

Effect of Irrigation and nutrient management studies on Sesame (*Sesamum indicum* L.)

ABSTRACT

Aim:To study the effect of Irrigation and nutrient management studies on Sesame (*Sesamum indicum* L.) in red and laterite soil of Odisha.

Study design:Treatments included three irrigation levels (I_1 : 2 irrigations at 21 and 63 days after sowing, I_2 : 2 irrigations at 21 and 42 days after sowing and I_3 : 3 irrigations at 21, 42 and 63 days after sowing) are treated in main plot and four nutrient management (N_1 : 100% RDF, N_2 : 100% RDF + 2 t/ha FYM, N_3 : 100% RDF + 2 t/ha FYM + Jeevamrut @250 l/ha and N_4 : 75% RDF + 2 t/ha FYM + Jeevamrut @250 l/ha) are treated in sub plot were experimented in split plot design replicate thrice.

Place and duration of study:A field experiment was conducted during Summer at khujimahal, Chandaka, Faculty of Agricultural Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar Odisha.

Results:The results showed that highest seed yield ($643.49 \text{ kg ha}^{-1}$), haulm yield ($1820.13 \text{ kg ha}^{-1}$) and harvest index (26.04%) was obtained in I_3 . N_4 (75% RDF + 2 t/ha FYM + Jeevamrut @250 l/ha) showed second highest seed yield ($652.21 \text{ kg ha}^{-1}$), haulm yield ($1882.07 \text{ kg ha}^{-1}$) and harvest index (25.74%) which is at par with N_3 . Highest water use efficiency ($2.72 \text{ kg ha}^{-1} \text{ m}^{-1}$) was calculated in I_2N_3 .

Conclusion:cultivation of sesame under 75% RDF + 2 t/ha FYM + Jeevamrut @250 l/ha with 2 irrigations at 21 and 42 days after sowing proved better in terms of yield, economics and water use efficiency.

Keywords: Irrigation, Nutrient management, Sesame, Yield, Water use efficiency

1. INTRODUCTION

Sesame (*Sesamum indicum* L.) is generally known as til and it is called as "queen of oilseeds", has been known to the earliest edible oilseeds used by human. It is grown in wide range of environments covering semi-arid tropics, subtropics to temperate regions. It belongs to the family pedaliaceae, which consists of about 16 genera and nearly 60 species. Sesame is known variously as Till, Simsim, Beniseed, Gingelly, Gergelimetc and it is one of the most important oilseed crops grown extensively in India. Sesame stands 2nd in position, next to groundnut among the six major oilseed crops in case of production of edible oil are concerned. Its oil content varies from 46 to 52% and protein content between 20 to 26%. On an average, 70% of the sesame produced in India is used for oil extraction while, 20% for domestic uses like, culinary and confectionary purposes in manufacturing of paint perfumed oils, preparation of sweet candies as condiments, pharmaceuticals and insecticides. The fatty acid composition in sesame like, linoleic, oleic, stearic and palmitic acids are its major constituents. The sesame oil is highly resistant to oxidative rancidity and also characterized for its stability and quality. Sesame oil is also known to as "poor man's substitute for ghee". The byproduct of sesame cake obtained from milling industry is rich in protein, vitamin (Niacin) and minerals (Ca and P). The sesame cake contains 6.0-6.2% N, 2.0-2.2% P.

Despite of being such an important oilseed crop, the average productivity is quite low in comparison to global as well as national level. Generally, sesame is cultivated as sole or mixed crop during

Comment [Anon1]: Kindly reduce the text to the word count of between 3000-6000 words according to the author guidelines.

Comment [Anon2]: Kindly capitalize the initial letter of each word except linking words such as of, and

Comment [Anon3]: Include the full name of the species instead of the abbreviation in title such as

Effect of Irrigation and nutrient management studies on *Sesamum indicum* L.

The define abbreviation in introduction in text according to the format

Sesamum indicum L. (Sesame)

The use abbreviation in the text after the definition

Comment [Anon4]: Increase the aim to two sentence paragraph to give detail of the research objective.

