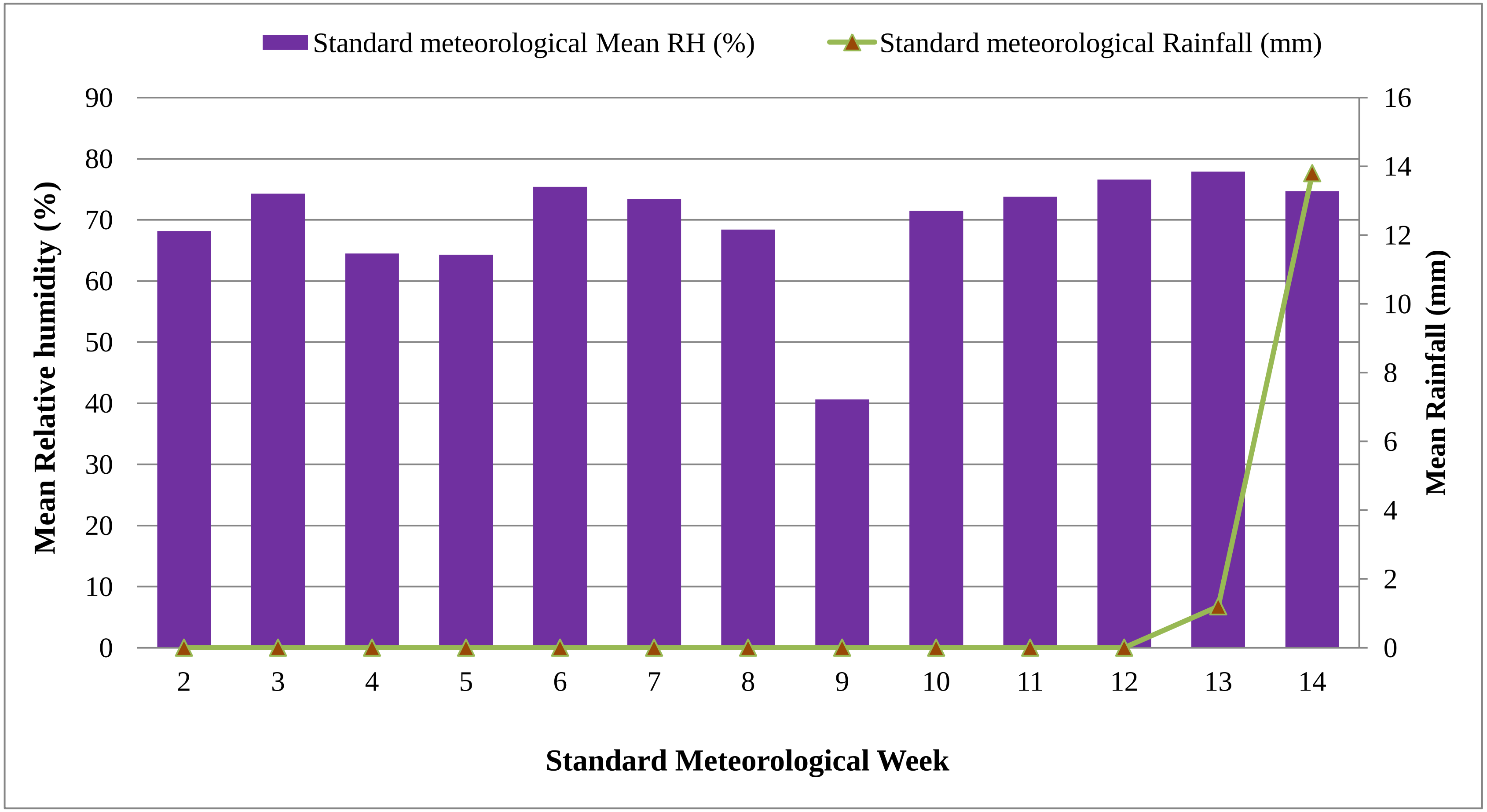


Fig. 3.2 Weekly Rainfall and mean Relative humidity data during the crop period

Table 3.2. Physical and Physico-chemical properties of the experimental soil

Soil Properties	Value	Method adopted
A. Mechanical analysis		
Sand (%)	77.6	Bouyoucos hydrometer method (Piper, 1966)
Silt (%)	4.2	
Clay (%)	18.2	
Textural class	Sandy loam	
B. Chemical analysis		
pH (1: 2.5 soil-water suspension)	7.1	Glass electrode method (Jackson, 1973)
EC (dSm^{-1} at 25^oC)	0.5	Digital electrical conductivity meter (Jackson, 1973)
Organic Carbon (%)	0.30	Walkley and Black's modified method (Walkley and Black, 1934)
Available N (kg ha^{-1})	245	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 (kg ha^{-1})	28	Olsen's method (Olsen *et al.*, 1954)
Available K_2O (kg ha^{-1})	290	Neutral normal ammonium acetate method (Jackson, 1973)

Based on soil analysis, the soil of the experimental site was classified as sandy loam in texture, saline and low in organic carbon, low in available nitrogen and medium in available phosphorus and high in available potassium.

Table 3.3 N, P and K contents (%) of organic manures on dry weight basis

Organic manures	N	P	K
Farm Yard Manure	0.5	0.2	0.5
Poultry manure	3.8	2.5	2.3
Sunhemp green manuring in-situ	2.3	0.5	1.8

3.4 CROPPING HISTORY OF THE EXPERIMENTAL SITE

The experimental site has been under cultivation for many years. The cropping history for the consecutive preceding years.

Year	Season		
	kharif	***rabi***	***summer***
2014-15	rice	fallow	fallow
2015-16	rice	fallow	fallow
2016-17	vegetables	fallow	fallow
2017-18	Present investigation		

3.5 EXPERIMENTAL DETAILS

The experiment was conducted at the Agricultural College Farm, Bapatla with two Factors. Factor A comprising planting density and Factor B comprising five nutrient sources Replicated thrice. The experiment was conducted in Factorial Randomized Block Design

3.5.1 Treatments

Factor – A (spacings)

S_1 = 45cm X 10 cm

S_2 = 30cm X 10cm

Factor- B - (Nutrient sources)

F_1: 100 % Recommended dose of fertilizers (60, 40,60kg NPK ha^{-1})

F_2: 75% Recommended dose of fertilizers + 5t FYM ha^{-1}

F_3: 75% Recommended dose of fertilizers + 0.75t Poultry manure ha^{-1}

F_4: 75% Recommended dose of fertilizers + 1.3t Sunhemp green manuring ha^{-1}

F_5: 25% Recommended dose of fertilizers + 5t FYM ha^{-1} +0.75 t Poultry manure ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}.

3.5.2 Experimental design and layout

The experiment was conducted in Factorial Randomized Block Design with two factors, Factor A comprising planting density and Factor B comprising five nutrient sources Replicated thrice.

Gross plot size : 6m x 4m

Net plot size : 4.5m x 3.2m

3.6 DESCRIPTION OF SESAME CULTIVAR

Sesame variety YLM- 66 (Sarada) was selected for *rabi*. This cultivar developed at the Agricultural Research Station, Yellamanchili, Visakhapatnam district of Andhra Pradesh, is a cross between YLM 17 and P.S. 201. The cultivar is brown seeded one with yield potential of 600-800 kg ha^{-1} and matures in 80-85 days. It is moderately resistant to Phyllody, Phytopthora blight, Macrophomina stem rot and Cercospora leaf spot.

3.7 CULTIVATION DETAILS

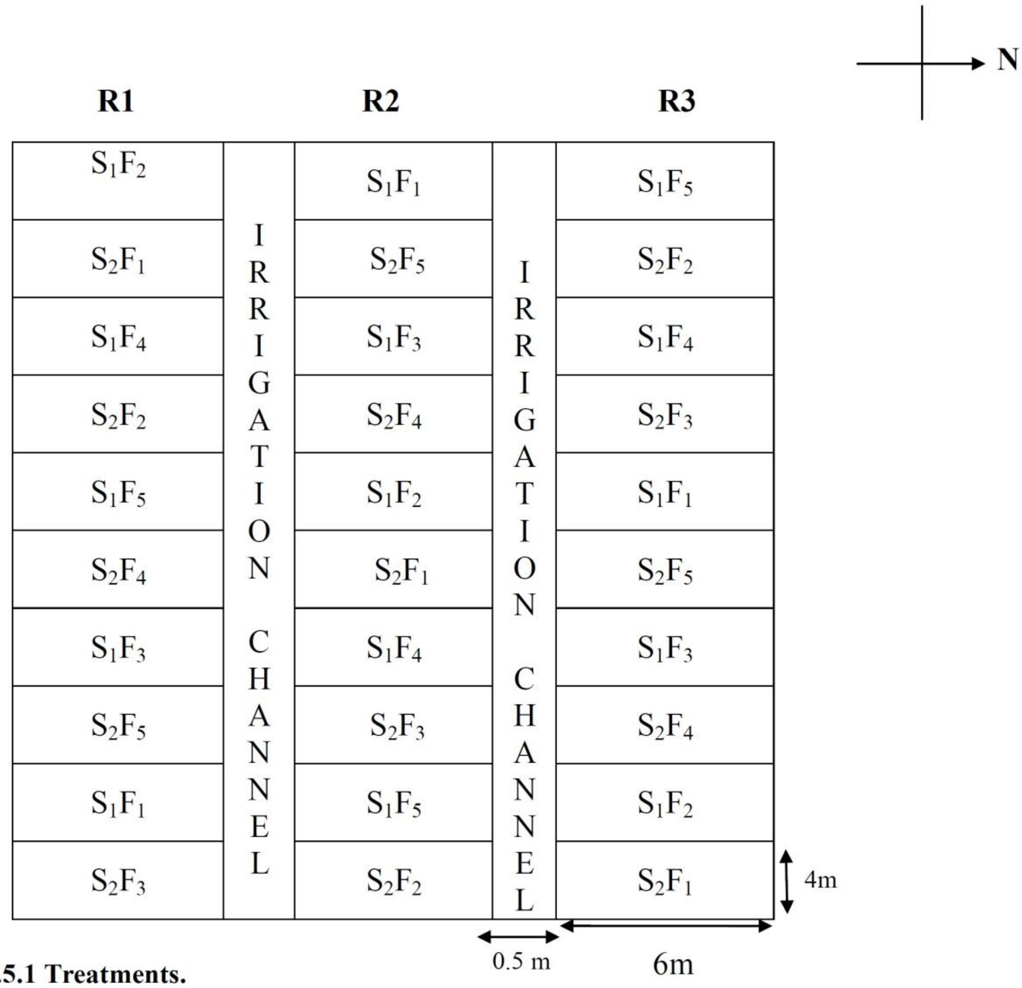
Cultivation practices adopted for sesame are presented here. The calendar of operations however, is furnished in Appendix B.

3.7.1 Land Preparation

The land was ploughed with tractor drawn mouldboard plough and then the soil was brought to fine tilth using a rotavator. The field layout was done as per randomised block design with factorial concept and FYM, Poultrymanure, Greenmanure(Sunhemp) was incorporated before sowing in individual plots as per treatments.

3.7.2 Layout

The field was divided into required number of plots as per the layout plan (Fig 3.3). Individual plots were separated by bunds, buffer channels and irrigation channels to provide irrigation.



3.5.1 Treatments.

Factor - A

S_1 = 45cm X 10 cm

S_2 = 30cm X 10cm

Factor- B - (Nutrient sources)

F_1: 100% RDF (60, 40,60kg NPKha^{-1})

F_2: 75% RDF + 5t FYM ha^{-1}

F_3: 75% RDF + 0.75t Poultry manure ha^{-1}

F_4: 75% RDF+ 1.3t Sun hemp green manuring ha^{-1}

F_5: 25% RDF + 5t FYM ha^{-1} +0.75 t Poultry manure ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}

Fig. 3.3 Layout plan of the experiment

3.7.3 Green manuring

3.7.3.1. Sunhemp

Sunhemp (*Crotalaria juncea*, L.) a plant of subfamily *Papilionaceae* of family *Leguminaceae* is an annual shrub cultivated as a multipurpose legume. It is native to India. Sunhemp is the fastest growing species of the genus and is very effective in smothering of weeds. Almost any well drained soil is suitable for raising this crop. Sunhemp grown during rainy season is mainly utilized as a green manure crop; it can produce a biomass yield of approximately 15 to 20 t ha^{-1}. It is a short day plant, but vegetative growth is favoured by long days.

3.7.3.2. Raising and Incorporation of Green Manure Crop.

Seeds of green manure crop *Sunhemp* (30 Kg) was broadcasted on the soil as per the treatments. Irrigations were provided to green manure as per the requirement. Sowing of the green manure was done in such a way that can be incorporated before 20 days to facilitate sowing of sesame at an optimum date of sowing. *In-situ* incorporation of green manure crop was done at 45 DAS (flowering stage) as per the treatments. Tractor drawn rotavator was used for incorporation of green manures.

3.7.4 Application of FYM

FYM was applied as per the treatments 15 days before sowing and thoroughly incorporated with the help of spade in soil.

3.7.5 Application of poultry manure

Poultry manure was applied as per the treatments 15 days prior to sowing and thoroughly incorporated in the soil upto root zone depth like FYM.

3.7.6 Sowing

Sesame crop was sown in lines of 30 cm and 45cm apart drawn by marker. Shallow furrows are opened at 30 cm and 45cm apart with the help of marker. The seeds were hand sown uniformly 10 cm apart in the furrows and covered with soil immediately after sowing.

3.7.7 Fertilizer Application

Nitrogen was applied as per the treatments in two equal splits *i.e.* basal and at 35 DAS through urea. Entire phosphorous and potassium were applied at the time of sowing through SSP and MOP. In the treatment F_2 – 75% RDF along with 5t FYM ha^{-1} was applied, F_3 -75% RDF along with 0.75t Poultry manure ha^{-1} was applied, F_4 - 75% RDF along with green manuring (1.3t Sunhemp ha^{-1}) was applied, F_5 – 25% RDF along with 5t FYM ha^{-1}, 0.75t Poultry manure ha^{-1}, Green manuring (1.3t Sunhemp ha^{-1}) was applied.

3.7.8 Gap filling

To maintain desired level of plant population, gap filling was done 12 days after sowing.

3.7.9 Irrigation

The crop was irrigated soon after sowing the seed and thereafter three light (4 cm depth) irrigations were given uniformly to all the plots at critical stages.

3.7.10 Weeding

Weeding was done manually with hand hoes at 20 and 35 DAS to control weeds.

3.7.11 Plant Protection

The incidence of leaf folder was observed during the initial crop growth period against which chloripyriphos @ 2.5 ml l^{-1} was sprayed. Thrips and white fly incidence was observed at 40 DAS against which monocrotophos 35 EC @ 2 ml l^{-1} was sprayed using a spray volume of 500 l ha^{-1}.

Incidence of Cercospora leaf spot and Alternaria leaf spot was observed at 65 DAS against which Carbendazim 12% + Mancozeb 63% WP 400gm per acre was used for spraying.

3.7.12 Harvesting and Threshing

The crop was harvested at maturity when the leaves and stem turned yellow. The border rows were harvested first from each plot, leaving the net plot area. Before harvesting net plots, the plants selected for recording post-harvest observations were harvested separately. Later, the net plots were harvested. Harvested produce of each plot was tied in bundles and left in the field for 8 days to allow sun drying. Threshing was done separately by beating the plants with sticks treatment wise manually and seed was cleaned and sun dried. Seed and stalk yields were recorded plot wise after drying. The seed weight from sample plants was also added to the net plot yields.

3.8 BIOMETRIC OBSERVATIONS ON SESAME

3.8.1 SAMPLING TECHNIQUE

Ten plants were tagged in each net plot area randomly for recording growth observations that did not involve destructive sampling. All the observations were recorded on these plants at 30, 60, DAS and at maturity. Five plants from the second border row in each plot were pulled out for recording drymatter accumulation.

3.8.2. Pre-Harvest Observations

3.8.2.1. Plant population (m^{-2})

All the plants in 1.0 m^2 area demarcated in the net plot were counted at 20 days after sowing as initial plant population and final plant population was recorded just before harvest of the crop.

3.8.2.2. Plant height (cm)

Plant height was measured from the ground level to the terminal bud of the plant at 30, 60 DAS and at maturity from the selected tagged ten plants in each treatment in all the three replications. Average value of plant height for each treatment was computed and expressed in centimeters (cm).

3.8.2.3. Dry matter accumulation

Five successive plants were sampled to record dry matter accumulation. After removal of root portion, the samples were shade dried for some days followed by hot - air oven at 60˚C till a constant weight was obtained. The data obtained was used to estimate the total dry matter production per plant. The weights were averaged and expressed as kg ha^{-1}.

3.8.3. Post - Harvest Observations

3.8.3.1. Yield attributing characters

The yield attributes listed below were studied at the time of harvest from the sample of ten plants selected for pre-harvest observations.

3.8.3.2. Number of capsules $plant^{-1}$

Total number of capsules harvested from 10 tagged plants were counted in each treatment, averaged and expressed as number of capsules $plant^{-1.}$

3.8.3.3. 1000 - seed weight (g)

Sample of 1000 seeds were collected from net plot yield treatment wise and weight of these samples was recorded. The average was calculated and expressed in grams.

3.8.3.4. Seed yield (kg ha^{-1})

After threshing, the produce from each net plot was collected separately treatment wise and then seeds were cleaned. Weight of cleaned seeds obtained from each plot was recorded. Finally seed yield $plot^{-1}$ was converted into kg ha^{-1}.

3.8.3.5 Stalk yield (kg ha^{-1})

After threshing, the plants from the net plot area were dried and weight was recorded. Stalk yield ha^{-1} was worked out and expressed in kg ha^{-1}.

3.8.3.6. Harvest Index (%)

Harvest index is the ratio of seed yield to the total biological yield and expressed in percentage by using the formula (Donald and Humblin, 1976), given.

$$\text{Harvest Index (\%)} = \frac{\text{Seed yield (kg ha}^{-1}\text{)}}{\text{Seed yield + stalk yield}} \times 100$$

3.9 QUALITY PARAMETERS

3.9.1 Oil Content (%)

Oil content in sesame seeds was determined by using Soxhlet's Ether Extraction Method. A composite seed sample of each treatment was taken to analyze the oil content (%).

3.9.2 Protein Content (%)

The protein content of the seed was worked out by multiplying nitrogen content (%) in the seed (estimated by Micro-Kjeldahl method as per procedure suggested by Jackson., 1976) with the factor 6.25. Protein content was calculated by formula given under (AOAC, 1960).

Protein content (%) = Kjeldahl nitrogen content (%) x 6.25*

(**based on the assumptions that nitrogen constitutes 16 % of a protein*).

3.10 CHEMICAL ANALYSIS

3.10.1 Plant Analysis

The plant samples at harvest of the sesame crop from each plot were collected separately and dried in oven at constant temperature of 60 ^{0}C until constant weight was obtained. The dried samples (seed and stalk) were ground in a Willey mill to pass through 40 mesh sieve. The ground material was collected in butter paper bags and later used for chemical analysis.

3.10.2 Nutrient Uptake

Nitrogen content in seed and stalk was estimated separately by Micro Kjeldahl's method (Jackson, 1973), Phosphorus was estimated by Vanado molybdate phosphoric yellow colour method (Jackson, 1973) and potassium was determined in both samples by Flame photometer method (Jackson, 1973). The results were expressed in percentage.

Nutrient uptake was calculated by using the formula given below:

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (\%) x Weight of dry matter (kg ha}^{-1}\text{)}}{100}$$

The uptake of N, P and K was expressed in kg ha^{-1}.

3.11 SOIL ANALYSIS

3.11.1 Collection and Preparation of Soil Samples

The initial soil samples were collected before starting of experiment and final soil samples at post-harvest were drawn from each plot as per treatments seperately and then shade dried, ground with a wooden hammer, passed through a 2 mm sieve and finally stored in labeled airtight polythene bags for laboratory analysis. Processed soil samples were used for analysing various nutrients.

3.11.2 Soil Reaction (pH)

Soil reaction was determined in 1: 2.5 soil water suspension using combined Glass electrode method (Jackson, 1973).

3.11.3 Electrical Conductivity (EC)

The soluble salt content of soil samples were determined in 1: 2.5 soil water suspension using Digital electrical conductivity meter (Jackson, 1973).