Comment [Anon5]: Abstract should be a maximum of 200 words. Rewrite according to the journal.

Comment [Anon6]: Capitalize the initial letter of each word included in the abstract.

kharif, rabi and also in summer season in all the districts of the Odisha. Low productivity occurring is due to use of in proper rate of fertilizer, poor management and cultivation of sesame in marginal and sub-marginal lands. Mainly, poor irrigation management and deficiency of nutrient such as nitrogen, phosphorus, potassium and micronutrient is predominant. Variety, TKG-21 is suitable for summer cultivation. The major reasons for low yield of sesame in the country are its cultivation on marginal lands under dryland conditions, without proper use of fertilizers, inadequate plant stand and lack of proper water management. The scope for increasing the area under irrigation in the state is limited and in dry farming regions under rainfed condition only the practice which might contribute to production and productivity by way of better and efficient utilization of available resources and can ensure maximum conservation of soil and water.

Considering limited water supply, growing drought-tolerant crops is a useful strategy in many situations. Sesame is one of the important drought-resistant crops and suitable for cultivation in semiarid areas than other arable crops. Unlike other crops, grain filling period is the most important in determining productivity of sesame. Although the test weight is genetic characteristic, environmental stresses such as drought can cause yield loss and decrease test weight. The integration of chemical fertilizers with organic manures have been found to be quite promising not only in maintaining higher productivity but also providing greater stability in crop production (Nambiar and Abrol, 1992). A judicious combination of organic and inorganic fertilizers can maintain long term fertility and sustain higher productivity of crops. Considering the low nutrient status of soil (particularly N and P as well as organic carbon) there is need of integrated nutrient management (organic and inorganic fertilizer), in a balanced proportion than which either alone or in combination can increase and sustainable growth and yield of crops. Therefore, the present study aimed to determine the compatibility of sesame. Therefore, the present investigation entitled "Irrigation and nutrient management studies on summer sesame (*Sesamum indicum* L.)" was carried out with the objectives i.e., to compare different irrigation management on growth parameters and yield & to evaluate the performance of sesame crop under different nutrient management.

2. MATERIALS AND METHODS

A field experiment entitled "Irrigation and nutrient management studies on summer sesame (*Sesamum indicum* L.)", during Summer at khujimahal, Chandaka, Faculty of Agricultural Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar Odisha. experiment was formulated to know the performance of sesame in South east coastal plain zone of Odisha under different irrigation levels and nutrient management. The experiment was laid out in split-plot design. Number of irrigation regimes was three were taken in main plot treatment and nitrogen sources (integration) were four were taken as subplot treatment. So, for each experiment, numbers of total treatment combinations were 12 and replicated thrice. The material used and techniques adopted for collection of soil, plant samples, analytical methodologies followed and statistical methods adopted. In main plot 3 irrigation regimes are conducted i.e., I₁- 2 irrigations at 21 and 63 days after sowing I₂- 2 irrigations at 21 and 42 days after sowing and I₃-3 irrigations at 21, 42 and 63 days after sowing and in sub plot 4 doses of nutrients are applied i.e., N₁- 100% RDF, N₂- 100% RDF + 2t/ha FYM, N₃- 100% RDF + 2t/ha FYM + Jeevamrut @250l/ha, N₄- 75% RDF + 2t/ha FYM + Jeevamrut @ 250l/ha whereas RDF = 30:15:15 (N:P₂O₅:K₂O) kg ha⁻¹ is considered. To estimate the various physico-chemical properties of soil, soil samples (0-15 cm depth) were collected from different spots of the experimental field systematically in a zigzag manner from the field and bulked to form a composite sample prior to land preparation and also after harvest of the crop from each plot. The composite soils sample thus collected were air dried, sieved through 2 mm sieve and stored in polythene bag, subjected to mechanical, physical and chemical analysis for obtaining initial analysis data using standard analytical procedure. The soil type belongs to order Inceptisol, with sandy loam texture. The initial pH and EC were recorded 5.65 and 7.33 ds m⁻¹ respectively. The soil available nitrogen, phosphorus, potassium and organic carbon were found to be 137.98 kg/ha, 20.29 kg/ha, 194.16 kg/ha and 0.30% respectively. After harvesting of crop, the soil samples (0-15cm) were collected from each plot. Sampling was done with the help of spade in order to prevent contamination. The soil samples were air dried, sieved