3.11.4 Organic Carbon (%)

Organic carbon content in the soil was determined by Walkley and Black's modified method (Walkley and Black, 1934) and the results were expressed in percentage.

3.12 AVAILABLE SOIL N, P AND K STATUS AFTER HARVEST OF THE CROP

3.12.1 Available Nitrogen

Available nitrogen content in the soil was determined by Alkaline permanganate method (Subbiah and Asija, 1956).

3.12.2 Available Phosphorus

Available phosphorus in the soil samples was extracted with 0.5M $NaHCO_3$ of pH 8.5 and the phosphorus in the extract was estimated colorimetrically by Olsen's method using spectrophotometer at 660 nm (Olsen *et al.*, 1954).

3.12.3 Available Potassium

Available potassium in the soil was extracted using Neutral normal ammonium acetate method (Jackson, 1973) and potassium in the extract was determined flame photometrically.

3.13 ECONOMICS

By using all the inputs, total cost of cultivation was calculated for each treatment. Based on prevailing market price of the output, gross returns were calculated. The net returns from each treatment were arrived at by deducting the cost of cultivation worked out based on these prevailing costs of inputs and labour wages.

The Benefit: Cost ratio (BCR) for all the treatments was worked out on the basis of net return in terms of rupees after deducting the cost of treatments from gross returns.

Net return (Rs. ha^{-1}) = Gross return (Rs ha^{-1}) – Cost of cultivation (Rs ha^{-1})

$$\text{B: C Ratio} = \frac{\text{Net return (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

3.14 STATISTICAL ANALYSIS

The experimental data on various growth and yield parameters were analysed by using Fisher´s method of analysis of variance as outlined by Panse and Sukhatme (1978). The level of Significance of the treatments was tested by ‘F’ test at 0.05 level of probability and critical differences were worked out for the significant effects. The treatment differences that were not significant were denoted by ‘NS’.

Chapter – IV

Results and Discusion

Chapter IV

RESULTS AND DISCUSSION

Results of the field experiment entitled **“Planting Density and INM Interventions in Sesame Production”** conducted at the Agricultural College Farm, Bapatla are presented in this chapter.

4.1 SOIL AND SEASONAL CONDITIONS

The soil of the experimental site was sandy loam in texture, slightly alkaline, low in organic carbon, low in available nitrogen, medium in available phosphorus and high in available potassium. Sesame crop was sown in the 2^{nd} week of January (2^{nd} standard meteorological week). The weekly mean maximum temperatures ranged from 25.6^0C to 34.7^0C with an average of 31.51^0C. The weekly mean minimum temperatures ranged from 14.2^0C to 25^0C with an average of 19.45^0C. During the corresponding period, mean relative humidity ranged from 40.6 to 77.9 per cent with an average of 69.51 per cent. The total amount of 15 mm of rainfall was received during the entire crop growth period.

4.2 GROWTH PARAMETERS

4.2.1 Plant Population

Initial and final plant population was recorded to check whether the expected population as per treatments maintained or not. Data pertaining to plant population was shown in Appendix-II.

4.2.2 Plant height

Data pertaining to plant height (cm) of sesame measured at different growth stages of crop *viz.,* 30, 60 DAS and at maturity presented in table 4.1 and graphically depicted in fig 4.1.

Table 4.1 Plant height (cm) at different growth stages of sesame as influenced by planting density and INM interventions

Treatment	30 DAS	60 DAS	Maturity
Spacings (S)			
45 cm X 10 cm	29.6	56	69.8
30 cm X 10 cm	31.9	59.6	77.3
S.Em±	0.83	1.43	1.85
CD (p = 0.05)	NS	NS	5.5
Fertilizer levels (F)			
100% RDF 60, 40, 60 NPK ha^{-1}	30.9	57.3	73.8
75% RDF + 5t FYM ha^{-1}	32.5	59.8	77.9
75% RDF + 0.75 t PM ha^{-1}	25.5	50.0	62.7
75% RDF + 1.3t Sunhemp green manuring ha^{-1}	29.6	57.0	72.0
25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}	35.3	64.9	81.5
S.Em±	1.32	2.26	2.93
CD (p = 0.05)	3.9	6.7	8.7
Interaction (S X F)			
S.Em±	1.87	3.19	4.0
CD (p = 0.05)	NS	NS	NS
CV (%)	10.4	9.5	9.4

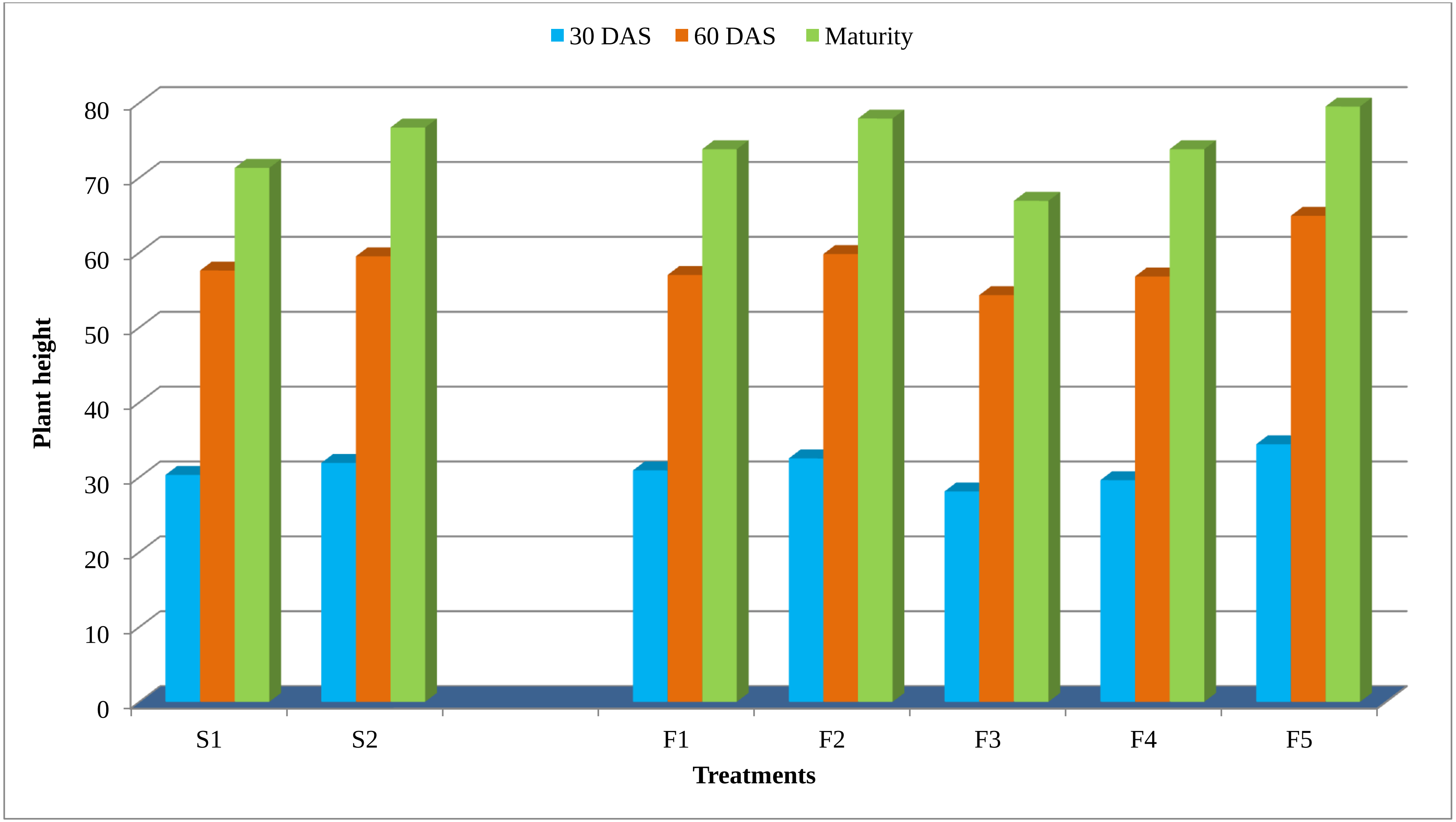


Fig. 4.1. Plant height (cm) at different growth stages of sesame as influenced by planting density and INM interventions

The plant height has increased progressively with advancement in the age of the crop. However, the plant height increased at a rapid rate from 30 to 60 DAS and there after the increase was marginal.

At 30 DAS, the plant height did not got significantly influenced by planting densities but significantly influenced by different nutrient treatments.

At 30 DAS, numerically tall plants were recorded (31.9 cm) at a spacing of 30 cm x 10 cm (3.33 lakh plants ha^{-1}) than that of 45 cm x 10 cm (2.22 lakh plants ha^{-1}).

At 30 DAS, significantly taller plants (35.3cm) were recorded with F_5 treatment (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} $^{+}$ 1.3t Sunhemp green manuring ha^{-1}) which was however on par with the F_2treatment (75%RDF + 5t FYM ha^{-1}) (32.5cm) followed by F_3 treatment (100% RDF@ 60, 40, 60 NPK kg ha^{-1}) and treatment F_4 respectively. Lower plants (25.5cm) were recorded with F_3treatment (75% RDF + 0.75 t PM ha^{-1}).

At 60DAS, similar trend was observed as that noticed at 30 DAS. Numerically tall plants were registered (59.6 cm) at a spacing of 30 cm x 10 cm (3.33 lakh plants ha^{-1}) than that of 45 cm x 10 cm (2.22 lakh plants ha^{-1}).

At 60 DAS also F_5 treatment recorded significantly the highest plant height (64.9 cm) but it was however on par with F_2 treatment(75%RDF + 5t FYM ha^{-1}) (59.8 cm) followed by F_1treatment (100%RDF 60, 40, 60 NPK ha^{-1}) (57.3 cm) and F_4 treatment(75%RDF + 1.3t Sunhemp green manuring ha^{-1}). Lower plant height (50 cm) was associated with F_3 treatment (75% RDF + 0.75 t PM ha^{-1}).

The plant height of sesame measured at maturity registered significantly the maximum plant height (77.3 cm) at a spacing of 30 cm x 10cm (3.33 lakh plants ha^{-1}) than plant height (69.8 cm) of 45 cm x 10 cm (2.22 lakh plants ha^{-1}).

Significant increase in plant height with increasing in population densities seems to be the resultant of mutual shading due to overcrowding of plants. Mutual shading due to increased population might have reduced the availability of light within the crop canopy and accelerated the elongation of lower internodes, resulting into increased plant height.

At harvest, similar trend was observed as that noticed at 60 DAS. Plant height (81.5 cm) recorded was significantly the highest in F_5 treatment (75% RDF + 5t FYM ha^{-1}) being at par with T_2 (75%RDF + 5t FYM ha^{-1}) (77.9 cm) followed by F_1 &F4 treatments. The lowest plant height (62.7 cm) was recorded with F_3 treatment (75% RDF + 0.75 t PM ha^{-1}).

The plant height increased significantly with increasing organic manures level along with inorganic fertilizers. this might be be due to more synthesis of aminoacids cell elongation, cell enlargement and increase in chlorophyll synthesis, in the and thus improving the photosynthetic activity ultimately enhancing the growth rate. The results have clearly indicated that integrated use of chemical fertilizers and organic manure was better than application of these manures, chemical fertilizers alone. This may due to supply of nutrients from diversified sources and prolonged availability of nutrients to the growing plants resulted in better plant growth. the increase in plant height in response to higher levels of nutrient viability was in conformity with the previous findings of Barik and Fulmali (2011), Halepyati (2001), Deshumkh *et al*. (2010).

Interaction effects of planting densities and nutrient treatments with respect to plant height were found non -significant.

4.2.3 Drymatter production

The data recorded on drymatter accumulation by sesame at different growth stages (30 DAS, 60DAS and at maturity) is presented in Table 4.2 and graphically depicted in Fig 4.2.

Drymatter production at different growth stages of sesame was significantly influenced by plant densities and different nutrient management practices.

At 30 DAS, the maximum drymatter accumulation (567 kg ha^{-1}) was recorded with a closer spacing of 30 cm x 10 cm (3.33 lakh plants ha^{-1}), which was significantly superior to drymatter accumulation (518 kg ha^{-1}) of 45 cm x15 cm (2.22 lakh plants ha^{-1}).

At 30 DAS, significantly the highest drymatter production (600 kg ha^{-1}) was recorded with F_5 treatment (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}), which was however comparable with F_2 treatment (75%RDF + 5t FYM ha^{-1}) (583 kg ha^{-1}) and treatment F_1 followed by F_4 respectively Significantly the lowest drymatter production(442 kg ha^{-1}) was recorded with F_3 treatment (75% RDF + 0.75 t PM ha^{-1}).

At 60 DAS, the maximum drymatter accumulation (1348 kg ha^{-1}) was recorded with a closer spacing of 30 cm x 10cm (3.33 lakh plants ha^{-1}), which was significanlty superior to 45cm x15 cm (1.4 lakh plants ha^{-1}).

At 60 DAS, significantly the highest drymatter production (1659 kg ha^{-1}) was recorded with F_5 treatment (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}), followed by drymatter production (1325 kg ha^{-1}) of F_2 treatment (75%RDF + 5t FYM ha^{-1}) followed by treatments F_1 and F_4 respectively. The lowest drymatter production (897 kg ha^{-1}) was recorded in F_3 treatment.

At maturity, a similar trend was observed as that noticed at 30, 60 DAS respectively. The highest drymatter production(2548 kg ha^{-1}) was registered at a plant density of 3.33 lakh plant ha^{-1}, which was significantly superior to drymatter production(2134 kg ha^{-1}) at plant density of 2.22 lakh plant ha^{-1}.

Lower plant spacing reduced the drymatter accumulation per individual plant due to increased competitive interaction among the plants for need of various inputs, but due to increased plant population per unit area there was increase in drymatter accumulation at lower plant spacing.

Table 4.2 Drymatter production (kg ha^{-1}) at different growth stages of sesame as influenced by planting density and INM interventions

Treatment	Drymatter production		
	30 DAS	60 DAS	MATURITY
Spacings (S)			
45 cm X 10 cm	518	1144	2134
30 cm X 10 cm	567	1348	2548
S.Em±	14.1	39.1	93.6
CD (p = 0.05)	41.8	116.3	278.0
Fertilizer levels (F)			
100% RDF 60, 40, 60 NPK ha^{-1}	579	1228	2352
75% RDF + 5t FYM ha^{-1}	583	1325	2402
75% RDF + 0.75 t PM ha^{-1}	442	897	1945
75% RDF + 1.3t Sunhemp green manuring ha^{-1}	509	1120	2303
25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}	600	1659	2704
S.Em±	22.3	61.9	148.0
CD (p = 0.05)	66.2	183.8	439.6
Interaction (S X F)			
S.Em±	31.5	87.5	209.3
CD (p = 0.05)	NS	NS	NS
CV (%)	10.1	12.2	15.5

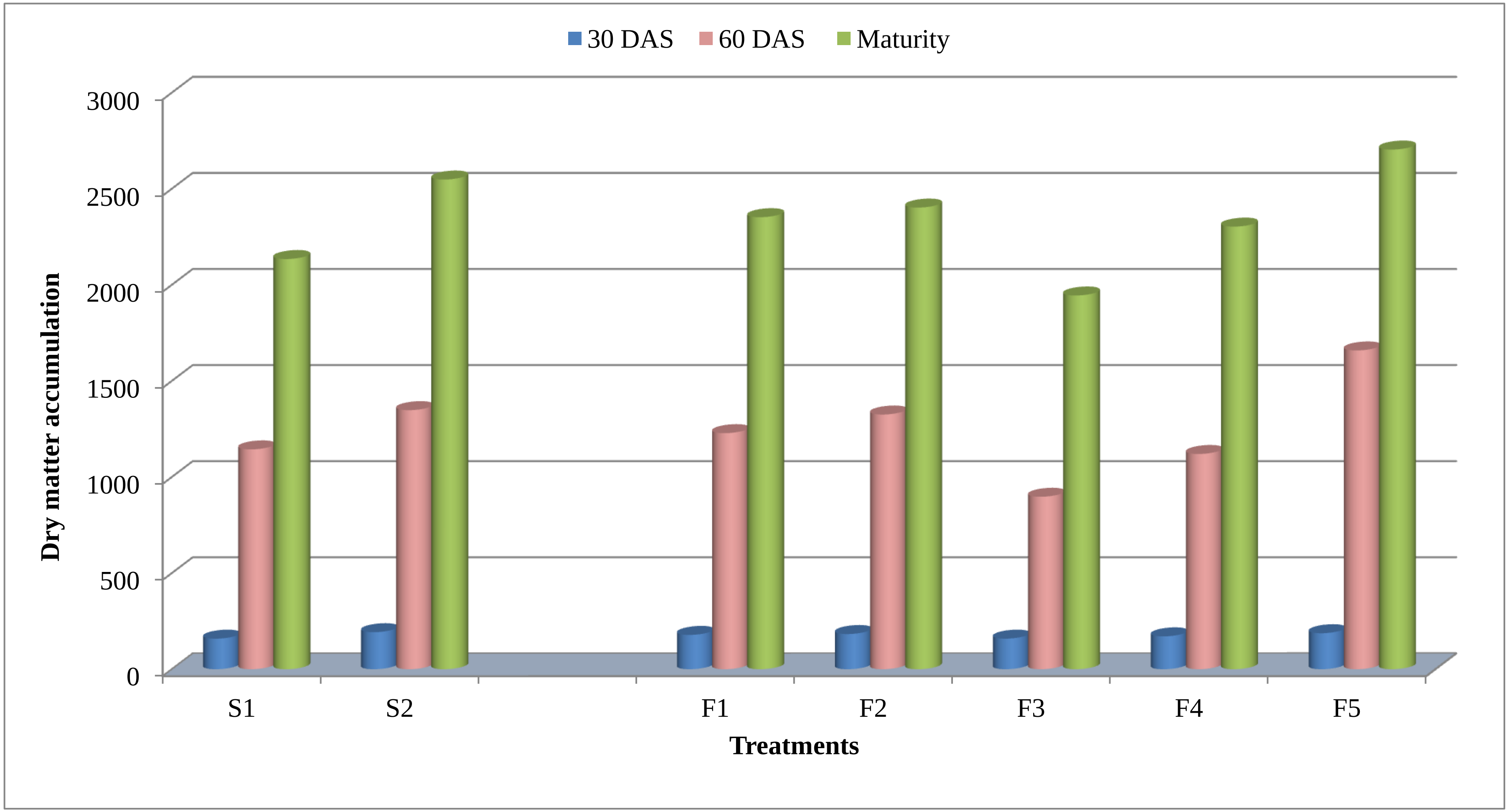


Fig. 4.2. Drymatter production (kg ha^{-1}) at different growth stages of sesame as influenced by planting density and INM interventions

At maturity, significantly the highest drymatter production (2704 kg ha^{-1}) was recorded with F_5 treatment (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}), which was superior to all other treatments but it was on par with drymatter production (2402 kg ha^{-1}) of F_2 treatment (75%RDF + 5t FYM ha^{-1}).the treatments F_1, F_4 and F_3 statistically on par with each other.

Data pertaining to the drymatter production reveals that the increasing levels of organic manures along with inorganic fertilizers significantly increased the drymatter production at all growth stages of sesame. Total drymatter accumulation is the sum total of gains in leaves, stem and capsule weights. Cell division and cell elongation are two important physiological processes which affect the plant growth (height, number of leaves, branches etc.) and ultimately the total drymatter accumulation. The maximum drymatter production was observed at maturity. The photosynthates synthesized in plants were utilized for improvement in vegetative growth of plants, therefore drymatter accumulation in plants were slow in early growth stage.

Integrated use of FYM might have improved soil physical conditions. Especially the humus content of organic matter in the soil, might have had favourable effect on modifying the soil environment to hold more nutrients, better aeration and microbial activity generating a favourable environment for an increased uptake of nutrients by the plant and also had solubility effect on fixed forms of nutrients. Poultry manure application might have lower down the soil pH and thus led to maintenance of balanced nutrition which might have resulted in greater availability of nutrient elements from the soil. Organic matter content is often considered to have direct influence on nutrients uptake by plants, there by leading to improvement in drymatter production as demonstrated in present investigation confirms with the previous findings of Kathiresan (2002), Barik and Fulmali (2011), Halepyati (2001).