through 2 mm sieve and stored in polythene bag for analysis of various physical and chemical property. The crop was harvested after attaining physiological maturity at 85 days after sowing. The stover from each treatment plot was harvested and sun dried. The weighed stover was recorded and expressed in kg ha⁻¹. The Samples were oven dried in hot air oven at 60° c up to constant weight or till the samples become moisture free. The over dried weight was recorded. The over dried stover and grain samples were then powdered in a grinder and stored for analysis.

3. RESULTS AND DISCUSSION

3.1. Crop growth rate:

Water management significantly affects most of the crop growth parameters. Crop growth rate (CGR) significantly responded to water management as well as different nutrient treatments differences. There is no significant difference among the treatment combination on Crop growth rate in different date's interval. Irrespective of nutrient management, I₃ produced significantly highest crop growth rate (CGR) 6.45 gm-2 day-1 followed by I₂ (6.23 gm-2 day-1) during 60 to 90 DAS and 8.12 gm-2 day-1 followed by I₂ (7.68 gm-2 day-1) during 90 DAS to maturity. In 100% RDF treated plot (N₁) found lowest CGR (5.67 gm-2 day-1) and 16.48 gm-2 day-1) during 60 to 90 DAS and 90 DAS to maturity respectively (Table 1). There is no significant difference among the treatment combination on Crop growth rate in different observation dates. From the study the positive response of sesame to application of irrigation in critical growth stages was also observed by Garai and Datta, (2002). The present result showed that improved vegetative growth due to combined application of FYM with fertilizers which is similar to the findings of Jain et al., 2000.

Table 1: Effect of irrigation and nutrient management on crop growth rate (gm⁻² day⁻¹) of summer sesame

Treatments	30-60DAS	60-90DAS	90-105 DAS(ATMATURITY)
I ₁ (2irrigationsat21and63days aftersowing)	5.60	4.93	7.20
I ₂ (2irrigationsat21and42days aftersowing)	5.77	6.23	7.68
I ₃ (3irrigationsat21,42and63daysaftersowing)	5.78	6.45	8.12
SEm(±)	0.04	3.4	0.13
CD(0.05)	1.5	1.06	0.48
N ₁ 100%RDF	5.21	5.67	6.48
N ₂ (100% RDF+ 2 t/ha FYM)	5.80	5.81	7.85
N ₃ (100%RDF+2 t/haFYM+ jeevamrut@250l/ha)	6.35	5.85	9.03

3.2. Number of Branches/plant:

The number of branches per plant of sesame crop is registered significant variations under different treatments are presented in Table 2. The branches numbers differed significantly with different nutrient management possibly due to their genetical traits. There is significant variation of number of branches count per m² in different irrigation levels. I₃ produced statistically highest number of branches per m² (4.4) at maturity, whereas, lowest was founded in I₁ (3.9). Integrated nutrient management showed non-significant variation of amount of branches/plant. The observed data showed that, there are no significant differences among the treatment combination on amount of branches/plant at different observation

Comment [Anon7]: Kindly capitalize all letters of headings.

Comment [Anon8]: Unbold the caption of tables and figures according to the journal

Comment [Anon9]: Kindly define the description of each acronym such as Irrigation treatment (I) in the introduction of the text.

Comment [Anon10]: Including these for the reader. The mention without definition in the text.

dates. Number of branches/plants differed significantly due to change in irrigation levels was also reported by Bhatti et al. (2014). The number of branches is found highest in combined application of inorganic and organic fertilizers Sahu et al., (2017). This similar result also observed in present research work.