Interaction effects of planting densities and nutrient treatments with respect to plant drymatter production were found non –significant.

4.2.4 Number of branches $plant^{-1}$

Data pertaining to number of branches $plant^{-1}$ was significantly influenced by crop geometry and nutrient sources. (Table 4.3)

Sesame grown at closer spacing of 45 cm x 10 cm with a plant density of 2.22 lakh plants ha^{-1} had significantly higher number of branches $plant^{-1}$ (3.9) compared to sesame grown at a spacing of 30 cm x 10 cm with planting densities of 3.33 lakh plants ha^{-1} (3.4).

The number of branches progressively increased with increasing spacing.. Increased number of branches in wider spacing or lower planting densities might be due to adequate space, nutrients, and moisture availability and less competition from less plant population. Under wider spacing which provided increased photosynthesis activity and more space for development of branches and increase in number of branches $plant^{-1}$ compared to high plant density.

Data pertaining to number of branches $plant^{-1}$ (4) recorded significantly higher number of branches in F_5 treatment (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}) followed by number of branches $plant^{-1}$ (4) in F_2 treatment (75%RDF + 5t FYM ha^{-1}). The treatment F_1 which was statistically on par with treatment F_2. The lowest number of branches $plant^{-1}$ was recorded in treatment F_3.

Normal studies indicated that litter-N exists in both organic and inorganic forms. However the inorganic fraction which is usually in the ammonical form, and constitute 10 to 60% of the total litter-N is readily available for plant absorption. The organic fraction of the litter- N on the other hand exist in the form of proteins, nucleic acids, and other organic compounds derived from plant or animal tissues, which may constitute 40 to 90% of the total litter-N. This fraction of litter N form is available only after mineralization through soil microbial activity. It is therefore difficult to predict how much of the N from the organic fraction is readily available for plant uptake and utilization during the growing season. Further, litter-N availability may be influenced not only by the field conditions (soil properties and weather) but also management strategies (Chadwick *et al*., 2000).

Inorganic N from most chemical fertilizer sources is available within few weeks after its application. However, on the other hand when poultry manure is applied, N is released slowly over time and may take multiple years before all of it becomes available.

Earlier researchers have focussed on grain N concentration rather than on leaf, stems or branches concentration of the crop and opined N concentration in leaves and stems gradually decreases over the course of the growth season. The significantly negative response of leaf, stem & branches N to poultry litter application may be attributed to the prolong mineralization process of the poultry litter apart from the heat generated during this process which might have resulted in lesser availability of N fraction to the growing roots. Also that several studies have observed that only 40%-60% of poultry litter is removed from the field after harvest and thus lead to a lower leaf, stem and branches N concentration compared to inorganic N fertilizer with the same N application rate.

Since in the present investigation the Gingelly crop was raised in the sandyloam soil with low nutrient concentration availability of organic N from poultry litter might have get hampered due to slow mineralization process owing to less moisture availability as a result of high environmental temperature. More over the heat that is generated during the process of decomposition could be one of the possible reason for low availability of N to the growing crop that manifested stunted growth and less number of branches as reflected in the present study confirms that findings of (Tewolde *et al*., 2007).

Since this the first year of study concurrent validity of the nutrient availability could not be arrived and requires further long term studies to derive at confirm results.

Organic matter content has direct influence on uptake of nutrients by plants, improvement in growth parameters, yield attributing characters. These treatments received desired quantity of nutrients, which resulted into production of highest number of capsules. Farmyard manure, Poultry manure and green manuring improved the physical and biological properties of soil including supply of almost all the essential plant nutrients for growth and development of plants. These results were in conformity with the findings of of Kathiresan (2002), Barik and Fulmali (2011), Halepyati (2001) and Deshmukh *et al.* (2010).

Table 4.3 Number of branches plant^{-1} of sesame as influenced by plant densities and INM interventions

Treatment	Number of branches plant^{-1}
Spacings (S)	
45 cm X 10 cm	4
30 cm X 10 cm	3
S.Em±	0.09
CD (p = 0.05)	0.3
Fertilizer levels (F)	
100% RDF 60, 40, 60 NPK ha^{-1}	4
75% RDF + 5t FYM ha^{-1}	4
75 RDF % + 0.75 t PM ha^{-1}	2
75% RDF + 1.3t Sunhemp green manuring ha^{-1}	3
25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp greenmanuring ha^{-1}	5
S.Em±	0.14
CD (p = 0.05)	0.4
Interaction (S X F)	
S.Em±	0.20
CD (p = 0.05)	NS
CV (%)	9.6

4.2.5 Number of capsules per plant

Data pertaining to number of capsules plant^{-1} was significantly influenced by crop geometry and nutrient sources. (Table 4.4)

Sesame grown at wider spacing of 45 cm x 10 cm with a plant density of 2.22 lakh plants ha^{-1} had significantly higher number of capsules plant^{-1} (35) compared to sesame grown at a spacing of 30 cm x 10 cm with planting densities of 3.33 lakh plants ha^{-1} (32.6).

The number of capsules progressively increased with increasing spacing. Increased number of capsules in wider spacing or lower planting densities might be due to adequate space, more number of branches, nutrients, and moisture availability and less competition from lower plant population. Under wider spacing which provided increased photosynthetic activity besides more colosal space for setting of capsules can be attributed to increase in number of capsules plant^{-1} compared to high plant density as reflected in the present investigation agrees with the findings of Barik and Fulmali (2011), Gunri and nath (2012).

Data pertaining to number of capsules plant^{-1} (38.0) recorded significantly higher number of capsules in F_5 treatment (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}) followed by number of capsules plant^{-1} (34.9) in F_2 treatment (75%RDF + 5t FYM ha^{-1}). The treatment F_1 which was statistically on par with treatment F_2. The lowest number of capsules plant^{-1} was recorded in treatment F_3

Organic matter content has been found to have direct influence on uptake of nutrients by plants, improvement in growth parameters and yield attributing characters. These treatments that received desired quantity of nutrients, depicting favourable effect on sink component could have led to better development of plants in terms of plant height and drymatter accumulation and partitioning leading to increased bearing capacity which ultimately resulted into production of highest number of capsules. Farmyard manure, Poultry manure and greenmanuring is known for the improved physical and biological properties of soil including supply of almost all the essential plant nutrients for a longer growing period on growth and development of plants. These results were in conformity with the findings of Halepyati (2001), Kathiresan (2002), Barik and Fulmali (2011), and Deshmukh *et al.* (2010).

Interaction effects of planting densities and nutrient treatments with respect to number of capsules plant^{-1} were found non -significant.

4.2.6 Number of seeds per capsule

Data pertaining to number of seeds capsule^{-1} was not significantly influenced by crop geometry (Table 4.5).

Sesame grown at wider spacing of 45 cm x 10 cm with a plant density of 2.22 lakh plants ha^{-1} had numerically higher number of seeds capsule $^{-1}$ (52) compared to sesame grown at a spacing of 30 cm x 10 cm with planting densities of 3.33 lakh plants ha^{-1} (51).

Data pertaining to number of seeds capsule^{-1} was significantly influenced by different nutrient treatments. Number of seeds capsule $^{-1}$ (57) recorded significantly higher number of capsules in F5 treatment (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}) followed by number of seeds capsule $^{-1}$ (52) in F_2 treatment (75%RDF + 5t FYM ha^{-1}). The lowest number of seeds capsule $^{-1}$ was recorded in treatment F_3.

Increase number of seeds capsule^{-1} might be due to application of organic manures along with inorganic fertilizers increase the supply of easily assimilated major as well as micro nutrients to plant, besides mobilizing unavailable nutrients to available form. It is needed mostly by young, fast growing tissue and performs a number of functions related to growth, development, photosynthesis and utilization of carbohydrates. These all process favorably improved with application of organic manure. These results were in conformity with the findings of Kathiresan (2002), Deshmukh *et al.* (2010).

Table 4.4 Number of capsules plant^{-1} of sesame as influenced by planting density and INM Interventions

Treatment	Number of capsules plant^{-1}
Spacings (S)	
45 cm X10 cm	34.6
30 cm X 10 cm	32.6
S.Em±	0.6
CD (p = 0.05)	1.9
Fertilizer levels (F)	
100% RDF 60, 40, 60 NPK ha^{-1}	33.2
75% RDF + 5t FYM ha^{-1}	34.9
75% RDF + 0.75 t PM ha^{-1}	31.1
75% RDF + 1.3t Sunhemp greenmanuring ha^{-1}	31.7
25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp greenmanuring ha^{-1}	37.0
S.Em±	1.0
CD (p = 0.05)	3.0
Interaction (S X F)	
S.Em±	1.4
CD (p = 0.05)	NS
CV (%)	7.3

Table 4.5 Number of seeds capsule^{-1} of sesame as influenced by plant densities and INM interventions

Treatment	Number of seeds capsule^{-1}
Spacings (S)	
45 cm X10 cm	52.0
30 cm X 10 cm	51.0
S.Em±	0.85
CD (p = 0.05)	NS
Fertilizer levels (F)	
100% RDF 60, 40, 60 NPK ha^{-1}	51
75% RDF + 5t FYM ha^{-1}	52
75% RDF + 0.75 t PM ha^{-1}	48
75% RDF + 1.3t Sunhemp green manuring ha^{-1}	50
25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + Sunhemp Greenmanuring 1.3t ha^{-1}	57
S.Em±	1.35
CD (p = 0.05)	4.00
Interaction (S X F)	
S.Em±	1.91
CD (p = 0.05)	NS
CV (%)	6.4

4.2.7 Test weight (g)

Data pertaining to test weight was not influenced significantly by crop geometry and nutrient sources. (Table 4.6)

Sesame grown at closer spacing of 30 cm x 10 cm with a plant density of 3.33 lakh plants ha^{-1} had recorded the highest test weight (2.49g) compared to test weight (2.44g) of sesame grown at a spacing of 45 cm x 10 cm with planting densities of 2.22 lakh plants ha^{-1}.

Data pertaining to test weight (2.56) recorded the maximum in F_5 treatment (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} $^{+}$ 1.3t Sunhemp green manuring ha^{-1}) followed by treatment F_2 (75%RDF + 5t FYM ha^{-1}), F_1 (100% RDF @ 60, 40, 60 NPK kg ha^{-1}) and F_4 (75 % RDF + 1.3t Sunhemp Green manuring ha^{-1}) respectively. The lowest test weight was recorded with the treatment F_3.

Test weight attribute of the sesame crop was found to be non-significant since it was mostly governed by the genetic characteristic feature of the species. The test weight could not reflect its significant influence on the yield feature of the crop as well. The findings of Shinde *et al*. (2011), Roy *et al*. (2009), Kathiresan (2002) and Kadam *et al.* (1989) corroborate with the present results.

Interaction effects of planting densities and nutrient treatments with respect to test weight were found non –significant.

Table 4.6 Test weight of sesame as influenced by planting density and INM interventions

Treatment	Test weight (g /1000 seed)
Spacings (S)	
45 cm X10 cm	2.44
30 cm X 10 cm	2.49
S.Em±	0.03
CD (p = 0.05)	NS
Fertilizer levels (F)	
100% RDF 60, 40, 60 NPK ha^{-1}	2.44
75% RDF + 5t FYM ha^{-1}	2.50
75% RDF + 0.75 t PM ha^{-1}	2.39
75% RDF + 1.3t Sunhemp greenmanuring ha^{-1}	2.39
25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp Greenmanuring ha^{-1}	2.56
S.Em±	0.05
CD (p = 0.05)	NS
Interaction (S X F)	
S.Em±	0.06
CD (p = 0.05)	NS
CV (%)	4.5

4.2.8 Seed yield (kg ha^{-1})

Data pertaining to seed yield of sesame not influenced significantly by planting densities were presented in table 4.7 and depicted graphically in Fig.4.3

Numerically maximum seed yield (714 kg ha^{-1}) was recorded with a closer spacing of 30 cm x 10cm (3.33 lakh plants ha^{-1}). This was superior to seed yield (700 kg ha^{-1}) of 45cm x10 cm (2.22 lakh plants ha^{-1}).

Seed yield of sesame was significantly influenced by different nutrient treatments. Significantly the highest seed yield (794 kg ha^{-1}) was recorded with F_5 treatment (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} $^+$ 1.3t Sunhemp green manuring ha^{-1}), followed a descending order with respect to seed yield (725 kg ha^{-1}) of treatment F_2 (75%RDF + 5t FYM ha^{-1}), seed yield (710 kg ha^{-1}) of treatment F_1 (100%RDF 60, 40, 60 NPK ha^{-1}). The lowest seed yield (619 kg ha) was recorded under the treatment F_3 (75% RDF+0.75t PM ha^{-1}). The magnitude of increase in seed yield with F_5, F_2 and F_1over F_3 was to the extent of 128, 117 and 114 percent respectively.

The present finding indicated that a suitable combination of organic and inorganic sources of nutrient maintain a long term soil fertility and sustain high level of productivity. The reason for better growth and development in the above treatments might be due to increased availability of nitrogen and phosphorus to the plant initially through fertilizers and then through manures in the cropping season. It is an established fact that organic manures such as FYM, PM and greenmanure improve the physical and biological properties of soil including supply of almost all the essential plant nutrients for growth and development of plants. Thus, balanced nutrition under favorable environment might have helped in production of new tissues and development of new shoots which have ultimately increased the sesame seed yield. The important factors considered to reaping better production were mainly due to low nutrient status of the soil and the ability of organic manures to supply of nutrients in balanced form and in adequate amount to support crop growth. The increased vegetative growth and a low C:N ratio of poultry manure might have mineralized faster to release the nutrients and increased the synthesis of carbohydrates, which ultimately promoted higher yield. Similar results were obtained by Javia *et al.* (2010), Barik and Fulmali (2011), Gunri and nath (2012), Shashidhara *et al.* (2009).

Interaction effects of planting densities and nutrient treatments with respect to seed yield were found non -significant.

4.2.9 Stalk yield (kg ha^{-1})

Data pertaining to stalk yield of sesame measured not significantly influenced by planting densities are presented in table 4.7 and depicted graphically in Fig.4.3

The maximum Stalk yield (1604 kg ha^{-1}) was observed with a closer spacing of 30 cm x 10cm (3.33 lakh plants ha^{-1}), which was superior to seed yield (1587 kg ha^{-1}), measure under 45cm x10 cm (2.22 lakh plants ha^{-1}).

The decrease in stalk yield from closer spacing to wider spacing is mainly attributed to the higher number of plant population per unit area obtained at closer spacing. Though individual plant weight was the highest at wider spacing, it could not compensate the loss in stalk yield due to less number of plants per unit area. Higher nutrient uptake by this plant density resulted in higher values of growth parameters and ultimately helped in realization of higher stalk yield

The perusal of data depicted, significant difference among the treatments with respect to stalk yield, as influenced by different nutrient treatments. (Table 4.7).

Application of treatment F_5 (25%RDF + 5t FYM ha^{-1} + 0.75 t PM $ha^{-1 +}$ 1.3t Sunhemp green manuring ha^{-1}) has significantly produced more stalk yield (1795 kg ha^{-1}) which was however at par with stalk yield (1704 kg ha^{-1}) of F_2 treatment (75%RDF + 5t FYM ha^{-1}) followed by stalk yield (1570) of F_1(100% RDF 60,40,60 NPK ha^{-1}). Significantly lower stalk yield (1363 kg ha^{-1}) was noticed with F_3 treatment (75%RDF + 0.75 t PM ha^{-1}). The magnitude of increase in stalk yield with F_5, F_2 and F_1over F_3 was to the extent of 132, 125 and 115 percent respectively.

This was mainly due to higher vegetative growth in terms of plant height, number of leaves, number of branches and drymatter plant^{-1} with integrated application of organic and inorganic nutrient sources. This could be ascribed to its positive influence on both vegetative and reproductive growth of the crop which led to increase in stalk yield. Organic matter content have direct influence on uptake of nutrients by plants, improvement in growth parameters and yield attributing characters. Balanced nutrition under favorable environment might have helped in production of new tissues and development of new shoots which have ultimately increased the stalk yield. These results are also supported with the findings of other researchers from their studies on nutrient management from different locations of the country (Narkhede *et al.* (2001), Shashidhara (2009), (Javia *et al.* (2010).

Interaction effects of planting methods and nutrient management practices were not significant with respect to stalk yield.

4.2.10 Harvest index

Data pertaining to harvest index of sesame measured not influenced significantly by planting densities and nutrient management practices are presented in table 4.7.

Harvest index did not differ significantly due to methods of planting. However, maximum harvest index (30.8) was recorded with a closer spacing of 30cm X 10cm, which was superior to harvest index (30.6) of 45cm X 10cm spacing.

None of the nutrient management practices were effective with respect to harvest index. However, the application of treatment F_2 (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}) recorded higher harvest index (31.5 %) as compared to other nutrient management practices. Followed by F_2, F_1, F_4. Numerically the lowest harvest index (29.5 %) was observed in treatment F_3.

Similar results were obtained with the findings of shashidhara (2009), (Javia *et al.* 2010.). Interaction effects of planting methods and nutrient management practices were non-significant with respect to harvest index.

Table 4.7 Seed yield, stalk yield and harvest index of sesame as influenced by planting density and INM Interventions

Treatment	**Seed yield (kg ha^{-1})**	**Stalk yield (kg ha^{-1})**	**Harvest index (%)**
Spacings (S)			
45 cm X 10 cm	700	1587	30.8
30 cm X 10 cm	714	1604	30.6
S.Em±	13.7	36.4	0.7
CD (p = 0.05)	NS	NS	NS
Fertilizer levels (F)			
100% RDF 60, 40, 60 NPK ha^{-1}	710	1570	30.8
75% RDF + 5t FYM ha^{-1}	725	1704	30.9
75% RDF + 0.75 t PM ha^{-1}	619	1362	29.5
75% RDF + 1.3t Sunhemp greenmanuring ha^{-1}	688	1545	30.7
25% RDF + FYM 5t ha^{-1} + PM 0.75 t ha^{-1} + 1.3t Sunhemp greenmanuring ha^{-1}	794	1795	31.5
S.Em±	21.6	57.5	1
CD (p = 0.05)	64.3	170.8	NS
Interaction (S X F)			
S.Em±	30.6	81.3	1.5
CD (p = 0.05)	NS	NS	NS
CV (%)	7.5	8.8	8.4

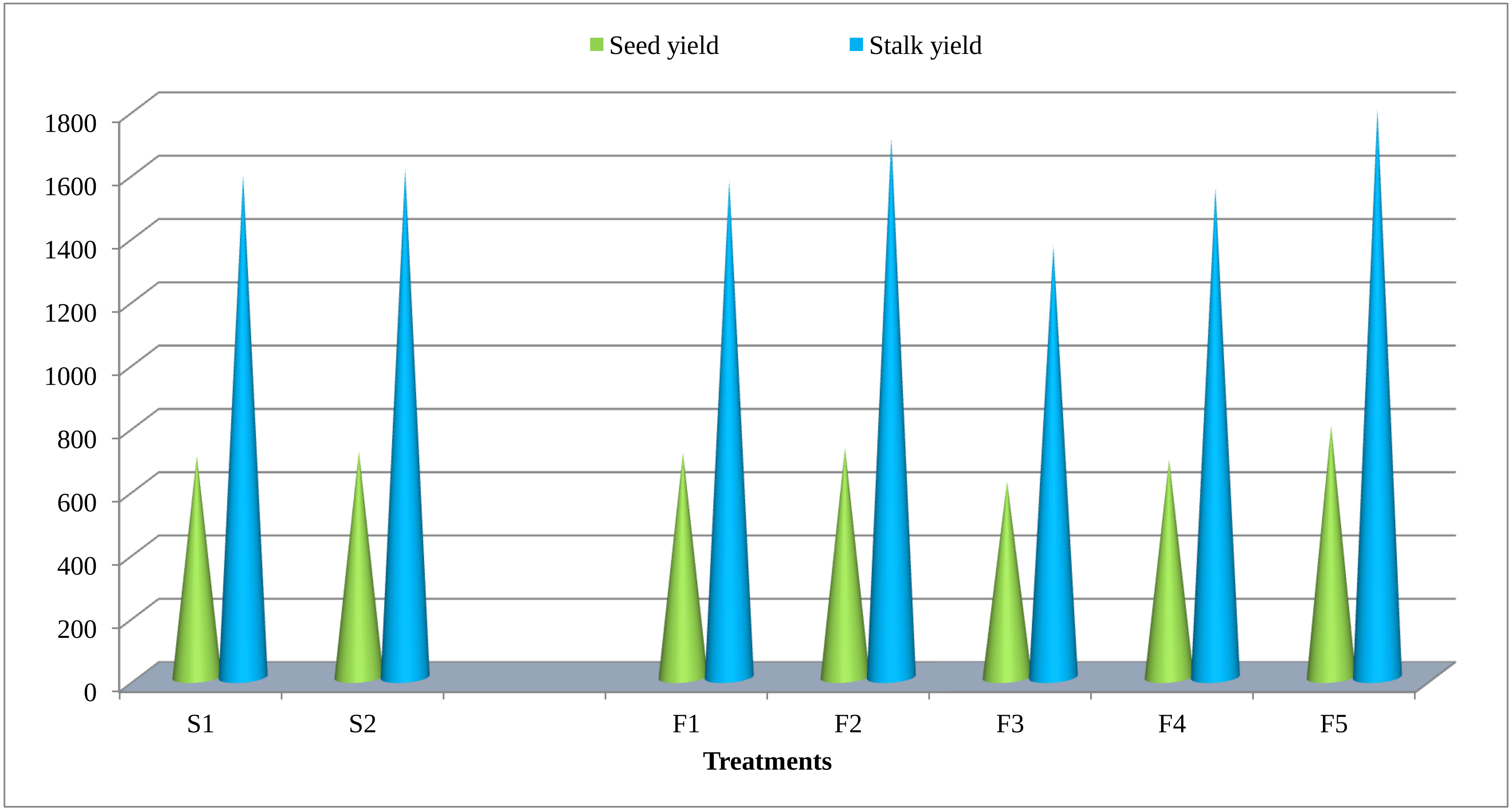


Fig. 4.3. Seed yield (kg ha^{-1}) and Stalk yield (kg ha^{-1}) of sesame as influenced by plant densities and INM Interventions

4.3 QUALITY PARAMETERS AND NUTRIENT UPTAKE OF SESAME AS INFLUENCED BY PLANTING DENSITY AND INM INTERVENTIONS

To study the effect of different treatments on seed quality, plot wise seed samples were collected and determined the oil content. The results are presented in table 4.8.

4.3.1 Oil Content

The data presented in table (4.8) revealed that oil content of sesame did not differ significantly by planting methods and nutrient management practices.

Though oil content did not differ significantly due to plant densities, higher oil content (48.24 %) was recorded with a closer spacing of 30 cm X 10 cm (3.33 lakh plant ha^{-1}), which was superior to oil content recorded (48.16 %) in 45cm X 10cm spacing(2.22 lakh ha^{-1}).

Oil content did not differ significantly even due to nutrient management practices as well. However, maximum oil content (48.8 %) was recorded in treatment F_5 (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} $^{+}$ 1.3t Sunhemp green manuring ha^{-1}) as compared to other nutrient management practices followed by oil content (48.8 %) of treatment F_2 (75% RDF + 5.0 t FYM ha^{-1}) and oil content (48.6 %) of F_1 treatment. The lowest oil content (47.4 %) was recorded in treatment F_3 (75%RDF + 0.75 t PM ha^{-1}). The non-significant effect of either planting density or INM interventions as noticed in the present study confirms the findings of Moinuddin *et al*. (2017), Choudhary *et al.* (2017).

Interaction effects of planting methods and nutrient management practices were non-significant with respect to oil content.

Table 4.8 Oil content of sesame as influenced by planting density and INM interventions

Treatments	Oil content (%)
Spacings (S)	
45cm X10cm	48.16
30cm X 10cm	48.24
S.Em±	0.5
CD (p = 0.05)	NS
Fertilizer levels	
100% RDF 60, 40, 60 NPK ha^{-1}	48.6
75% RDF + 5t FYM ha^{-1}	48.7
75% RDF + 0.75 t PM ha^{-1}	47.4
75% RDF + 1.3t Sunhemp green manuring ha^{-1}	47.8
25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}	48.79
S.Em±	0.7
CD (p = 0.05)	NS
Interaction (S X N)	
S.Em±	1.0
CD (p = 0.05)	NS
CV (%)	3.6

4.3.2 Oil yield

The data presented in table (4.9) and depicted in fig 4.4 revealed that Oil yield of sesame was not significantly differ by planting density, but significantly influenced by different nutrient management practices.

Though oil yield did not differ significantly due to plant densities, the maximum oil yield (344 kg ha^{-1}) was recorded with a closer spacing of 30 cm X 10 cm compared to oil yield (338 kg ha^{-1}) at 45cm X 10cm spacing.

Oil yield was significantly differ due to nutrient management practices, significantly the highest oil yield (388 kg ha^{-1}) was recorded in treatment F_5 (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}), followed by treatment F_2 which was received 75% RDF + 5.0 t FYM ha^{-1} (352 kg ha^{-1}) and F_1 treatment (344 kg ha^{-1}). The lowest oil yield (293 kg ha^{-1}) was recorded in treatment F_3. The magnitude of increase in oil yield of sesame with F_5, F_2 and F_1over F_3 was to the extent of 132, 120 and 117 percent respectively.

Oil yield was increased with application of organic along with inorganic fertilizers could be ascribed to the fact that the supply of balanced N, P, K might have helped in absorption of greater amounts of N, P, K which were an important constituents of nucleic, fatty acids and phospholipids and thus played a crucial role in promoting oil accumulation in the seed. Significant effect of INM interventions with respect to oil yield was noticed in the present study confirms the findings of Moinuddin *et al*. (2017), Choudhary *et al.* (2017).

Table 4.9 Oil yield (kg ha^{-1}) of sesame as influenced by plant densities and INM interventions

Treatments	**Oil yield**
Spacings (S)	
45 cm X 10 cm	338
30 cm X 10 cm	344
S.Em±	6.8
CD (p = 0.05)	NS
Fertilizer levels (F)	
100% RDF 60, 40, 60 NPK ha^{-1}	344
75% RDF + 5t FYM ha^{-1}	352
75% RDF + 0.75 t PM ha^{-1}	293
75% RDF + 1.3t Sunhemp greenmanuring ha^{-1}	328
25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + Sunhemp greenmanuring 1.3t ha^{-1}	388
S.Em±	10.8
CD (p = 0.05)	32.1
Interaction (S X F)	
S.Em±	15.3
CD (p = 0.05)	NS
CV (%)	7.8

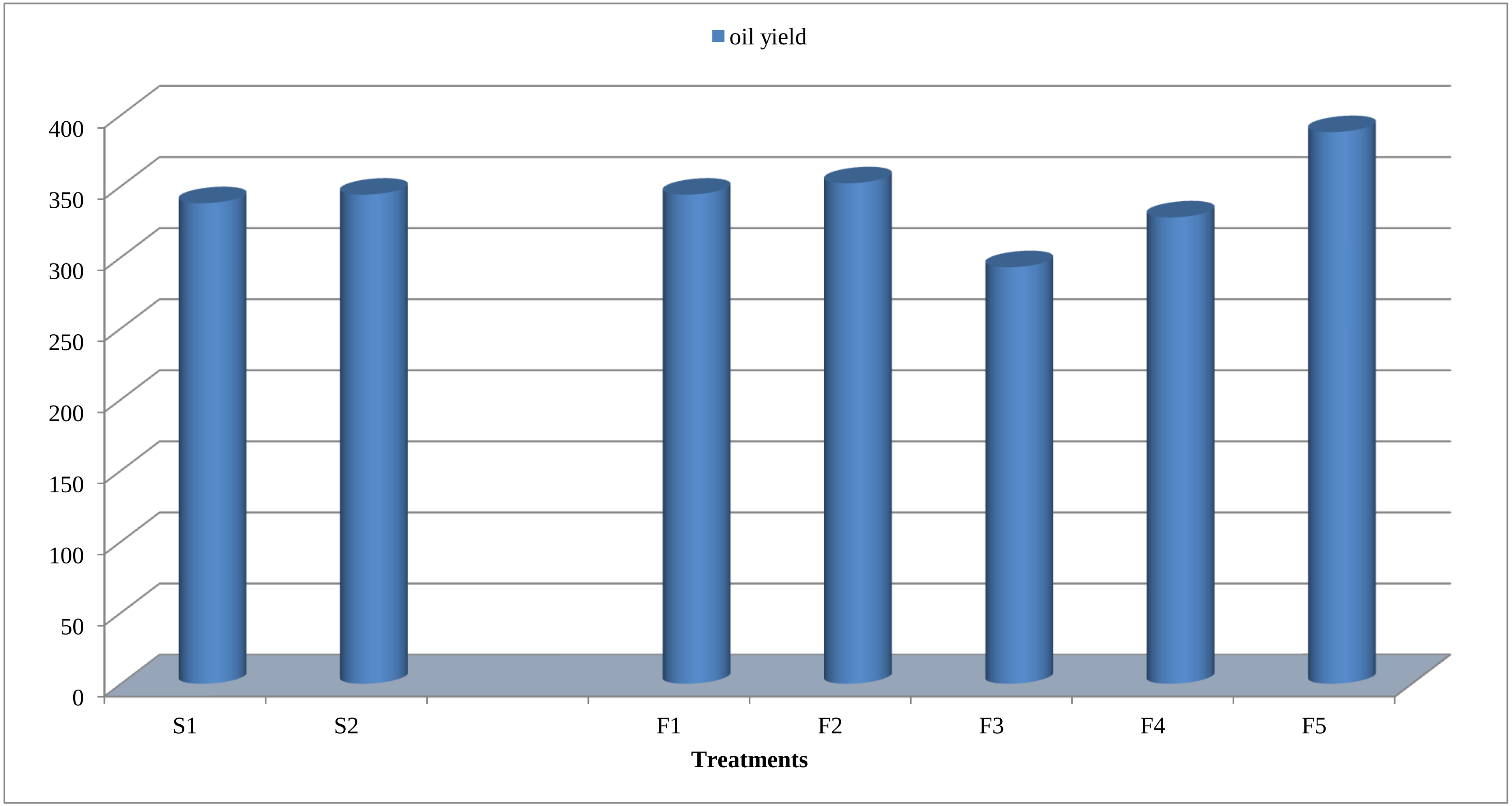


Fig. 4.4. Oil yield (kg ha^{-1}) of sesame as influenced by plant densities and INM interventions

4.3.3 Protein Content

The data presented in table 4.10 and depicted graphically in 4.5 revealed that protein content of sesame was not significantly differ by planting density, but significantly influenced by different nutrient management practices.

Though Protein content did not differ significantly due to plant densities, the maximum Protein content (23.47 %) was recorded with a closer spacing of 30cm X 10cm compared to Protein content of (23.03 %) at 45cm X 10cm spacing.

The Protein content of sesame differ significantly due to nutrient management practices. Significantly the highest protein content of 24.41 % was registered in treatment F_5(25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}), which was however at par with the protein content(23.9 %) of treatment F_2(75% RDF + 5.0 t FYM ha^{-1}) and protein content(23.1 %) of treatment F_1. The lowest protein content (22.3%) was found to occur in treatment F_3.

It is an evident from the present study that integrated use of inorganic fertilizers and organic manures have exhibited positive outcome in the protein content of sesame. It may be attributed to supply of nutrients from diversified sources besides promoted availability of nutrients thus reflecting in increased total uptake of nitrogen, phosphorus and potassium by plants. Of all the essential nutrients, nitrogen is a major element which required by plants required by plants in the largest quantity and is most frequently the limiting factor in crop productivity. It is observed to be the most essential nutrient for the crop since it activates the metabolic reactions and transformation of energy, besides chlorophyll and protein synthesis. This might have reflected in increased process of photosynthesis occurs at high rates when there is sufficient availability of nitrogen. Plants receiving adequate nitrogen usually exhibit vigorous plant growth, and being an essential element of all amino acids might have resulted an increase growth and development of all living tissues thus improving the protein content of seed. These findings as demonstrated in the present investigation corroborate with findings of Moinuddin *et al*. (2017), Choudhary *et al*. (2017).

Interaction effects of planting methods and nutrient management practices were Non-significant with respect to protein content.

Table 4.10 Protein content of sesame as influenced by planting density and INM interventions

Treatments	**Protein content (%)**
Spacings (S)	
45 cm X 10 cm	23.03
30 cm X 10 cm	23.47
S.Em±	0.32
CD (p = 0.05)	NS
Fertilizer levels	
100% RDF 60, 40, 60 NPK ha^{-1}	23.1
75% RDF + 5t FYM ha^{-1}	23.9
75% RDF + 0.75 t PM ha^{-1}	22.3
75% RDF + 1.3t Sunhemp Greenmanuring ha^{-1}	22.6
25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp Greenmanuring ha^{-1}	24.41
S.Em±	0.50
CD (p = 0.05)	1.48
Interaction (S X F)	
S.Em±	0.8
CD (p = 0.05)	NS
CV (%)	5.25

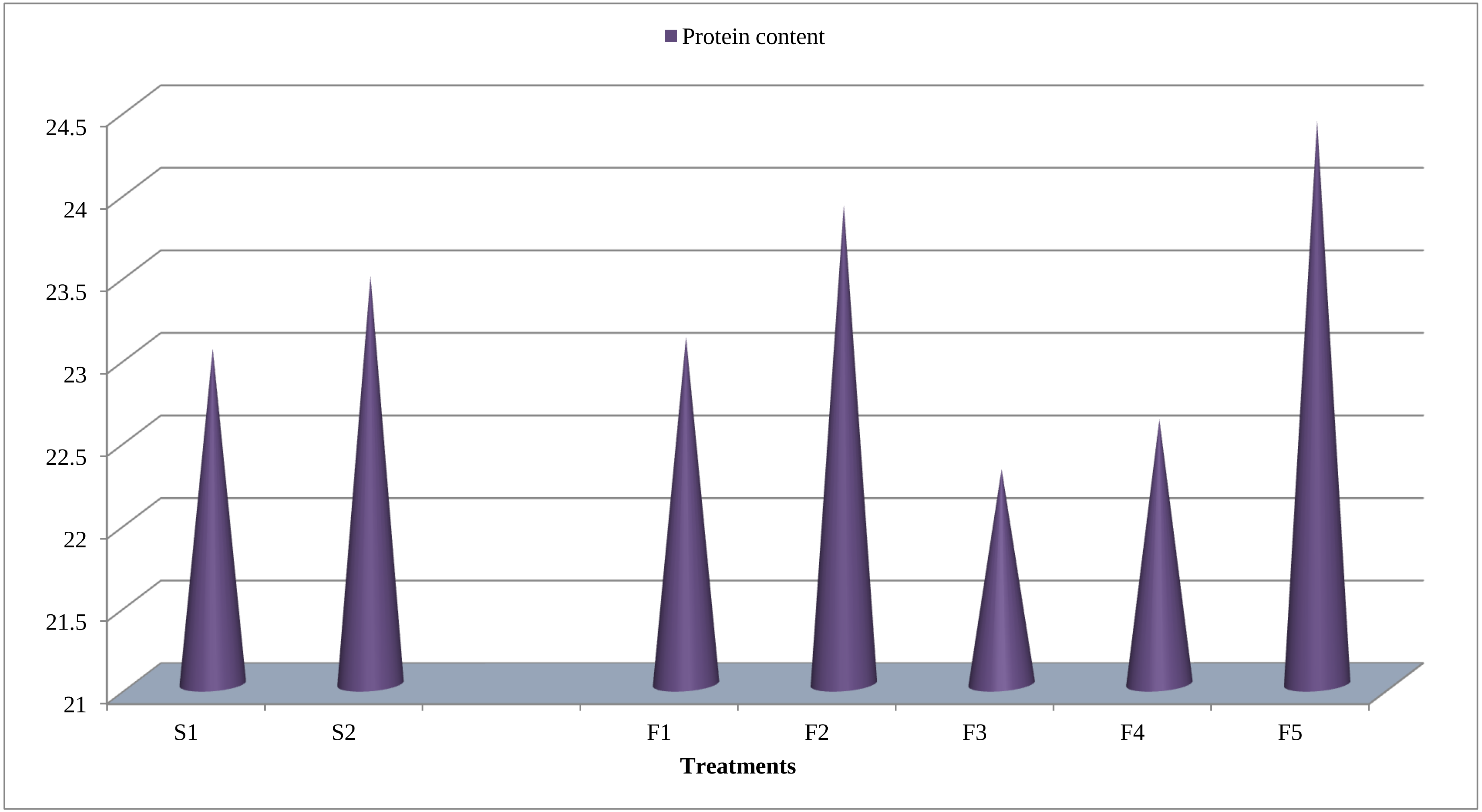


Fig. 4.5. Protein content of sesame as influenced by planting density and INM interventions

4.3.4 Nitrogen Content in Seed (%)

A perusal of the data in Table 4.11 reveals that the nitrogen content in sesame seed was not affected significantly by the plant densities but exhibited significant among different nutrient management practices.

Significantly the highest nitrogen content in seed was recorded with treatment F_5 which was received 25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1} (3.91%) which was on par with 75% RDF + 5.0 t FYM ha^{-1} (F_2) treatment (3.82%) and 100 % RDF @60-40-60 kg NPK ha^{-1} (F_1) treatment (3.70 %). The lowest nitrogen content in seed (3.56%) was observed in treatment F_3 (75% RDF + 0.75 t PM ha^{-1}). The magnitude of increase in nitrogen content in seed with F_5, F_2 and F_1over F_3 was to the extent of 109, 107 and 103 percent respectively.

Better nutrition as a result of application of chemical fertilizers along with organic manures might have aided in higher root growth and development and enhanced the uptake and translocation of nitrogen thus increasing the nitrogen content in grain. These findings corroborate with results of Lalate and Padmani (2009), Hanumanthappa *et al*. (2016), Rao and Shaktawata (2005), Choudhary *et al*. (2017).

Interaction effects of planting densities and nutrient management practices were non-significant with respect to nitrogen content.

4.3.5 Nitrogen Content in Stalk (%)

A perusal of the data in Table 4.11 reveals that the nitrogen content in stalk was not significantly affected by the planting densities but it is significantly affected by the different management practices in sesame.

The highest nitrogen content in stalk (1.74%) was recorded with the planting density of 3.33 lakh ha^{-1}

Among the different nutrient management practices, application of 25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} $^{+}$ 1.3t Sunhemp green manuring ha^{-1} (F_5) treatment registered the highest N content in stalk (1.88 %) which was however on par with 75% RDF + 5.0 t FYM ha^{-1} (F_2) treatment (1.79%) followed by 100 % RDF @60-40-60 kg NPK ha^{-1} (F_1) treatment (1.71.%). The lowest nitrogen content in stalk (1.54%) was observed in treatment F_3 (75% RDF + 0.75 t PM ha^{-1}). The magnitude of increase in nitrogen content in seed with F_5, F_2 and F_1over F_3 was to the extent of 122, 116 and 111 percent respectively. These findings corroborate with results of Lalate and Padmani (2009), Hanumanthappa *et al*. (2016), Rao and Shaktawata (2005), Choudhary *et al*. (2017).

Increasing levels of inorganic fertilizers along with organic manures and resulted in continuous availability of essential nutrients higher photosynthetic activities with higher drymatter production from initial stages of crop growth indicating adequate availability of nutrient in the rhizosphere. This might have helped in better root growth and their activity resulting in higher absorption of nutrients from soil and their translocation to aerial parts thus increasing the concentration of nitrogen in stalk.

Interaction effects of planting densities and nutrient management practices were non-significant with respect to nitrogen content.

4.3.6 Nitrogen Uptake by Seed (kg ha^{-1})

A perusal of the data on nitrogen uptake by seed is presented in Table 4.11 revealed that nitrogen uptake by seed was not influenced significantly by the spacings but was affected significantly by the influence of nutrient management practices.

Maximum nitrogen uptake (26.7 kg ha^{-1}) by sesame seed was recorded at higher plant density (3.33 lakh ha^{-1})

In this present trial, significantly higher nitrogen uptake (31.0 kg ha^{-1}) by sesame seed was recorded with the application of 25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp greenmanuring ha^{-1} which was followed by the treatment F_2 (27.7 kg ha^{-1}) that received 75% RDF +FYM @ 5.0 t ha^{-1}. The treatment F_1 manifested statistically on par values with F_2 treatment. However the lowest uptake of nitrogen (22.0 kg ha^{-1}) in seed was associated in treatment F_3 (75% RDF + 0.75 t PM ha^{-1}).