Table 2: Effects of irrigation and nutrient management on number of Branches/plant of summer sesame

Treatments	60DAS	90DAS	105DAS(AT MATURITY)
I ₁ (2irrigationsat21and63days aftersowing)	3.7	3.8	3.9
I ₂ (2irrigationsat21and42days aftersowing)	3.9	4.2	4.2
I ₃ (3irrigationsat21,42and63daysaftersowing)	4.1	4.2	4.4
SEm(±)	0.1	0.1	0.1
CD(0.05)	0.3	0.4	0.4
N₁100%RDF	3.6	3.7	3.9
N₂(100% RDF+ 2 t/ha FYM)	3.9	4.0	4.1
N₃(100%RDF+2 t/haFYM+ jeevamrut@250l/ha)	4.2	4.3	4.4
N₄(75%RDF+2 t/haFYM + jeevamrut@250l/ha)	4.0	4.2	4.3
SEm(±)	0.1	0.1	0.1
CD(0.05)	0.2	0.3	0.4

3.3. Yield attributing characters:

Number of capsules per plant, test weight (1000 grain weight) etc. collectively shapes up the grain yield of sesame crop. Recorded data of capsules per plant, capsule length, no of seeds/capsule and test weight under different treatments have been furnished in Table 2 and Table 3. Number of capsules/plant (42.2), capsule length (2.9 cm), number of seeds/capsule (54) and test weight (3.45 g) counted to be highest in I₃ regimes. Among different nutrient management, 100% RDF + 2 t/ha + Jeevamrut @250 l/ha (N₃) produced maximum number of capsule/plant (41.4) and number of seeds/capsule (53) represented in Table 2. There is no significant difference on length of capsule, number of seeds/capsule and test weight under different treatments combination at 105 DAS (maturity).

The significant difference of number of seeds/capsules among the different nutrient management found highest in N₃ (53) followed by N₄ (51) whereas, significantly least number of seed/capsules recorded in N₁ (48) (Table 2). Test weight counted to be highest in I₃ treatment (3.45 g) and lowest in I₁ treatment (3.27 g). Tabulated result reflected that the significant difference of amount of capsules/plant among the treatment combination at maturity stage. The observation proved that different nutrient management at different irrigation regimes i.e. (I₃N₃) produced highest number of capsules/plant (44.3) and lowest number is found in I₁N₁ (34) (Table 4). Sahu et al., (2017) observed that the number of capsules/plants is found highest in combined application of inorganic and organic fertilizers. This result is in concurrent with present study. The number of capsules per plant and 1000 seed weight increased as irrigation frequency and

nitrogen fertilizer rates were increased. Our result is also similar to the findings of Mondal et al, 1997. The beneficial effect of nitrogen on test weight of sesame was also observed by Malik et al. (2003). Ghosh and Biswas (1984) observed that the crop receiving irrigation both at branching and flowering stages benefited more from applied water in terms of yield and yield attributes. My results are in agreement with this finding.

Table3: Effect of irrigation and nutrient management on number of capsules/plants, length of capsule (cm), number of seeds/capsule and test weight (g) of summer sesame

Treatments	Number of capsules/plant	Length of capsule (cm)	Number of seeds/capsule	Test weight (g)
I ₁ (2 irrigations at 21 and 63 days after sowing)	36.1	2.6	47	3.27
I ₂ (2 irrigations at 21 and 42 days after sowing)	40.1	2.8	51	3.37
I ₃ (3 irrigations at 21, 42 and 63 days after sowing)	42.2	2.9	54	3.45
SEm(±)	0.9	0.03	1.3	0.02
CD(0.05)	2.8	0.2	4.0	0.05
N ₁ 100% RDF	37.6	2.7	48	3.27
N ₂ (100% RDF + 2 t/ha FYM)	39.5	2.7	50	3.34
N ₃ (100% RDF + 2 t/ha FYM + jeevamrut @ 250l/ha)	41.4	2.8	53	3.45
N ₄ (75% RDF + 2 t/ha FYM + jeevamrut @ 250l/ha)	39.4	2.8	51	3.39
SEm(±)	0.4	0.1	0.9	0.09
CD(0.05)	1.3	0.4	2.8	0.36