Interaction effects of planting densities and nutrient treatments were non-significant with respect to uptake of nitrogen by sesame seed.

4.3.7 Nitrogen Uptake by Stalk (kg ha^{-1})

A perusal of the data on nitrogen uptake by stalk is presented in Table 4.11 revealed that nitrogen uptake by stalk was significantly influenced by the planting densities and the nutrient management practices.

The highest nitrogen uptake (44.3 kg ha^{-1}) by sesame stalk was recorded at higher plant density (3.33 lakh ha^{-1}) and this was followed by planting density of 2.22 lakh population ha^{-1} (35.7 kg ha^{-1}).

Among the different nutrient management studies, significantly higher nitrogen uptake (50.8 kg ha^{-1}) by sesame stalk was recorded with the application of 25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} +1.3t Sunhemp green manuring ha^{-1} (F_5) and it was followed by treatment F_2 (43.0 kg ha^{-1}) which was received 75% RDF +FYM @ 5.0 t ha^{-1}. The treatment F_1 (100% RDF @ 60-40-60 kg NPK ha^{-1}) statistically on par with F_2. Treatment $F_1$was recorded N uptake of 40.2 kg ha^{-1}. The lowest uptake of nitrogen (30.0 kg ha^{-1}) in sesame stalk was observed in treatment F_3 (75% RDF + 0.75 t PM ha^{-1}).

Interaction effects of planting methods and nutrient management practices were non-significant with respect to total uptake of nitrogen.

Table 4.11 Nitrogen content (%) and Nitrogen uptake (kg ha^{-1}) in seed and stalk of sesame at maturity as influenced by plant densities and INM interventions

Treatments	Content (%)		Uptake(Kg ha^{-1})	
	Seed	Stalk	Seed	Stalk
Spacings (S)				
45 cm X 10 cm	3.67	1.67	25.7	35.7
30 cm X 10 cm	3.74	1.74	26.7	44.3
S.Em±	0.06	0.03	0.6	1.4
CD (p = 0.05)	NS	NS	NS	4.0
Fertilizer levels (F)				
100% RDF 60, 40, 60 NPK ha^{-1}	3.70	1.71	26.3	40.2
75% RDF + 5t FYM ha^{-1}	3.82	1.79	27.7	43.0
75% RDF + 0.75 t PM ha^{-1}	3.56	1.54	22.0	30.0
75% RDF + 1.3t Sunhemp greenmanuring ha^{-1}	3.61	1.60	24.9	36.8
25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp greenmanuring ha^{-1}	3.91	1.88	31.0	50.8
S.Em±	0.09	0.05	0.9	2.1
CD (p = 0.05)	0.24	0.14	2.6	6.4
Interaction (S X F)				
S.Em±	0.13	0.07	1.3	3.0
CD (p = 0.05)	NS	NS	NS	NS
CV (%)	6	6.7	8.8	13.1

4.3.8 Total Nitrogen Uptake by Crop (kg ha^{-1})

A perusal of the data on total nitrogen uptake by sesame crop is presented in Table 4.14 and Fig.4.6 revealed that total nitrogen uptake by crop was significantly influenced by both planting densities and the nutrient management practices.

Significantly the higher total nitrogen uptake (71 kg ha^{-1}) by sesame was recorded at higher plant density (3.33 lakh ha^{-1}) and this was followed by planting density of 2.22 lakh population ha^{-1} (61.4 kg ha^{-1}).

In this trial, total nitrogen uptake by sesame crop was highest in F_5 (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}) treatment (81.8 kg ha^{-1}) which was significantly superior over rest of the treatments and it was followed by F_2 (70.7 kg ha^{-1}) treatment which was received 75% RDF +FYM @ 5.0 t ha^{-1} but it was statistically on par with F_1 (100% RDF @ 60-40-60 kg NPK ha^{-1}) *i.e.* 66.5 kg ha^{-1}. The lowest total uptake of nitrogen (52.0 kg ha^{-1}) was observed in treatment F_3 (75% RDF + 0.75 t PM ha^{-1}). The treatments $F_{5,}$ F_2 and F_1 were recorded 157,136 and 128 percent respectively higher total nitrogen uptake over F_3.

Interaction effects of planting methods and nutrient management practices were non-significant with respect to total uptake of nitrogen.

Increasing levels of inorganic fertilizers along with organic manures resulted into higher photosynthetic activities with higher drymatter production right from initial stages of the crop growth indicating adequate availability of nutrient in the rhizosphere. This might have aided in better root growth and their energizing activity resulted could have in higher absorption of nutrient from soil and faster their translocation to aerial parts thus increasing the uptake of nitrogen by stalk. These findings corroborate with results of Lalate and Padmani (2009), Hanumanthappa *et al*. (2016), Rao and Shaktawata (2005), Choudhary *et al*. (2017).

4.3.9 Phosphorus Content in Seed (%)

A perusal of the data in Table 4.12 reveals that the phosphorus content in seed as influenced by planting density and INM interventions.

Phosphorus content in seed was not significantly affected by the different spacings and different nutrient treatments. However numerically the highest phosphorus content in seed (1.35 %) at plant density of 3.33 lakh ha^{-1}.

Numerically higher phosphorus content in seed was recorded with treatment F_5 which was received 25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1} (1.36 %) followed by 75% RDF + 5.0 t FYM ha^{-1} (F_2) treatment (1.35 %) and 100 % RDF @60-40-60 kg NPK ha^{-1} (F_1) treatment (1.35 %). The lowest phosphorus content in seed (1.33 %) was observed in treatment F_3 (75% RDF + 0.75 t PM ha^{-1}). The magnitude of increase in phosphorus content in seed with F_5, F_2 and F_1over F_3 was to the extent of 102, 101and 101 percent respectively.

Interaction effects of planting densities and nutrient management practices were non-significant with respect to phosphorus content in straw.

4.3.10 Phosphorus Content in Stalk (%)

A perusal of the data in Table 4.12 reveals that the phosphorus content in stalk was not significantly affected by the planting densities but it is significantly affected by the different management practices in sesame.

The highest phosphorus content in stalk (0.39 %) was recorded with the planting density of 3.33 lakh ha^{-1}

Among the different nutrient management practices, the application of 25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1} (F_5) treatment (0.43 %) which was on par with 75% RDF + 5.0 t FYM ha^{-1} (F_2) treatment (0.40 %) followed by 100 % RDF @60-40-60 kg NPK ha^{-1} (F_1) treatment (0.39%). The lowest phosphorus content in stalk (0.35 %) was observed in treatment F_3 (75% RDF + 0.75 t PM ha^{-1}). The magnitude of increase in phosphorus content in seed with F_5, F_2 and F_1over F_3 was to the extent of 122, 114 and 111 percent respectively.

Interaction effects of planting densities and nutrient management practices were non-significant with respect to phosphorus content in straw.

4.3.11 Phosphorus Uptake by Seed (kg ha^{-1})

A perusal of the data on phosphorus uptake by seed is presented in Table 4.12 revealed that phosphorus uptake by seed was not significantly influenced by the spacings but significantly affected by the nutrient management practices.

Maximum phosphorus uptake (9.6 kg ha^{-1}) by seed was recorded at higher plant density (3.33 lakh ha^{-1})

In this research trial, significantly higher phosphorus uptake (10.8 kg ha^{-1}) by sesame seed was recorded with the application of 25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1} and it was followed by treatment F_2 (9.8 kg ha^{-1}) which was received 75% RDF +FYM @ 5.0 t ha^{-1}. The treatment F_1 statistically on par with F_2 and F_4. The lowest uptake of phosphorus (8.2 kg ha^{-1}) in seed was observed in treatment F_3 (75% RDF + 0.75 t PM ha^{-1}).

Interaction effects of planting methods and nutrient management practices were non-significant with respect to total uptake of phosphorus in seed.

4.3.12 Phosphorus Uptake by Stalk (kg ha^{-1})

A perusal of the data on phosphorus uptake by stalk is presented in Table 4.12 revealed that phosphorus uptake by stalk was significantly influenced by the planting densities and the nutrient management practices.

The highest phosphorus uptake (9.9 kg ha^{-1}) by sesame stalk was recorded at higher plant density (3.33 lakh ha^{-1}) and this was followed by planting density of 2.22 lakh population ha^{-1} (8.1 kg ha^{-1}).

Among the different nutrient management studies, significantly higher phosphorus uptake (11.6 kg ha^{-1}) by sesame stalk was recorded with the application of 25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1} (F_5) and it was followed by treatment F_2 (9.6 kg ha^{-1}) which was received 75% RDF +FYM @ 5.0 t ha^{-1}. The treatment F_1 (100% RDF @ 60-40-60 kg NPK ha^{-1}) statistically on par with F_2. Treatment $F_1$was recorded P uptake of 9.2 kg ha^{-1}. The lowest uptake of phosphorus (6.8 kg ha^{-1}) in sesame stalk was observed in treatment F_3 (75% RDF + 0.75 t PM ha^{-1}).

Interaction effects of planting methods and nutrient management practices were non-significant with respect to phosphorus uptake of sesame stalk.

4.3.13 Total Phosphorus Uptake by Crop (kg ha^{-1})

A perusal of the data on total phosphorus uptake by sesame crop is presented in Table 4.14 and Fig.4.6 revealed that total phosphorus uptake by crop was significantly influenced by both planting densities and the nutrient management practices.

Significantly the higher total nitrogen uptake (19.5 kg ha^{-1}) by sesame was recorded at higher plant density (3.33 lakh ha^{-1}) and this was followed by planting density of 2.22 lakh population ha^{-1} (17.5 kg ha^{-1}).

In this trial, total phosphorus uptake by sesame crop was highest in F_5 (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}) treatment (22.4 kg ha^{-1}) which was significantly superior over rest of the treatments and it was followed by F_2 (19.4 kg ha^{-1}) treatment which was received 75% RDF +FYM @ 5.0 t ha^{-1} but it was statistically on par with F_1 (100% RDF @ 60-40-60 kg NPK ha^{-1}) *i.e.* 18.8 kg ha^{-1}. The lowest total uptake of phosphorus (15.0 kg ha^{-1}) was observed in treatment F_3 (75% RDF + 0.75 t PM ha^{-1}). The treatments $F_{5,}$ F_2 and F_1 were recorded 149,129 and 125 percent respectively higher total phosphorus uptake over F_3.

This could be attributed to the fact that added nutrients with organic along with inorganic fertilizers increased the phosphorous content in stalk of sesame by providing balanced nutritional environment inside the plant and higher photosynthetic efficiency which favoured better growth and stalk yield thus increasing the uptake of phosphorus by stalk. This increase in uptake of phosphorus might be due to cumulative effect of increase seed and stalk yield. These findings colloborate with results of Lalate and Padmanl (2009), Hanumanthappa *et al*. (2016), Rao and Shaktawata. (2005), Choudhary *et al*. (2017).

Interaction effects of planting methods and nutrient management practices were non-significant with respect to total uptake of phosphorus.

Table 4.12. Phosphorus content (%) and uptake (kg ha^{-1}) in seed and stalk of sesame as influenced by plant densities and INM interventions

Treatments	Content (%)		Uptake(Kg ha^{-1})	
	Seed	Stalk	Seed	Stalk
Spacings (S)				
45 cm X 10 cm	1.34	0.38	9.4	8.1
30 cm X 10 cm	1.35	0.39	9.6	9.9
S.Em±	0.01	0.01	0.2	0.3
CD (p = 0.05)	NS	NS	NS	0.8
Fertilizer levels (F)				
100% RDF 60, 40, 60 NPK ha^{-1}	1.35	0.39	9.6	9.2
75% RDF + 5t FYM ha^{-1}	1.35	0.40	9.8	9.6
75% RDF + 0.75 t PM ha^{-1}	1.33	0.35	8.2	6.8
75% RDF + 1.3t Sunhemp green manuring ha^{-1}	1.34	0.37	9.2	8.5
25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}	1.36	0.43	10.8	11.6
S.Em±	0.02	0.01	0.3	0.4
CD (p = 0.05)	NS	0.03	0.8	1.3
Interaction (S X F)				
S.Em±	0.03	0.01	0.4	0.6
CD (p = 0.05)	NS	NS	NS	NS
CV (%)	4.0	5.7	7.3	11.5

4.3.14 Potassium Content in Seed (%)

A perusal of the data in Table 4.13 reveals that the potassium content in seed as influenced by planting density and INM interventions.

Potassium content in seed was not significantly affected by the different spacings and different nutrient treatments.

Numerically the highest potassium content in seed was recorded with treatment F_5 which was received 25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} $^{+}$ 1.3t Sunhemp green manuring ha^{-1} (1.94 %) followed by 75% RDF + 5.0 t FYM ha^{-1} (F_2) treatment (1.93%) and 100 % RDF @60-40-60 kg NPK ha^{-1} (F_1) treatment (1.93 %). The lowest nitrogen content in seed (1.91 %) was observed in treatment F_3 (75% RDF + 0.75 t PM ha^{-1}). The magnitude of increase in nitrogen content in seed with F_5, F_2 and F_1over F_3 was to the extent of 102, 101 and 101 percent respectively.

Interaction effects of planting densities and nutrient management practices were non-significant with respect to potassium content in seed.

4.3.15 Potassium Content in Stalk (%)

A perusal of the data in Table 4.13 reveals that the potassium content in stalk was not significantly affected by the planting densities but it is significantly affected by the different nutrient management practices in sesame.

The highest potassium content in stalk (1.40 %) was recorded with the planting density of 3.33 lakh ha^{-1} followed by potassium content in stalk (1.36 %) of 2.22 lakh plant^{-1}.

Among the different nutrient management practices, significantly the highest potassium content in stalk with the application of 25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} $^{+}$ 1.3t Sunhemp green manuring ha^{-1} (F_5) treatment (1.54 %) which was on par with 75% RDF + 5.0 t FYM ha^{-1} (F_2) treatment (1.41 %) followed by 100 % RDF @60-40-60 kg NPK ha^{-1} (F_1) treatment

(1.35%). The lowest potassium content in stalk (1.31 %) was observed in treatment F_3 (75% RDF + 0.75 t PM ha^{-1}). The magnitude of increase in potassium content in seed with F_5, F_2 and F_1over F_3 was to the extent of 118, 108 and 103 percent respectively.

Interaction effects of planting densities and nutrient management practices were non-significant with respect to potassium content in straw.

4.3.16 Potassium Uptake by Seed (kg ha^{-1})

A perusal of the data on potassium uptake by seed is presented in Table 4.13 revealed that potassium uptake by seed was not significantly influenced by the spacings but significantly affected by the nutrient management practices.

Maximum potassium uptake (13.8 kg ha^{-1}) by seed was recorded at higher plant density (3.33 lakh ha^{-1})

In this research trial, significantly higher potassium uptake (15.4 kg ha^{-1}) by sesame seed was recorded with the application of 25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1} which was on a par with F_2 (14.0 kg ha^{-1}) which was received 75% RDF +FYM @ 5.0 t ha^{-1} followed by treatment F_3. The lowest uptake of potassium (11.8 kg ha^{-1}) in seed was observed in treatment F_3 (75% RDF + 0.75 t PM ha^{-1}).

Interaction effects of planting methods and nutrient management practices were non-significant with respect to uptake of potassium in seed.

4.3.17 Potassium Uptake by Stalk (kg ha^{-1})

A perusal of the data on potassium uptake by stalk is presented in Table 4.13 revealed that potassium uptake by stalk was significantly influenced by the planting densities and the nutrient management practices.

Significantly the highest potassium uptake (35.7 kg ha^{-1}) by sesame stalk was recorded at higher plant density (3.33 lakh ha^{-1}) and this was followed by planting density of 2.22 lakh population ha^{-1} (29.2 kg ha^{-1}).

Among the different nutrient management studies, significantly higher potassium uptake (41.6 kg ha^{-1}) by sesame stalk was recorded with the application of 25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1} (F_5) and it was followed by treatment F_2 (33.9 kg ha^{-1}) which was received 75% RDF +FYM @ 5.0 t ha^{-1}. The treatment F_1 (100% RDF @ 60-40-60 kg NPK ha^{-1}) statistically on par with F_2. Treatment $F_1$was recorded K uptake of 31.6 kg ha^{-1}. The lowest uptake of phosphorus (25.5 kg ha^{-1}) in sesame stalk was observed in treatment F_3 (75% RDF + 0.75 t PM ha^{-1}).

Interaction effects of planting methods and nutrient management practices were non-significant with respect to potassium uptake of sesame stalk.

4.3.18 Total potassium uptake by crop (kg ha^{-1})

A perusal of the data on total potassium uptake by sesame crop is presented in Table 4.14 and Fig.4.6 revealed that total phosphorus uptake by crop was significantly influenced by both planting densities and the nutrient management practices.

Significantly the higher total potassium uptake (49.5 kg ha^{-1}) by sesame was recorded at higher plant density (3.33 lakh ha^{-1}) and this was followed by planting density of 2.22 lakh population ha^{-1} (42.6 kg ha^{-1}).Greater uptake of these nutrients at higher plant densities was due to higher biomass production ha^{-1} produced at higher plant density.

In this trial, total potassium uptake by sesame crop was highest in F_5 (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}) treatment (57.0 kg ha^{-1}) which was significantly superior over rest of the treatments and it was followed by F_2 (47.9 kg ha^{-1}) treatment which was received 75% RDF +FYM @ 5.0 t ha^{-1} but it was statistically on par with F_1 (100% RDF @ 60-40-60 kg NPK ha^{-1}) *i.e.* 45.3 kg ha^{-1}. The lowest total uptake of potassium (37.3 kg ha^{-1}) was observed in treatment F_3 (75% RDF + 0.75 t PM ha^{-1}). The treatments $F_{5,}$ F_2 and F_1 were recorded 153,128 and 121 percent respectively higher total potassium uptake over F_3.

The increase in potassium content and uptake may be attributed to higher levels of organic manures and potassic fertilizers. This might be due to increased concentration of potassium in soil solution by addition of organic manures to soil which in turn increased the organic acids in the soil by the decomposition of organic manures. These acids act up on soil colloids and releases the potassium into the soil solution there by the plant might have utilized the potassium very effectively. Similar results are also reported by Lalate and Padmanl (2009), Hanumanthappa *et al*. (2016), Rao and Shaktawata. (2005), Choudhary *et al*. (2017).

Interaction effects of planting methods and nutrient management practices were non-significant with respect to total uptake of potassium of sesame.

Table 4.13. Potassium content (%) and uptake (kg ha^{-1}) in seed and stalk of sesame as influenced by plant densities and INM interventions

Treatments	Content (%)		Uptake(Kg ha^{-1})	
	Seed	Stalk	Seed	Stalk
Spacings (S)				
45 cm X 10 cm	1.92	1.36	13.4	29.2
30 cm X 10 cm	1.93	1.40	13.8	35.7
S.Em±	0.02	0.03	0.3	1.14
CD (p = 0.05)	NS	NS	NS	3.40
Fertilizer levels (F)				
100% RDF 60, 40, 60 NPK ha^{-1}	1.93	1.35	13.7	31.6
75% RDF + 5t FYM ha^{-1}	1.93	1.41	14.0	33.9
75% RDF + 0.75 t PM ha^{-1}	1.91	1.31	11.8	25.5
75% RDF + 1.3t Sunhemp green manuring ha^{-1}	1.92	1.31	13.2	30.2
25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}	1.94	1.54	15.4	41.6
S.Em±	0.03	0.05	0.5	1.81
CD (p = 0.05)	NS	0.14	1.4	5.37
Interaction (S X F)				
S.Em±	0.04	0.07	0.7	2.56
CD (p = 0.05)	NS	NS	NS	NS
CV (%)	4.05	8.36	8.8	13.66

Table 4.14 Total uptake of N, P, K of sesame as influenced by planting density and INM interventions

Treatment	TOTAL crop uptake (kg ha^{-1})		
	Nitrogen	Phosphorus	Potassium
Spacings (S)			
45 cm X 10 cm	61.4	17.5	42.6
30 cm X 10 cm	71.0	19.5	49.5
S.Em±	1.5	0.3	1.19
CD (p = 0.05)	4.4	1.0	3.53
Fertilizer levels (F)			
100% RDF 60, 40, 60 NPK ha^{-1}	66.5	18.8	45.3
75% RDF + 5t FYM ha^{-1}	70.7	19.4	47.9
75% RDF + 0.75 t PM ha^{-1}	52.0	15.0	37.3
75% RDF + 1.3t Sunhemp green manuring ha^{-1}	61.7	17.7	43.4
25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}	81.8	22.4	57.0
S.Em±	2.3	0.5	1.88
CD (p = 0.05)	7.0	1.5	5.58
Interaction (S X F)			
S.Em±	3.3	0.7	2.66
CD (p = 0.05)	NS	NS	NS
CV (%)	8.6	6.7	10.00

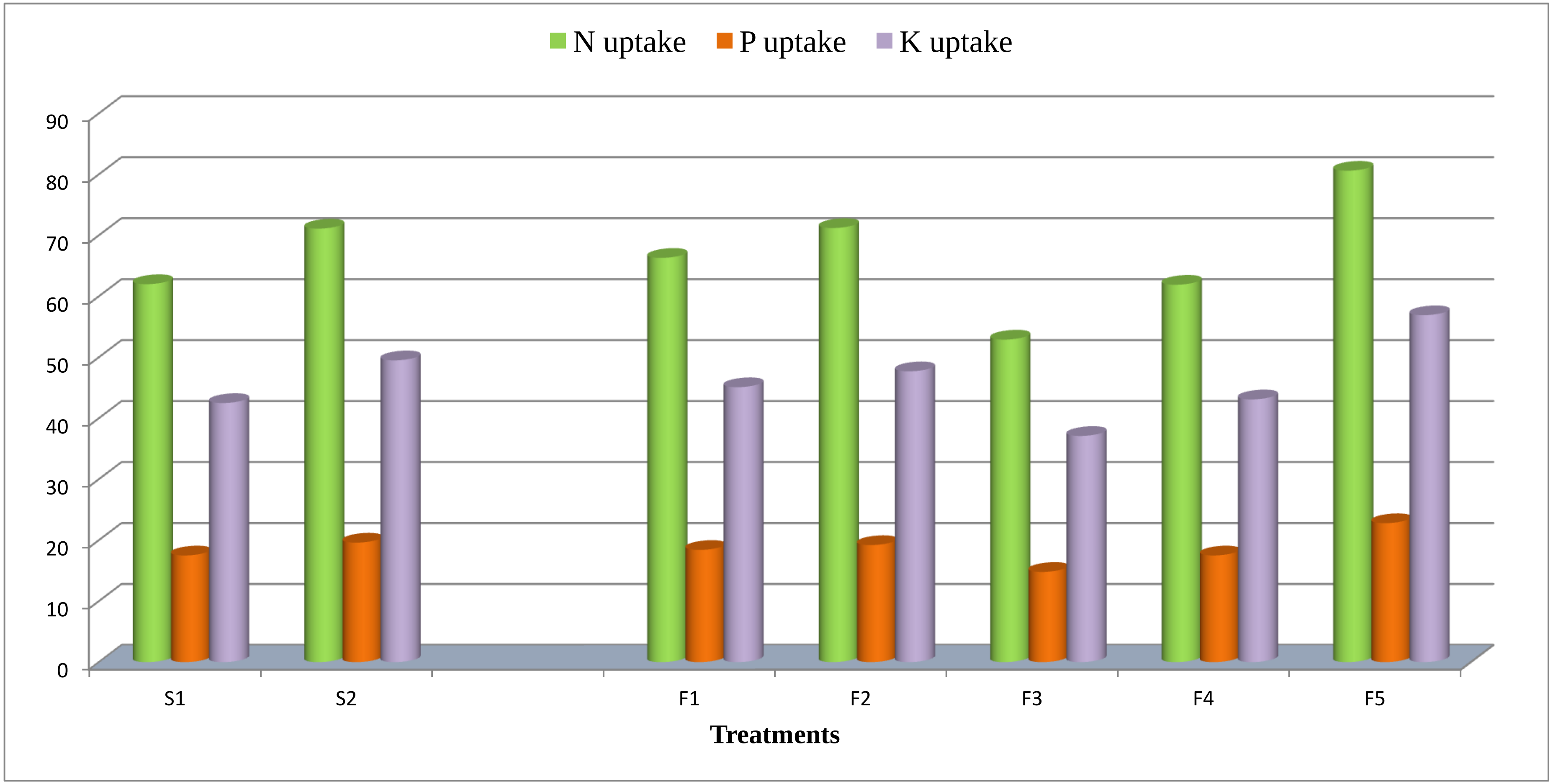


Fig. 4.6. Total uptake (kg ha^{-1}) Nitrogen, Phosphorus and Potassium at maturity by sesame as influenced by planting density and INM interventions

4.4 SOIL NUTRIENT (NPK) STATUS AFTER HARVEST OF CROP

4.4.1 Available Nitrogen (kg ha^{-1})

A perusal of the data (Table 4.15) reveals that the available nitrogen in the soil after harvest of the crop was significantly affected by planting densities and INM interventions

The maximum available nitrogen (183kg ha^{-1}) was recorded with a spacing of 45cm x10 cm (2.22 lakh plants ha^{-1}), which was significanlty superior to available phosphorous (174 kg ha^{-1}) measure under 30 cm x 10cm (3.33 lakh plants ha^{-1}).

Significantly the highest available Nitrogen (192 kg ha^{-1}) was recorded with the application of 25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} $^{+}$ 1.3t Sunhemp Green manuring ha^{-1}) followed by (75%RDF + 5t FYM ha^{-1}) (183 kg ha^{-1}) and (100% RDF 60, 40, 60 NPK Kg ha^{-1})(179 kg ha^{-1}). The lowest available nitrogen was recorded with 75%RDF + 0.75 t PM ha^{-1} (164 kg ha^{-1}). The treatments $F_{5,}$ F_2 and F_1 were recorded 117,112 and 109 percent respectively higher available nitrogen over F_3.

The increase in available nitrogen in the soil might be due to the addition of organic manures to the soil and inturn improve the nutrient holding capacity, soil colloidal properties and reduce the nutrient leaching losses from the soil. Interaction effects of planting densities and nutrient management practices were non-significant with respect to available nitrogen in soil after harvest of sesame.

These findings corroborate with the results obtained by Haruana and Abumiki (2012), Hanumanthappa *et al.* (2016), Mondal *et al.* (1993).

4.4.2 Available Phosphorus (kg ha^{-1})

A perusal of the data (Table 4.15) reveals that the available phosphorous in the soil after harvest of the crop was significantly affected by planting densities and INM interventions.

The maximum available phosphorous (10.5 kg ha^{-1}) was recorded with a spacing of 45cm x10cm (2.22 lakh plants ha^{-1}), which was significanlty superior to available phosphorous (8 kg ha^{-1}) measure under 30cm x 10cm (3.33 lakh plants ha^{-1}).

Significantly the highest available phosphorus (13.2 kg ha^{-1}) was recorded with the application of 25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp Green manuring ha^{-1}) followed by treatment F_2 (75%RDF + 5t FYM ha^{-1})(9.6 kg ha^{-1}) and F_1 (100% RDF@ 60, 40, 60 NPK kg ha^{-1}) (8.8 kg ha^{-1}). The lowest available Phosphorus was recorded with treatment F_3 (5.2 kg ha^{-1}). The treatments $F_{5,}$ F_2 and F_1 were recorded 253,185 and 169 percent respectively higher available phosphorus over F_3.

The increase in available phosphorus in the soil might be due to the addition of organic manures to the soil and inturn release of the organic acids during decomposition of phosphorus and it gets solubilization which ultimately more available for longer period of time in the soil solution.

These findings corroborate with the results obtained by Haruana and Abumiki (2012), Hanumanthappa *et al.* (2016), Mondal *et al.* (1993).

Interaction effects of planting densities and nutrient management practices were non-significant with respect to available phosphorous in soil after harvest of sesame.

4.4.3 Available Potassium (kg ha^{-1})

A perusal of the data (Table 4.15) reveals that the available potassium in the soil after harvest of the crop significantly affected by planting densities and INM interventions.

The maximum available potassium (268 kg ha^{-1}) was recorded with a spacing of 45cm x10 cm (2.22 lakh plants ha^{-1}), which was significanlty superior to available nitrogen (251 kg ha^{-1}) measure under 30 cm x 10cm (3.33 lakh plants ha^{-1}).

Available potassium in the soil also followed the same trend as in the case of nitrogen and phosphorus. Significantly the highest available potassium (276 kg ha^{-1}) was recorded with the application of 25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp Green manuring ha^{-1}) which is at par with F_2 (75%RDF + 5t FYM ha^{-1}) (264 kg ha^{-1}) followed by available potassium(250 kg ha^{-1}) of treatment F_1(100% RDF@ 60, 40, 60 NPK kg ha^{-1}). The lowest available potassium was recorded with treatment F_3 (250 kg ha^{-1}).

The increase in available potassium in the soil might be due to the addition of organic manures to the soil and inturn release of organic acids during decomposition so conversion of non exchangeable K to exchangeable K. This is helpful in availability of potassium for longer period of time in the soil solution. These findings corroborate with the results obtained by Haruana and Abumiki (2012), Hanumanthappa *et al*. (2016), Mondal *et al.* (1993).

Interaction effects of planting densities and nutrient management practices were non-significant with respect to available potassium in soil after harvest of sesame.

Table 4.15 Soil nutrient availability after harvest of sesame crop as influenced by planting density and INM interventions

Treatment	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_20 (kg ha^{-1})
Spacings (S)			
45 cm X 10 cm	183	10.5	268
30 cm X 10 cm	174	8	251
S.Em±	1.5	0.3	2.5
CD (p = 0.05)	4.4	1	7.5
Fertilizer levels (F)			
100% RDF 60, 40, 60 NPK ha^{-1}	179	8.8	262
75% RDF + 5t FYM ha^{-1}	183	9.6	264
75% RDF + 0.75 t PM ha^{-1}	164	5.2	250
75% RDF + 1.3t Sunhemp green manuring ha^{-1}	174	10.5	256
25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}	192	13.2	276
S.Em±	2.3	0.5	4
CD (p = 0.05)	7	1.5	11.9
Interaction (S X F)			
S.Em±	3.3	0.7	5.6
CD (p = 0.05)	NS	NS	NS
CV (%)	3.2	13.1	3.7

4.5 ECONOMIC STUDIES

The data in respect of gross monetary return, cost of cultivation and net monetary return with benefit: cost ratio of sesame as influenced by different treatments are presented in Table 4.16.

4.5.1 Gross monetary returns

A gross monetary return was not significantly influenced due to methods of planting and different INM treatments. However, higher Gross monetary returns (Rs 37,814 ha^{-1}) were noticed with 30cm X 10cm method of planting as compared to Gross monetary returns (Rs 37,114 ha^{-1}) in 45cm X 10cm method of planting in sesame.

Application of treatment F_5 (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp Green manuring ha^{-1}) numerically exhibited the highest gross monetary returns (Rs. 42,091 ha^{-1}) of sesame over all other treatments followed by gross monetary returns(Rs 38,399 ha^{-1}) in treatment F_2(75 % RDF + 5 t FYM ha^{-1}). The lowest gross monetary returns (Rs. 32,781 ha^{-1}) were recorded under the treatment F_3 (75RDF % + 0.75 t PM ha^{-1}). The GMRs of these treatments were significantly higher than remaining treatments mainly due to higher seed and stalk yields.

4.5.2 Net monetary returns

Net monetary returns did not influence significantly due to methods of planting and different INM treatments. However, a higher net monetary return (Rs 14,286 ha^{-1}) was noticed with 30cm X 10cm method of planting as compared to net monetary returns (Rs 13,786 ha^{-1}) in 45cm X 10cm method of planting in sesame.

Among the treatments, the application of treatment F_5 (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp Green manuring ha^{-1}) numerically exhibited the highest net monetary returns (Rs. 18, 026 ha^{-1}) of sesamum over all other treatments followed by net monetary returns (Rs 14,261 ha^{-1}) with the

Table 4.16 Economics of different treatments of sesame as influenced by planting density and INM interventions

Treatment	Cost of cultivation	Gross returns	Net returns	B: c ratio
Spacings (S)				
45 cm X 10 cm	23328.00	37114	13786	1.59
30 cm X 10 cm	23528.00	37814	14286	1.61
S.Em±	-	725.6	726	0.03
CD (p = 0.05)	-	NS	NS	NS
Fertilizer levels (F)				
100% RDF 60, 40, 60 NPK ha^{-1}	24100	36446	13504	1.56
75% RDF + 5t FYM ha^{-1}	24138	38399	14261	1.59
75% RDF + 0.75 t PM ha^{-1}	21400	32781	11381	1.53
75% RDF + 1.3t Sunhemp green manuring ha^{-1}	23437	37604	13009	1.56
25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}	24065	42091	18026	1.75
S.Em±	-	1147.2	1147	0.05
CD (p = 0.05)	-	NS	3408	0.15
Interaction (S X F)				
S.Em±	-	1622.4	1622	0.07
CD (p = 0.05)	-	NS	NS	NS
CV (%)	-	7.5	20	7.71

treatment F_2 (75 % RDF + 5 t FYM ha^{-1}). The lowest net monetary returns (Rs. 11,381 ha^{-1}) were recorded under the treatment F_3 (75RDF % + 0.75 t PM ha^{-1}). The NMR of a particular treatment is true net monetary gain because it was determined by substracting the cost of cultivation under a particular treatment from the GMR of the same treatment .similar results were also reported by Deshmukh *et al.* (2002), Duhoon (2008), Javia *et al.*(2010) and Prasannakumara *et al.*(2014).

4.5.3 Benefit: cost ratio

Benefit: cost ratio was not significantly influenced due to methods of planting and different INM treatments. However, the higher benefit: cost ratio (1.61) was noticed with 30cm X 10cm method of planting as compared to benefit: cost ratio (1.59) in 45cm X 10cm method of planting in sesame.

Table 4.11 shows that the application of treatment F_5 (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp Green manuring ha^{-1}) recorded the highest benefit: cost ratio (1.75) and was significantly superior over rest of the treatments. The lowest benefit: cost ratio (1.53) was obtained under the treatmnet F_3. It is the actual profit over each rupee of investment, because it is determined by dividing GMR values with cost of cultivation of a particular treatment. The indices per plot under different treatments can be expressed in percentage and it is also termed as profitability. Similar, findings were supported by Basavaraj *et al.* (2000), Deshmukh *et al.* (2002).

Chapter – V

Summary and Conclusions

Chapter V

SUMMARY AND CONCLUSIONS

5.1 Summary

A field experiment entitled "Planting Density and INM Interventions in Sesame Production" was conducted at the Agricultural College Farm, Bapatla during *rabi* 2017-18. The treatments comprised combination of two planting densities *viz.,* S_1(2.22 lakh plants ha^{-1}), S_2(3.33 lakh plants ha^{-1}) and five nutrient treatments F_1(100% RDF (60, 40, 60 NPK ha^{-1}), F_2(75% RDF + 5t FYM ha^{-1}), F_3(75% RDF + 0.75 t PM ha^{-1}), F_4(75% RDF + 1.3t Sun hemp green manuring ha^{-1}) , F_5(25% RDF + FYM 5t ha^{-1} + PM 0.75 t ha^{-1} + Sun hemp green manuring 1.3t ha^{-1}). The experiment was laid out in Factorial Randomized Block Design with three replications.

The experimental soil was analyzed before the initiation of experiment. NPK fertilizers were applied to the respective plots. Recommend dose of fertilizer (60, 40, 60 kg N, P, K ha^{-1}) was applied in two split doses as per the treatments. Entire quantity of P_2O_5 (40 kg ha^{-1}) and K_2O (60 kg ha^{-1}) were applied as basal. Green manure incorporation was done as per treatments 15 days prior to sowing and thoroughly incorporated in the soil with the help of rotavator. FYM and Poultry manure was applied as per treatments 15 days before sowing and thoroughly incorporated with a spade in soil upto root zone depth.

The experimental soil was sandy loam in texture, slightly alkaline and low in organic carbon, low in available nitrogen, and medium in available phosphorus and high in available potassium. A popular variety "YLM 66" was used for the study.

The salient findings of the experiment are summarized as follows

Results of the experiment revealed that numerically taller plants were produced at higher planting density of 3.33 lakh plants ha^{-1} than lower planting density (2.22 lakh plants ha^{-1})at 30, 60 DAS but significantly taller plants (77.3 cm)was recorded at maturity.

The plant height of sesame measured at 30, 60 DAS and at maturity differed significantly due to different nutrient treatments. Significantly the tallest plants (34.4cm, 64.9cm, and 79.5cm) were recorded with the application of 25%RDF + FYM 5t ha^{-1} + PM 0.75 t ha^{-1} + Sun hemp green manuring 1.3t ha^{-1} at 30, 60 DAS and at maturity, respectively which were at par with plant height obtained with F_2 (75%RDF + 5t FYM ha^{-1}). The lowest plant height was recorded among all the growth stages under the treatment F_3.Interaction between planting densities and nutrient treatments was non - significant among the all growth stages of sesame.

Drymatter accumulation ha^{-1} was significantly higher in plant densities of 3.33 lakh plants ha^{-1} at all the stages of crop growth (30, 60 DAS and at maturity) which was superior to plant densities of 2.22 lakh plants ha^{-1}. Application of treatment F_5 (RDF 25%+ FYM 5t ha^{-1} + PM 0.75 t ha^{-1} + Sunhemp Green manuring 1.3t ha^{-1}) produced significantly higher drymatter (187, 1659, 2704 kg $ha^{-1)}$ at 30, 60 DAS and maturity which was on par with treatment F_2.

Number of capsules per plant recorded were significantly higher in plant density (2.22 lakh ha $^{-1}$) with a spacing of 45cm X 10cm over 30cm X 10 cm plant density (3.33 lakh ha^{-1}). Application of treatment F_5 (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}) recorded significantly higher number of capsules per plant (37.0) over all the other treatments. Lower number of capsules per plant (31.1) was noticed with treatment F_3. Interaction effects of planting density and nutrient treatments with respect to number of capsules per plant were found non -significant.

Test weight of sesame was not significantly affected by different spacings and Nutrient management and their combinations. However numerically higher test weight (2.49 g) was recorded with the spacing of 30 cm X 10 cm. among the treatments test weight was recorded numerically higher with the treatment F_5. Interaction effects of planting densities and nutrient treatments with respect to test weight were found non –significant.

The highest seed yield (713.5 kg ha^{-1}) was produced in higher planting density (3.33lakh ha^{-1}) with the spacing of 30cm X 10cm as compared to lower planting density (2.22 lakh ha^{-1}) with spacing of 45cm X 10cm *i.e.*,700 kg ha^{-1}. Among the nutrient treatments significantly the highest seed yield (794 kg ha^{-1}) was recorded under F_5 treatment (25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} $^{+}$ 1.3t Sunhemp green manuring ha^{-1}) followed by treatment F_2 and the lowest seed yield was recorded with the treatment F_3. Interaction effects of planting densities and nutrient treatments with respect to seed yield were found non -significant.

Stalk yield did not differ significantly due to plant densities. However, 30cm X 10cm (3.33 lakh plant ha^{-1}) plant density recorded more stalk yield (1604 kg ha^{-1}) as compared to stalk yield (1587 kg ha^{-}1) of 45cm X 10 cm (2.22 lakh plant ha^{-1}) plant density. Application of treatment F_5 (RDF 25%+ FYM 5t ha^{-1} + PM 0.75 t ha^{-1} $^{+}$ 1.3t Sunhemp green manuring ha^{-1}) was recorded highest stalk yield (1795 kg ha^{-1}) and it was significantly superior over the other treatments. The lowest stalk yield (1362.5 kg ha^{-1}) was noticed with treatment F_3. Interaction effects of planting methods and nutrient management practices were not significant with respect to stalk yield.

Numerically the highest harvest index (30.8 %) was noticed in 30cm X 10cm planting density as compared to 45cm X 10 cm planting density (30.6 %). Application of treatment F_5 (25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} $^{+}$ 1.3t Sunhemp green manuring ha^{-1}) recorded numerically higher harvest index (31.5%) as compared to other nutrient management practices. Lowest harvest index (29.5 %) was recorded with treatment F_3. Interaction effects of planting methods and nutrient management practices were Non-significant with respect to harvest index.