Table 4: Interaction effects of irrigation and nutrient management on amount of capsules/plant of summer sesame

Irrigation	Nutrient management				Mean
	N ₁	N ₂	N ₃	N ₄	
I ₁	34.0	37.0	37.3	36.1	36.11
I ₂	38.3	39.7	42.4	40.0	40.12
I ₃	40.6	41.9	44.3	42.1	42.22
Mean	36.1	39.5	41.4	39.4	

CD (P=0.05) Irrigation at the same nutrient management =

2.4 Nutrient management at same irrigation = 2.1

3.4 Yield:

Results revealed significant differences in seed yield due to the different water management treatments (Table 4) where the lowest seed yield (597.33 kg ha⁻¹) were recorded for I₁ regimes. 3 irrigations at 21, 42 and 63 days after sowing (I₃) resulted the highest seed yield of 643.49 kg ha⁻¹ followed by I₂ (629.84 kg ha⁻¹). The maximum amount of seed yield in I₃ may be due to producing maximum number of capsule per plant on account of higher availability of water. Irrespective of irrigation levels, in different nutrient management, 100% RDF + 2 t/ha FYM + Jeevamrut @250 l/ha (N₃) produced highest yield (652.21 kg ha⁻¹) followed by N₄ (632.99 kg ha⁻¹) whereas, 100% RDF (N₁) gave significantly lowest seed yield (591.94 kg ha⁻¹).

From the result it was found that, application of three numbers of irrigations at branching, flowering and seed development stages increased yield attributing characters and yield of summer sesame crop. The same was reported by Dutta et al., 2000. Choradia and Gaur, (1986) reported that under limited water supply, higher yield can be obtained by proper irrigation scheduling which is in concurrent with it present result. The increase in growth and yield of sesame by irrigation could be attributed to the fact that timely supply of adequate water to plants results in greater photosynthesis which ultimately leads to increased dry-matter production (Kirkham, 2005). T. Oweis, H. Zhang, and P. Mustafa, 2000 also observed that the amount of irrigation water applied significantly affected the seed yield of sesame.

Significantly highest seed yield recorded in I₃N₃ treatment (676.5 kg ha⁻¹) followed by I₂N₃ (654.6 kg ha⁻¹) and I₃N₄ (654.2 kg ha⁻¹) and lowest in I₁N₁ treatment (570.00 kg ha⁻¹) (Table 4). Data from table 4 showed that, the higher haulm yield was found in I₃ (1828.13 kg ha⁻¹) followed by I₂ (1794.27 kg ha⁻¹). The observed data also showed that, haulm yield differs with variation of nutrient management. It is recorded highest in N₃ (1882.07 kg ha⁻¹) followed by N₄ (1878.82 kg ha⁻¹). Haulm yield recorded in I₃N₃ treatment (1930.6 kg ha⁻¹) (Table 5).

Haulm yield preferably increased with integrated nutrient management with fertilizer + FYM + Jeevamrut was also reported by Raman and Suganya, 2018.

Harvest Index was founded to be highest in I₃ regimes. The observation proved that difference nutrient management at different irrigation treatments i.e., (I₃) produced highest harvest index (26.04%) followed by I₂ (25.98%). Irrespective of irrigation levels, highest harvest index was calculated in N₃ (25.74%) followed by N₄ (25.20%). There is no significant difference among the treatment combination on harvest index. Higher yield obtained in increased irrigation are associated with higher harvest index found by Lin et al., 2007.

Table 5: Effect of irrigation and nutrient management on seed yield (kg ha⁻¹), haulm yield (kg ha⁻¹) and harvest index (%) of summer sesame

Treatments	Seed yield(kg ha ⁻¹)	Haulm yield(kg ha ⁻¹)	Harvest index(%)
I ₁ (2irrigationsat21and63days aftersowing)	597.33	1775.19	25.18
I ₂ (2irrigationsat21and42days aftersowing)	629.84	1794.27	25.98
I ₃ (3irrigationsat21,42and63daysaftersowing)	643.49	1828.13	26.04
SEm(±)	3.84	7.42	0.04

CD(0.05)	15.03	29.45	0.15
N₁ 100%RDF	591.94	1786.71	24.89
N₂ (100% RDF+ 2 t/ha FYM)	617.08	1837.85	25.14
N₃ (100%RDF+2 t/haFYM+ jeevamrut@250l/ha)	652.21	1882.07	25.74
N₄ (75%RDF+2 t/haFYM + jeevamrut@250l/ha)	632.99	1878.82	25.20
SEm(±)	6.16	6.46	0.15
CD(0.05)	24.66	25.30	0.56

Table6: Interaction effects of irrigation and nutrient management on seed yield (kg ha⁻¹) on summer sesame

Irrigation	Nutrient management				Mean
	N₁	N₂	N₃	N₄	
I₁	570.00	586.7	625.6	607.1	597.34
I₂	598.96	628.1	654.6	637.7	629.85
I₃	606.88	636.5	676.5	654.2	643.49
Mean	591.9	617.1	652.2	633.0	

CD (P=0.05) Irrigation at the same nutrient management =

28.7 Nutrient management at same irrigation =24.2

Table7: Interaction effects of irrigation and nutrient management on haulmy yield (kg ha⁻¹) of summer sesame

Irrigation	Nutrient management				Mean
	N₁	N₂	N₃	N₄	
I₁	1732.00	1752.1	1820.8	1795.8	1775.19
I₂	1808.33	1880.2	1919.8	1903.1	1877.87
I₃	1819.79	1881.3	1930.6	1912.5	1886.04
Mean	1786.7	1837.8	1890.4	1870.5	

CD (P=0.05)

Irrigation at the same nutrient management=22.7

Nutrient management at same irrigation =9.5

4.2.3. Oil content:

Oil content under different irrigation levels and nutrient management are represented in Table 8. I₃ resulted the statistically highest oil content of 51.44% and lowest oil content was found in I₁ (46.05%). Among the different nutrient management, in 100% RDF + 2 t/ha FYM + Jeevamrut @250 l/ha (N₃) found the highest oil

content 50.04% (Table 8). There is no significant difference among the treatment combination on oil content. Oil content differences among the irrigation levels may be due to water stress was also reported by Boydak *et al.*, 2007. Increased oil content and oil yield may be due to application of nitrogen was also reported by Das and Das, (1995).

Table 8: Effect of irrigation and nutrient management on oil content (%) of summer sesame

Treatments	Oil content (%)
I ₁ (2 irrigations at 21 and 63 days after sowing)	46.05
I ₂ (2 irrigations at 21 and 42 days after sowing)	47.99
I ₃ (3 irrigations at 21, 42 and 63 days after sowing)	51.44
SEm (±)	0.5
CD (0.05)	2.04
N1 (100% RDF)	46.69
N2 (100% RDF + 2 t/ha FYM)	48.01
N3 (100% RDF + 2 t/ha FYM + jeevamrut @ 250 l/ha)	50.04
N4 (75% RDF + 2 t/ha FYM + jeevamrut @ 250 l/ha)	49.24
SEm (±)	0.8
CD (0.05)	3.1

4.3. Water use efficiency:

Crop water production functions describe the relationship of seed yield (Y) response to varying levels of water input and can be useful for various water management applications. Improving agricultural water use efficiency (WUE) is essential because of the demand for increased grain production in India. The results revealed significant difference in seed yield due to the different water management treatments (Figure 1). The lowest WUE was recorded for I₃N₁ (2.02 kg ha⁻¹ mm⁻¹). Because, there was not much yield increment with the increase application of water. Treatment I₂N₃ produced highest WUE of 2.72 kg ha⁻¹ mm⁻¹ followed by I₂N₄ (2.65 kg ha⁻¹ mm⁻¹).