Higher oil content *i.e* 48.24 % was observed in plant density of 3.33lakh plant ha^{-1}, which was numerically higher than plant density of 2.22 lakh plant ha^{-1}.Among the nutrient treatments the oil content higher *i.e* 48.8 % was recorded maximum under the treatment F_5.

Numerically higher protein content (23.47 %) was observed in plant density of 3.33lakh plant ha^{-1}, which was numerically higher than protein content in plant density of 2.22 lakh plant ha^{-1}. Application of treatment F_5 (RDF 25%+ FYM 5t ha^{-1} + PM 0.75 t ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}) was recorded higher protein content (24.41%) and it was on par with treatment F_2 and F_1.

Higher nitrogen content in seed and stalk (3.74%, 1.74 %) was noticed in 30cm X 10 cm spacing as compared to 45cm X 10cm method of planting (3.67 & 1.67% respectively). Significantly the highest nitrogen content in seed and stalk (3.91 %, 1.88 %) were recorded with treatment F_5 (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}) followed by treatment F_2 (3.82 %, 1.79 %, respectively).

Significantly the highest total nitrogen uptake (69.5 kg ha^{-1}) of sesame was recorded with 30 cm X 10 cm spacing than 45cm X 10cm (63 kg ha^{-1}) spacing. Among the nutrient treatments, maximum total uptake of nitrogen (81.6 kg ha^{-1}) in sesame was recorded with treatment F_5 (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}) which was significantly superior over rest of the treatments, and this was followed by F_2 treatment (70.7 kg ha^{-1}).

Maximum phosphorus content in seed and stalk (1.35 %, 0.39 %) were noticed in 30cm X 10cm plant density as compared to spacing of 45cm X 10cm (1.34 & 0.38 % seed and stalk, respectively) Maximum phosphorus content in seed and stalk (1.36% 0.43%) was recorded with treatment F_5 (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}) followed by treatment F_2 (1.35%, 0.40% respectively).

Significantly the highest total uptake of phosphorus (19.5 kg ha^{-1}) in sesame was registered with a spacing of 30 cm x 10cm (3.33 lakh plants ha^{-1}) this was superior to the spacing of 45 cm x 10 cm (17.5 kg ha^{-1}.) Among the treatments total uptake of phosphorus (22.3 kg ha^{-1}) was recorded with treatment F_5 (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}) which was significantly superior to other treatments, followed by treatment F_2 (19.2 kg ha^{-1}).

Higher potassium content in seed and stalk (1.93 %, 1.40 %) were noticed in 30cm X 10cm plant density as compared to spacing of 45cm X 10cm (1.34 & 0.38 % seed and stalk respectively). Numerically higher potassium content (1.94 %) in seed was recorded under the treatment F_2 (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}). Significantly the highest potassium content (1.54 %) in stalk was recorded with the treatment F_2.

Significantly the highest total uptake of potassium (57 kg ha^{-1}) in sesame was recorded with treatment F_5 (25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1}) which was significantly superior over the other treatments, followed by treatment F_2 (100 % RDF+5t FYM ha^{-1}).

Interaction effects of planting densities and nutrient management practices were non-significant with respect to N, P, K contents and uptake of sesame.

The highest available nitrogen (183 kg ha^{-1}), phosphorus (10.5 kg ha^{-1}) and potassium (268 kg ha^{-1}) in soil after harvest of sesame was recorded in 45cm X 10cm spacing(2.22 lakh plant ha^{-1}) and it was significantly superior over available nitrogen (174 kg ha^{-1}), phosphorus(8 kg ha^{-1}) and potassium (251 kg ha^{-1}) in soil after harvest of sesame in 30cm X 10cm spacing (3.33 lakh plant ha^{-1}).

Application of 25%RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp green manuring ha^{-1} showed that significantly higher available nitrogen (192 kg ha^{-1}), phosphorus (13.2 kg ha^{-1}) and potassium (276 kg ha^{-1}) over the other treatments followed by treatment F_2 after harvest of sesame. Interaction effects of planting methods and nutrient management practices were Non-significant with respect to available N, P, and K in soil after harvest of sesame.

The highest gross returns (Rs.42091 ha^{-1}), net returns (Rs. 17926 ha^{-1}) and returns per rupee investment (1.74) were recorded with application of 25% RDF + 5t FYM ha^{-1} + 0.75 t PM ha^{-1} + 1.3t Sunhemp Green manuring ha^{-1} over all other treatment combinations, followed by treatment F_2.

The following conclusions can be drawn from the study conducted:

1. It can be concluded that growth, yield attributing characters, quality parameters and yield of sesame crop were higher at a spacing of 30cm x 10cm.

2. Application of 25% RDF along with 5 t FYM ha^{-1}, 0.75 t PM ha^{-1} and 1.3 t sunhemp green manuring exhibited maximum growth and quality parameters.

3. The investigation also revealed the possibility of reducing costly inorganic fertilizer application because of application of organic manures supply to the sesame crop.

4. Based on economic analysis, the highest gross return, net return and B: C ratio were obtained with application of 25% RDF+5t FYM ha^{-1}+0.75 t PM+1.3 t sunhemp green manuring.

Literature Cited

LITERATURE CITED

A.O.A.C. 1960. Official Methods of Analysis. 18th *Edition*, *Association of Official Agricultural Chemists*, Washington.

Abolel, M. F., Abo, E. L. 1996. Effects of organic waste compost addition on sesame growth, yield and chemical composition. *Agriculture. Ecosystem and Environment.* 60(2-3): 157-164.

Ahmad, R., Mahmood, T., Saleem, M. F. and Ahmad, S. 2002. Comparative performance of two sesamum varieties under different row spacing. *Asian Journal of Plant Science.* 1(5): 546-547.

Anonymous, 2014. Vital Agricultural Statistics, Directorate of Agriculture, Govt. of Rajasthan. pp. 60.

Anonymous, 2016. Directoarte of Agriculture,Rajasthan. Jaipur.

Anonymous, 2017. Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India. (http:// www. agricoop.nic.in.)

Aruna, E and Mohammad, S. 2005. Influence of conjunctive use of organic and inorganic source of nutrients in rice (*Oryza sativa*) on crop growth, yield components, yield and soil fertility in rice- sunflower(*Helianthus annuus*) sequence. *Indian Journal of Agronomy.* 50(4): 265-268.

Azeez, J. O and Van Averbeke, W. 2012. Dynamics of soil pH and electrical conductivity with the application of three animal manures. *Communication in Soil Science and Plant Analysis*. 43: 865-874.

Babalad, H. B., 1999. Integrated nutrient management for sustainable production in soybean based cropping system. *Ph.D. Thesis*, University of Agricultural Sciences, Dharwad.

Bajpai, R. P. 2000. Performance of sesame as influenced by organic, inorganic and biofertilizer. *National Seminar on Oilseed.* 2 (4): 152.

Barik, A. K and Fulmali, J. 2011. Effect integrated plant nutrient supply through organic and mineral sources on productivity of summer sesame. *Journal of Oilseed Research.* 28(2): 120-122.

Basavaraj, B., Shetty, R. A., Patil, S. G. and Hunshal, C. S. 2000. Nutrient content and uptake by sesame varieties as influenced by fertilizer and population levels under summer irrigated conditions. *Karnataka Journal of Agricultural Sciences.* 13: 141-143.

Bhal, G. S. and Pasricha, N. S. 2000 Direct and residual effect on green manuring in relation to fertilizer nitrogen on toria and sunflower. *Journal of the Indian Society* of *Soil Science.* 49(1):113-117.

Bindra, A. and Kharwara, P. C. 1992. Response of sunflower (*Helianthus annus*) to nitrogen application and spacing. *Indian Journal of Agronomy*. 37 (2): 283-284.

Brar, Z. S., Bal, D. S. and Johl, A. S. 1998. Influence of sowing dates, nitrogen and planting geometry on the performance of gobhi sarson (*Brassica napus spp. Olerifera var. annua*). *Indian Journal of Agronomy*. 43 (1): 133-137.

Chadwick, D. R., John, F., Pain, B. F. Chambers, B. J and Williams J. 2000. Plant uptake of nitrogen from the organic nitrogen fraction of animal manures: A laboratory experiment. *Journal of Agricultural Science.* 134: 159-168.

Chapman, H. D. and Pratt, R. T. 1978. Methods of Analysis for Soils, Plants and Water. University of California, Division of *Agriculture Science* 169.

Chaturvedi, S. and chandel, A. S. 2005. Influence of organic and inorganic fertilization on soil fertility and productivity of soybean (Glycine max). *Indian Journal of Agronomy* 50(4): 311-313.

Chaurasia, S. K., Neeta jain and Namrata. 2009. Effect of integrated use of fertilizers, organic manures and micronutrients on productivity of sesame (*Sesamum indicum*). *Annals Agriculture Research New Series.* 30(4&4): 91-94.

Chimanshette, T. G and Dhoble, M. V. 1992. Effect of sowing date and plant density on seed yield of sesame (*Sesamum indicum* L.) varities. *Indian Journal of Agronomy*. 37 (2): 280-282.

Choudhary. S., Sharma, O.P,. Gora, M. K and Choudhary, R.R. 2017. Effect of Organic Manures and Molybdenum on Growth, Yield and Quality of Groundnut. *International Journal of Current Microbiology and Applied Sciences*. *6*(6): 736-742.

Dasani, A.K., Talashilkar S.C. and Mehta, V.B. 1999. Effect of poultry manure applied in combination with fertilizer on yield, quality and nutrient uptake of groundnut. *Journal of the Indian Society of Soil Science*. 47 (1) 166-169.

Deshmukh, K. K., Saraiya, A. B., Dubey, D. P. 2005. Effect of integrated nutrient management on productivity trends, economics and soil fertility in soybean chickpea cropping system. *Jawaharlal Nehru Krishi Vishwa Vidyalaya Research Journal.* 39(2): 29-32.

Deshmukh, K.K., Khatik, S.K and Dubey, D.P. 2005. Effect of integrated use of inorganic, organic and biofertilizers on production, nutrient availability and economic feasibility of soybean grown on soil of Kaymore Plateau and Satpura Hills. *Journal of Soils and Crops*. 15(1): 21-25.

Deshmukh, M. R and S. B., Duhoon. 2008. Effect of organic input on sesame (*Sesamum indicum*) under rainfed situation in kymore plateau zone of Madhya Pradesh. *Journal of Maharashtra Agricultural University.* 33 (3): 323-324.

Deshmukh, M. R., Jain. H. C., Duhoon, S. S and Goswami, U. 2002. Integrated nutrient management in sesame *(Sesamum indcum* L.) for *Kymore plateau zone* of *Madhya Pradesh Journal of Oilseeds Research.* 19(1): 73-75.

Deshmukh, P. R., Jamn, H. C., Duhloon, S. S and Goswami. U. 2002. Performance of niger *(Guizotia abyssnica* (L 1.) Cassl influenced by inorganic fertilizers FYM and bio-fertilizers in different soil types *Journal of Oilseeds Research.* 19(1) 79-81.

Deshmukh, S. S., Shaikh, A. A and Desai, M. M. 2010. Influence of integrated nutrient management on growth and yield contributing characters of summer sesame. *Maharashtra Journal of Agriculture University.* 35(1): 3-6.

Dey, D. 2016. Yield evaluation of sesame, (*Sesamum Indicum* L.) in acidic soil of Tripura. *International Journal of farm Sciences.* 6(2): 46-50.

Diacono, M and Montemurro, F. 2010. Long-term effects of organic amendments on soil fertility. A review. *Agronoimy for Sustainable Development.* 30: 401-422.

Dixit, J. P., Rao, V. S. N., Ambabatiya, G. R. and Khan, R. A. 1997. Productivity of sesame cultivars sown as semi-*rabi* under various plant densities and nitrogen levels. *Crop Res*earch. 31 (1): 27-31.

*Donald, C. M and Humblin, J. 1976. The biological yield and harvest index of cereals as agronomic and plant breeding criteria. *Advances in Agronomy*. 28: 361-405.

DOR 2009-10. Annual Progress Report Sesame and Niger p 238.

Duary, B. and Ghosh, A. K. 2009. Effect of nipping on productivity and economics of summer Sesamum (*Sesamum indicum* L.*)* under varying levels of plant density. *Madras Agricultural Journal.* 96(7- 12):386-388.

Duhoon, S. S., Jain, H. C., Deshmukh M. R. and Goswami, U. 2001. Integrated nutrient management in *Kharif* sesame *(Sesamum indicum* L.). *Journal of Oilseeds Research,* 18(1): 81-84.

Duhoon, S.S., Nema, S. and Deshmukh, M.R. 2009. Research and Development strategies for sesame, (*Sesamum indicum* L.). *In: Proc of National Symposium on vegetable oils scenario*- *'*Approaches to meet the growing demands' held at Hyderabad on January 29-31. pp. 22-28.

Elleuch, M., Dorothea, B and Abdel Zitoun. 2011. Sesame seeds in food, nutrition and health. *Nuts and seeds in health and disease prevention*. 1029-1036.

Farhad, W., M. F. Saleem, M. A. Cheema and H. M. Hammad 2009. Effect of poultry manure levels on the productivity of spring maize (*Zea mays* L.). *The Journal of Animal and Plant Science.* 19(3): 122-125.

Geethakumari, V. L. and Shivashankar, 1991, Studies on organic amendment and CO2 enrichment in ragi/soybean for intercropping systems. *Indian Journal of Agronomy*. 36 (2): 202-206.

Ghosh, D. C. and Patra, A. K. (1994). Effect of plant density and fertility levels on productivity and economics of summer sesamum (*Sesamum indicum* L.). *Indian Journal of Agronomy.* 39(1): 71-75.

Ghungarde, S. R., Chavan, D. A., Alse, U. N., Yeagaonkar, G. V. and Pangarkar, V. N. 1992. Effect of plant density and variety on yield of sesame (*Sesamum indicum* L.). *Indian Journal of Agronomy*. 37 (2): 385-386.

Gunri, S. K and Nath, R. 2012. Effect of organic manures, biofertilizers and biopesticides on productivity of summer groundnut (Arachis hypogeae L.) in red and laterite zone of West Bengal. *Legume Research.* 35(2): 144 – 148.

Halepyati, A. S. 2001. Conjunctive use of organic and inorganic fertilizers in rabi/summer groundnut in UKP area. *Karnataka Journal of Agricultural Science.* 14 (2): 454-55.

Hanumanthappa, M. and B. L., Dalavai. 2008. Dry matter production nutrient uptake and economics of sesame (*Sesamum indicum*) as influenced by organic manure and fertilizer level. *Mysore Journal of Agriculture Science* 42 (4): 629-634.

Hanumanthappa, M., Nagaraj, R., Ranjith, T. H., Sudhir Kamath, K.V. and Dhananjaya. B. 2016. Studies on residual effect of different organic sources of nutrients in paddy-groundnut cropping sequence under acidic soil of coastal Karnataka. *International Conference on Agricultural and Food Engineering (Cafei.2016).*

Haruna, I. M. 2011. Growth and yield of sesame (*Sesamum indicum* L.) as affected by poultry manure, nitrogen and phosphorus at Samara, Nigeria. *Journal of Animal and Plant Sciences;* 21 (4): 653-659.

Haruna, I. M. and Abimiku, M. S. 2012. Yield of sesame (*Sesamum indicum* L.) as influenced by organic fertilizers in the southern guinea savanna of Nigeria. *Sustainable Agriculture Research.* 1 (1): 66-69.

Haruna, I. M., Aloyu, L., Olufajo, O. O. and Odion E. C. 2011. Growth of sesamum (*Sesamum indicum* L.) as influenced by poultry manure, nitrogen and phosphorus in Samara, Nigeria. *Journal of Agricultural and Environmental* Sciences. 10(4): 561-568.

He, Z.Q., Tazisong, I. A., Senwo, Z. N and Zhang. D. L. 2008. Soil properties and macro cations status impacted by long-term applied poultry litter. *Communication in Soil Science and Plant Analysis*. 39: 858-872.

Hemalatha, S., Jagannatham, A and Rao, V. P. 1999. Effect of nitrogen fertilization and row spacing on growth and yield of sesame. *Journal of Oilseed Research.* 16 (1): 128-129.

Jain, H. C., Deshmukh, M. R., Goswami, U. and Hedge, D. M., 1999, Studies on time and method of sowing under rainfed conditions in vertisols for sesame production. *Journal of Maharashtra Agricultural University.* 24 (2):181-183.

Jain, H. C., Deshmukh, M. R., Goswami, U. and Hedge, D. M., 2000, Studies on land configuration and seed hardening on productivity of sesame in different soil types. *Journal of Maharashtra Agricultural University*. 25 (1):1-2.

*Jackson, A.H. 1976. Structure, properties and distribution of chlorophylls in chemistry and bio chemistry of plant pigments, 2nd edition Academic Press, London, pp. 1-63.

*Jackson, M.C. 1973. Soil chemical analysis, prentice hall of India private limited, New Delhi, pp.498.

Jakusko, B. B. and Usman, B. D. 2013. Effects of NPK fertilizer and plant population density on productivity of sesame (*Sesamum indicum* L.). *Research Journal of Agricultural and Environment Manag*ement. 2 (5): 121-126.

Javia, R. M, Vora, V. D., Sutaria, G. S, Akhari, K. N and Padmani, D. R. 2010. Effect of integrated nutrient management on productivity of sesame and soil fertility of sandy loam soils under rainfed condition. *Journal of Soil Science.* 5: 80-82.

Kachot, N. A., Malavia,D. D., Solanki, R. M. and Sagarka, B. K. 2001. Integrated nutrient management in rainy season groundnut (*Arachis hypogaea*). *Indian Journal of Agronomy.* 46(3): 516-522.

Kadam, W. G., Chavan, D. A. and Lad, N. G. 1989. Effect of row spacing and nitrogen on yield of sesamum. *Journal of Maharashtra Agricultural University.* 14 (2): 227-228.

Kadam, W. G., Sugave, S. and Jadhao, A., 2006, Response of castor genotypes to fertilizer application in vertisols. *Annual Review of Plant Physiology*. 20(1): 160-161.

Kashved, S. M., Raskar, B. S and Tamboli, B. D. 2010. Effect of integrated nitrogen management and irrigation regimes on productivity of mustard (*Brassica juncea* L.). *Journal of Maharashtra Agricultural University.* 35(3): 439-353.

Kathiresan, G. 2002. Response of summer sesamum (*Sesamum indicum* L.) genotypes to level of nutrients and spacing under different seasons. *Indian Journal of Agronomy.* 47 (4): 537-540.

Kathmale, D. K., Khadtare, S. V., Kamble, M. S. and Patil, R.C. 2000. Integrated nutrient management in groundnut (*Arachis hypogeal)*-wheat (*Triticum aestivum)* cropping system on vertisols of western Maharashtra Plans Zone. *Indian Journal of Agronomy.* 45 (2): 248-252.

Krishna, M. H., Reddy, A. P. K., Obulamma, U. and. Kumari, C. R. 2004. Crop geometry and intercropping on growth, yield attributes and yield of sesame and greengram *Journal of Research ANGRAU*. 32 (4): 1-4.

Kumar, S, Tewari, S. K. and Singh, S. S. 2011. Effect of sources and levels of sulphur and spacing on the growth, yield and quality of spring sunflower (Helianthus annuus). *Indian Journal of Agronomy*. 56 (3): 242-246.

Kumar, S. G., Tewari, S. K. and Singh, S. S. 2012. Effect of spacing, sources and levels of sulphur on the growth, yield, oil content and economics of sunflower (*Helianthus annuus*) var. “Morden” in sandy loam soil of Allahabad (U. P.). *Plant Archives.* 12 (1): 249-252.

Kumara, B. H. P., Chittapur, B. M., Hiremath, S. M., Malligwd, L. H., Nadaf, H. L. and Koti, R. V. 2014. Effect of fertilizer levels and planting geometry on the performance of sesamum genotype. *Karnataka Journal of Agricultural Science*. 27(3):289-292.

Lalate, P.Y and Padmani, D. R. 2009. Effect of organic manure and biofertilizers on yield, b: c ratio and nutrient uptake pattern of groundnut *(Arachis hypogaea.* L.*) Bioinfolet.* 6 (4): 323-325.

Maheswari, U. P., Krishna Murthy, S. K and Yellamanda Reddy, T. 2008. Effect of organic and inorganic nutrient sources on yield of castor(*Ricinus communis*). *Crop Research.* 36(1-3): 108-110.