Research studies show that the practice of limiting water applications to drought-sensitive growth stages aims at maximizing water productivity and stabilizing, rather than maximizing, yields which is supported by S. Geerts and D. Raes, (2009). Ucan, 2007 suggested that the WUE increases with irrigation amount, and water-saving techniques such as deficit level have been improved water use efficiency (WUE) with minimum yield reduction. The same trend was observed in this present study. The increase or decrease in seed yield due to different nutrient management practices in summer sesame commensurate with the corresponding water use by the crop resulting in similar trend in water use efficiency of the crop to its consumptive use of water. This is also established by Dutta *et al.*, 2000.

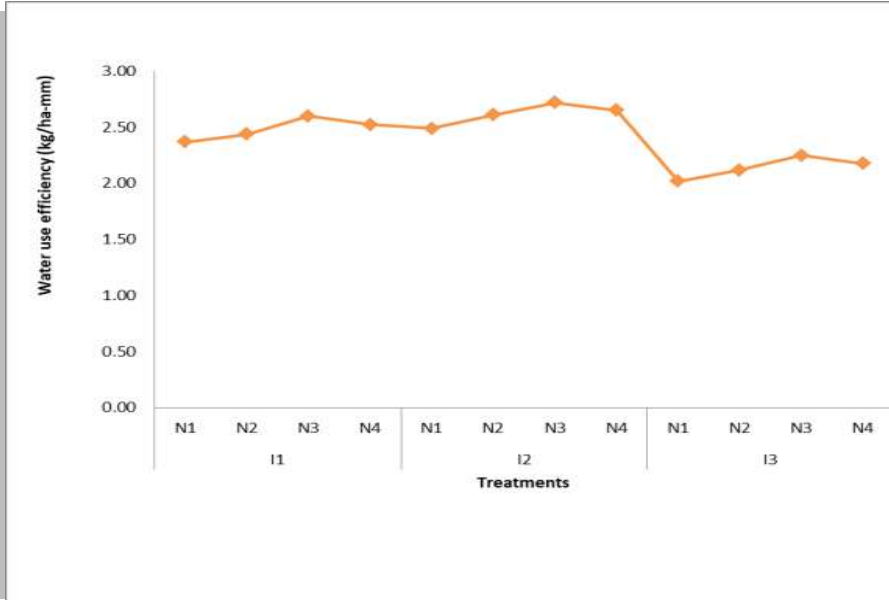


Fig. 1: Effects of irrigation and nutrient management on water use efficiency (kg ha⁻¹ mm⁻¹) of summer sesame.

Comment [Anon11]: Bold the figure heading.

4.4. Nutrient uptake

4.4.1 Nitrogen:

Total nitrogen content (%) in seed and haulm was obtained to be highest in I₃ treatment. The observation proved that I₃ produced highest nitrogen content in seed (3.34%) and in haulm (1.03%) whereas, in I₁ found lowest nitrogen content (2.91%) followed by I₂ treatment (2.91%). Total nitrogen content was found to be highest in N₃ treatment. The observation proved that (N₃) produced highest nitrogen content (3.15%) whereas in N₁ lowest nitrogen content (2.97%) observed (Table 9).

Likewise nitrogen content, total nitrogen uptake (kg ha⁻¹) by seed and haulm was observed to be highest in I₃ treatment. The observation proved that I₃ produced highest nitrogen uptake by seed (21.51 kg ha⁻¹) and by haulm (19.34 kg ha⁻¹) whereas, I₁ showed the lowest nitrogen uptake by seed (17.34 kg ha⁻¹) and by haulm (17.62 kg ha⁻¹). Total nitrogen uptake was found to be highest in N₃ treatment. The observation proved that 100% RDF + 2t/ha FYM + Jeevamrut @ 250l/ha produced highest nitrogen uptake by seed (20.56 kg ha⁻¹) and by haulm (19.29 kg ha⁻¹) whereas, (N₁) produced lowest nitrogen uptake by seed (17.57 kg ha⁻¹) and by haulm (17.45 kg ha⁻¹) (Table 10).