Majumdar, B., Venkatesh, M., Kumar, S. K., Kailash and Patiram. 2002. Efficiency of rock phosphate, superphosphate and their mixture with farm yard manure on soybean in an acid Alfisol of Meghalaya. *Annals of Agricultural Research.* 23(4): 697-703.

Makinde, E. A., Ayoola, O. T. 2008. Residual influence of early season crop fertilization and cropping system on growth and yield of cassava. *American journal of Agricultural and Biological Science* 3: 712-715.

Mali, S. S. and Gokhle, D. N. 2007. Influence of integrated nutrient management on yield and quality of soybean, *Glycine max* (L.) Merrill and and pigeonpea,*Cajanus cajan* intercropping system under rainfed condition. *Journal of Oilseed Research.* 24 (2): 324-325.

Manjappa, K. 1999. Sustainable production of planted and ratoon crop of hybrid rice under lowlands in hill zone of Karnataka. *Ph.D. Thesis*, University of Agricultural Sciences, Dharwad, pp. 241-245.

Mishra, S. K., Behera, A. K. and Sha, H. S. 1994. Response of summer sesame (*Sesamum indicum* L.) to row spacing and phosphorus. *Orissa Journal of Agriculture Research.* 7: Supplement, 99-101.

Moinuddin and Mohd kaleem. 2017. Yield and quality of groundnut (arachis hypogaea l.) under different organic sources of nitrogen. *International Journal of Agricultural Science and Research.* 7 (5): 295-298.

Mondal, S. S., Mondal, T. K., Sarkar, S and Pradhan, B. K. 1993. Integrated nutrient management with sulphur bearing fertilizers, FYM and crop residue on the yield attributes and yield of sesame. Indian Agriculturist 37(3): 175-180.

Monpara, B. A. and Vaghasia, D. R. 2016. Optimizing Sowing Time and Row Spacing for Summer Sesamum Growing in Semi-arid Environments of India. *International Journal of Current Research and Academic Review.* 4(1): 122-131.

Moore, P. A. J., Daniel, T. C. Sharpley, A. N and Wood, C.W. 1998. Poultry manure management, *In* R.J. Wright ed. Agricultural uses of municipal, anmial, and industrial byproducts. *U.S. Department of Agriculture (USDA) Conservation Research Report, No. 44. Washington DC, USA.*

More, S. R., Mendhe, S. N., Kolte, H. S., Yenprediwar, M. D. and Choudhary, R. L. 2008. Growth and yield attributes of soybean as influenced by nutrient management. *Journal of Soils and Crops.* 18(1): 154-157.

Narkhede, T. N., Wadile, S. C., Attarde, D. R., Suryawanshi, R. T. and Deshmukh, A. S. 2001. Response of macro and micro nutrients in combination with organic matter (FYM) on yield of sesamum (*Sesamum indicum L.). Journal of Soils and Crops.* 11(2): 203-205.

Narkhede, T.N., Wadile, S.C., Attarde, D. R. and Suryawanshi , R. T. 2001. Integrated nutrient management in rainfed sesame (Ses*amum indicum* L.) in assured rainfall zone. *Sesame and Safflower Newsletter.* 16: 57-59.

Nayek, S. S, Koushik, B and Chowdhury M. D. R. 2014. Integrated approach in nutrient management of sesame with special reference to its yield, quality and nutrient uptake. *The Bioscan.* 9 (1): 101-105.

Ngala, A. L., Dugje, I. Y. and Yakubu, H. 2013. Effects of inter-row spacing and plant density on performance of sesame (Sesamum indicum L.) in a Nigerian Sudan savanna *Science International*. 25 (3): 513-519.

Nirval, B. J., Bhosle, B. R., Chavan, A. A. and Shinde, J. S. 1995. Response of sesamum varities to sowing dates and plant densities. *Journal of Maharashtra Agricultural University.* 20 (3): 382-384.

Ogbonna, P. E. and Umar-Shaaba, Y. G. 2011. Yield responses of sesame (*Sesamum indicum* L) to rates of poultry manure application and time of planting in a derived savannah ecology of south eastern Nigeria. *African Journal of Biotechnology*, 10 (66): 14881-14887.

Okpara, D. A. Muoneke, C. O. and Ojikpong, T. O. 2007. Effects of nitrogen and phosphorus fertilizer rates on the growth and yield of sesame (*Sesamum indicum* L.) in the South eastern Rainforest Belt of Nigeria. *Nigerian Agriculture Journal*. 38: 1–11.

*Olsen, S. R., Cole, C. L., Watanable, F. S and Dean, D. A. 1954. *Estimation of available phosphorus in soils by extraction with sodium bicarbonate*. United States Development Agency Circular Number, 939.

Paneerselvam and Bheemaiah, G. 2005. Effect of integrated nutrient management practices on productivity, nutrient uptake and economics of sunflower intercropped with *Azadirachta indica* and *Melia azdirach* trees. *Journal of Oilseeds Research*. 22(1): 231-234.

*Panse, V.G and Sukhatme, P.V. 1978. Statistical methods for agricultural workers. Indian Council of Agricultural Research, New Delhi, pp. 361.

Panwar, A. S. and Munda, G. C. 2007. Response of groundnut (*Arachis hypogaea*) to organic and inorganic sources of nutrient supply under mid-hill altitude conditions. *Indian Journal of Agriculture Sciences.* 77(12): 814-818.

Paradkar, V. K. and Deshmukh M. R. 2004. Response of soybean , *Glycine max* (L.) Merril to application of inorganic fertilizers and their integration with farmyard manure in Satpura Plateau zone of Madhya Pradesh. *Journal of Oilseeds Research.* 21 (2): 288-289.

Paraye, P. M., Kashyap, T. L., Chaubey, A. K. 2009. Effect of nutrient management practices and row spacing on growth yield attributes and yield of Indian mustard (Brassica juncea L.). *Environment and Ecology*. 27 (2): 589-591.

Parihar, S. S. 2004. Effect of integrated source of nutrient, puddling and irrigation schedule on productivity of rice-wheat cropping system. *Indian Journal of Agronomy.* 49(2): 74-79.

Patel, C. R., Patel M. K., Khajanji S. N. and Patel J. R. 2012. Effect of integrated nutrient management on growth, yield and economics of soybean genotypes. *Journal of Agriculture Research and Technology*. 37(1): 8-10.

Patel, H. K., Patel, R. M., Desai, C. K. and Patel, H. B. 2014. Response of summer sesamum (*Sesamum indicum* L.) to different spacing and levels of nitrogen under north Gujarat condition. *International Journal of Agriculture Sciences.* 10(1):336-343.

Patel, J. R and Shelke, V. B. 2000. Effect of organic and inorganic fertilizers on yield of mustard. *Journal of Maharashtra Agricultural University.* 25(1):70-71.

Patil, A. B., Shinde, Y. M. and Jadhav, N. D. 1995. Influence of nitrogen levels and spacings on seed yield of sesamum. *Journal Maharashtra Agricultural University.* 21 (1): 368-369.

Patil, N. B., Ingole, G. L., Raut, P. D. and Dangore, S. T. 2003. Impact of manuring and fertilization on yield, quality and nutrient uptake of soybean. *Annual Review of Plant Physiology*. 16(2): 166-169.

Patil, S. S., Dabke, D. J., Dongate, J. H. and Chavan, R. N. (2006). Effect of nitrogen and sulphur levels on yield, quality and nutrient uptake by niger *(Guizotia abyssinica* (L .f.) Cass.] in lateritic soils of Kokan . *J. Maharashtra Agricultural University.* 31 (1):01-04.

Patra, A. K. and Mishra, A. 2000. Effect of variety, nitrogen, and spacing on yield attributes and yield of sesamum (*Sesamum indicum* L.) during post-rainy season. *Journal of Oilseed Research.* 17(1): 113- 116.

*Piper, C. S. 1966. *Soil and Plant Analysis*. Hans Publishers, Bombay, 338 & 351.

Prasad, P. V. V and Satyanarayana, V. 2002. Maximizing yields in rice-groundnut cropping sequence through integrated nutrient management. *Field Crop Res*. 75: 9-21.

Prasannakumara, B. H., Chittapur, B. M.; Hiremath, S. M.; Malligwad, L. H.; Nadaf, H. L. and Koti, R. V. 2014. Effect of fertilizer levels and planting geometry on the performance of sesame (*Sesamum indicum* L.) genotypes. *Karnataka Journal Agricultural Science.* 27 (3): 289-292.

Raiz Ahmad, Tariq Mahmood, M., Farrvkh Saleem and Shamin Ahmad, 2002, Comparative performance of two sesame varieties under different row spacings. *Asian Journal* of *Plant Sciences.* 5: 546-547.

Ramamurthy, V and Shivashankar, K., 1996, Effect of organic matter and phosphorus on growth and yield of soybean. *Indian Journal of Agronomy*. 41: 65-68.

Ramanathan, S. P. and Chandrashekharan, B. 1998. Effect of nipping, plant geometry and fertilizer on summer sesamum (S*esamum indicum* L.) *Indian Journal of Agronomy.* 43 (2): 329-332.

Rao, S. S and M. S. Shaktawat. 2005. Effect of organic manure, phosphorus and gypsum on nutrient uptake in groundnut. *Agropedology*. 15 (2): 100-106.

Reddy, B. N., Sudhakara Babu, S. N and Bhanurekha, K. 2007. Productivity and nutrient uptake of sunflower (*Helianthus annus* L.) as influenced by site specific integrated nutrient management on Alfisols. *Journal of Oilseed Research.* 24 (2): 331-333.

Roy, N., Abdullah Mamun, S. M. and Dr. Mohammad. S. J. 2009. Yield performance of sesame *(Sesamum indicum* L.) varieties at varying levels of row spacing. *Research Journal of Agriculture and Biology Science.* 5 (5): 823-827.

Sanaz, K., Amir, G and Seyed A. M. 2010. Effect of organic chemical and integrated fertilizers on quantitative traits of sunflower. *Tarbiat Modares University, Department of Agronomy, Iran*.110-120.

Sarkar, A. K. and Sinha, A. C. 2004. Seed production of tossa jute (*Corchorus olitorius* L.) as influenced by time of sowing and clipping apical bud under rainfed condition in Terai Region of West Bengal. *journal of Interacademicia.* 8 (1): 21-26.

Sarkar, R. K. and Banik, P. 2002. Effect of planting geometry, direction of planting and sulphur application on growth and productivity of sesamum (*Sesamum indicum* L.). *Indian Journal of Agriculture Sciences*. 72 (2): 70-73.

Sarkar, R. K. and Pal, P. K. 2005. Effect of crop geometry, fertility level and nipping on physiological parameters in relation to productivity of sesame (*Sesamum indicum*. L.). *Indian Journal of Agriculture Sciences.* 75(3): 143-146.

Sarwad, I. M., Guled, M. B. and Gundlur, S. S. 2005. Influence of integrated nutrient supply for rabi sorghum chickpea crop ration on crop yield and soil properties. *Karnataka Journal of Agricultural Science.* 18(3): 673-679.

SEAI (Solvent Extractor's Association of India) The Premier Association of Vegetable Oil Industry and Trade of India. ISO 9001: 2008 Organisation.

Senthilkumar, V., Imayavaramban, K., Thanunathan and Manickam, G. 2000. Effect of intra-row spacings and different levels of nitrogen in combination with Azospirillum inoculation on growth and yield of sesamum. *Research on crops.* 1 (3): 351-354.

Seshadri, R., Shivaraj, S. B and Reddy, V.C. 2004. Nutrient Uptake and Agronomic Efficiency of Groundnut as Influenced by Different Organic Manures. *Karnataka Journal of Agricultural Science.* 17(4): (670-675).

Sharma, K. L., Srinivas,K., Das, S. K., Vittal, K. P. R and Kusuma Grace, J. 2002. Conjunctive use of inorganic and organic sources of nitrogen for higher yield of sorghum in dryland alfisol. *Indian Journal of Dryland Agricultural Research and Development.* 17(2): 79-88.

Sharma, P. B. 2005. Fertilizer management in sesame (*Sesamum indicum* L) based intercropping system in tawa command area. *Journal of Oilseeds Research.* 22 (1): 63-65.

Sharnapa, S. P. and Shivaraj, B. 1995. Influence of pre-season crops and nitrogen levels on performance of rice (Oryza sativa L.) Sunflower (*Helianthus annaus* L.) sequence. *Indian Journal of Agronomy*. 40 : 262-264.

Shashidhara, G. C., Harsha, K. N., Krishnegowda, M., Ahmed Tanveer and Malligawad L. H. 2009. Effect of plating methods and nutrient management practices on yield of sesame, *Sesamum indicum* L. *Journal of Oilseeds Research.* 26: 259-260.

Sheetal, T., Gabhane, V. V and Pushpa, B. 2014. Effect of integrated nutrient management on yield, quality, nutrient content and uptake of groundnut in shrink-swell soil. *International Journal of Agricultural Sciences.* 10(1):291-293.

Shekh, M. A., Mathukia, R. K. and Sagarka, B.K. 2014. Sowing Time and Spacing for Summer Sesamum (*Sesamum indicum* L.). Agriculture: Towards a New Paradigm of Sustainability., Excellent Publishing House, Kishangarh, Vasant Kunj, New Delhi. pp. 111-115.

Shinde, P. S., Sankpal, V. Y., Jawale, S. M., Shaikh, A. A., Dalavi, N. D. and Jadhav, M. B. 2009. Effect of integrated nutrient management on yield attributes and quality of soybean. *Journal of Maharashtra Agricultural University*. 34(1): 107-108.

Shinde, S. D.; Raskar, B. S. and Tamboli, B. D. 2011. Effect of spacing and sulphur levels on productivity of sesame (Sesamum indicum L.) under summer condition. *Journal of Maharashtra Agricultural University*. 36 (1): 28-31.

Sivagamy, K. and Rammohan, J. 2013. Effect of sowing date and crop spacing on growth, yield attributes and quality of sesame. *IOSR Journal of Agriculture and Veterinary Science*. 5 (2): 38-40.

Sridhar, K., Yakadri, M. and Ramesh, T. 2012. Nitrogen management in rabi sunflower in relation to different tillage practices imposed during kharif. *Indian Journal of Dryland Agricultural Research and Development.* 2012. 27(2): 66-72.

Srinivasarao, A., Venkateswarlu, B. and Prasad, P. V. N. 2004. Sustainable groundnut production through integrated nutrient management. *The Andhra Agricultural Journal*. 51 (1&2): 14-17.

*Subbiah, B.V and Asija, G.L. 1956. A rapid procedure for the determination of available nitrogen in soil. *Current Science*. 25: 259-260.

Subhash Kumar 2002. Effect of planting pattern and fertilizer management on sesame. *Indian Journal of Agronomy* 47(3): 355-360.

Subrahmaniyan, K. and Arulmozhi, N. 1999. Response of sesame (*Sesamum indicum L.*) to plant population and nitrogen under irrigated condition. *Indian Journal of Agronomy,* 44 (2): 413-415.

Subrahmaniyan, K., Arulmozhi, N. and Kalaiselven, P. 2001. Influence of plant density and NPK levels on the growth and yield of sesamum (*Sesamum indicum* L.) genotype. *Agriculture Science Digest.* 21(3): 208-209.

Sutaria G .S. Akbari K.N., Vora V .D. Hirpara D.S. Padmani D.R. 2010. Response of legume crop to enriched compost and vermicompost on vertic ustochrept under rainfed agriculture *Legume. Res.* ,33 2): 128-130.

Tandon, H. L. S. 1992. Components of integrated plant nutrition. In: Tandon , H.L.S (ed) Organic manures, recyclable wastes and bio fertilizers. Fertilizer Development and Consultation Organisation 204, Bhanot corner 1-2, pampose Enclave, New Delhi, india. 148p.

Taware, S.P., Surve, V. D., Archanapatil., Pise, P. P and Ravt, V. M. (2006). Evalvation of elite sesame (*Sesamum indicum L.*) lines for oil quality and quantitative traits. *Indian Journal of Genetics.* 66(1): 51-52.

Tewolde, H., Sistani, K. R. Rowe, D. E., Adeli, A and Boykin, D. L. 2007. Nitrogen extraction by cotton fertilized with broiler litter. *Journal of Crop Science*. 47:1131-1142.

Thakur. N. S and Rajeev, U. 2007. Integrated nutrient management in niger, *Jawaharlal Nehru Krishi Vishwa Vidyalaya Research Journal*. 41(1): 36-39.

Thanunathan, K., Imayavarambarn, V., Singaravel, R. and Kandasamy, S., 2001. Effect of fly ash on growth, yield and nutrient uptake of sesame. *Sesame & Safflower Newsletter* No. 16.

Thorave, D. S. 2006. Effect of Integrated nutrient management on growth, yield and quality of summer groundnut. A M.Sc. (Agri.) thesis submitted to M.P.K.V. Rahuri (M.S.).

Thorave, D. S. and Dhonde, M. B. 2008. Effect of integrated nutrient management on yield and nutrient uptake in summer groundnut. *J. Maharashtra Agricultural University.* 33(2): 284-285.

Tiwari, K. P and Namdeo, K. N. 1997. Response of sesamum (*Sesamum indicum* L.*)* Planting geometry and nitrogen. *Indian Journal of Agronomy*, 42(2): 365-369.

Tripathi, M. L and Rajput, R. L .2007. Response of sesame (*sesamum indicum*) genotypes to level of fertilizers. *Advances in Plant Science* 20 (2): 521-522.

Tripathy, S and Bastia, D. K., 2012. Irrigation and nutrient management for yield augmentation of sesame (*Sesamum indicum* L.). *Journal of Crop & Weed* 8(2): 53-57.

Vaiyapuri, V., Amudha, A., Sriramachandrasekharan, M. V. and Ravichandran, M. 2003. Effect of sulphur levels and organics on seed quality and nutrient uptake of sesame. *Research on Crops* 4(3): 327-330.

Vanaja, M and Raju, S. A. 2004. Residual effect of organic, bio and inorganic sources of nutrients on sunflower in rice-sunflower cropping system. *Journal of Soils and Crops.* 14(2): 237-246.

Vani, K. P and Bheemaiah, G. 2003. Efficient use of fertilizers through alley cropping and Greenleaf manuring for increased productivity of rainfed castor. *Annals of Agricultural Research.* 24(3): 598-604.

*Walkley, A and Black, C.A. 1934. An examination of determining soil organic carbon and proposed modification of the chromic acid titration method. *Soil Science*. 37: 29-34.

www.indiastat.com. 2014-15.

Yadav, R. A., Mishra, A. and Singh, D. (2007). Response of sesame cultivars under various plant spacing and seed rates. *Plant Archives,* 7 (1): 287-288.

*** Original not seen**

Note: The pattern of literature cited presented above is in accordance with the guidelines for thesis presentation for Acharya N. G. Ranga Agricultural University, Lam, Guntur, Andhra Pradesh.

Appendices

APPENDIX - I

CALENDAR OF OPERATIONS

Operations	Date
Greenmanure incorporation with rotovator as per treatments	20-12-2017
Ploughing of field with cultivator and land preparation	24-12-2017
Layout of the field experiment and bund formation	25-12-2017
FYM and PM application as per the treatments	26-12-2017
Sowing and basal application of fertilizers as per the treatments	10-1-2018
Irrigation	11-1-2018
Irrigation	20-01-2018
Gap filling	30-01-2018
Manual weeding	04-02-2018
Irrigation	10-02-2018
Manual weeding	14-2-2018
Fertilizer (urea) application as per the treatments	16-02-2018
Spaying of Monochrotophos	19-02-2018
Irrigation	25-02-2018
Spaying of Carbendazim+ Mancozeb	04-03-2018
Irrigation	12-03-2018
Harvesting of border rows	04-04-2018
Harvesting of net plot	05-04-2018
Threshing and bagging	14-04-2018

APPENDIX II

Initial and final plant population (plants m^{-2}) of sesame as influenced by plant densities and INM interventions

Treatments	Initial Plant population (m^{-2})	Final Plant population (m^{-2})
S_1F_1	22	21
S_1F_2	22	22
S_1F_3	22	20
S_1F_4	22	21
S_1F_5	22	21
S_2F_I	33	32
S_2F_2	33	31
S_2F_3	33	32
S_2F_4	33	31
S_2F_5	33	32

Plate 1. General view of the experimental plot