An excessive N rate or an inadequate amount of N application could increase N content in seeds. Our result is also similar with the finding of Chamorro *et al.*, 2002.

4.4.2 Phosphorus:

Total phosphorus content (%) in seed and haulm was analyzed and presented in Table 11. It was observed that 3 irrigations at 21, 42 and 63 days after sowing showed highest phosphorus content (%) in seed (2.25%) and in haulm (0.27%) whereas in I₁ found lowest phosphorus content in seed (2.08%) and in haulm (0.22%). Total phosphorus content (%) was found to be highest in N₃ treatment. The observation proved that 100% RDF+2t/ha FYM+Jeevamrut@250l/ha produced highest phosphorus content in seed (2.17%) and in haulm (0.25%) The lowest phosphorus content was found in seed (2.08%) and in haulm (0.22%) in N₁.

Table 11 represented the total phosphorus uptake (kg ha⁻¹) by seed and haulm. The highest phosphorus uptake by seed (14.46 kg ha⁻¹) and by haulm (5.00 kg ha⁻¹) whereas, (I₁) produced lowest phosphorus uptake by seed (12.40 kg ha⁻¹) and by haulm (3.86 kg ha⁻¹). Total phosphorus content was found highest in 100% RDF+2t/ha FYM+Jeevamrut@250l/ha application in both seed (10.12 kg ha⁻¹) and haulm (2.95 kg ha⁻¹). The increases with irrigation frequency lead to higher phosphorus uptake due to the higher average moisture content in root zone of the crop. This result is in concurrent with Xu *et al.*, 2004.

4.4.3 Potassium:

Analyzed data of seed and haulm showed highest potassium content in I₃ (0.94%) and (1.18%). Irrespective of irrigation levels, N₃ (0.92%) in seed and (1.17%) in haulm found significantly highest potassium content.

Potassium uptake by both seed (6.04 kg ha⁻¹) and haulm (22.31 kg ha⁻¹) found highest in I₃. 100% RDF+2t/ha FYM+Jeevamrut@250l/ha showed highest potassium uptake by seed (6.03 kg ha⁻¹) and haulm (22.19 kg ha⁻¹) (Table 11).

Uptake of N, P and K was the highest when the crop was irrigated with appropriate quantity water. The uptake pattern mostly followed the biomass yield trend due to different irrigation regimes, (Dutta *et al.*, 2000). Uptake of nutrients by the plants was more efficient with the integrated use of inorganic and organic fertilization than that of using all organic sources alone. Beneficial effects of FYM have also been advocated by Deshmukh (2003), Mishra (2010) and Maravi (2010).

Table 9: Effect of irrigation and nutrient management on NPK content (%) in seed and haulm of summer sesame

Treatments	NPK content in seed			NPK content in haulm		
	N content (%)	P content (%)	K content (%)	N content (%)	P content (%)	K content (%)
I ₁ (2 irrigations at 21 and 63 days after sowing)	2.91	2.08	0.88	0.99	0.22	1.14
I ₂ (2 irrigations at 21 and 42 days after sowing)	2.91	2.07	0.88	0.98	0.22	1.14
I ₃ (3 irrigations at 21, 42 and 63 days after sowing)	3.34	2.25	0.94	1.03	0.27	1.18
SEm(±)	0.04	0.02	0.02	0.01	0.02	0.01
CD(0.05)	0.12	0.06	0.06	0.02	0.05	0.02

N₁ (100%RDF)	2.97	2.08	0.88	0.98	0.22	1.13
N₂ (100% RDF+ 2t/ha FYM)	3.11	2.13	0.91	1.01	0.24	1.16
N₃ (100%RDF+2 t/ha FYM+jeevamrut@250l/ha)	3.15	2.17	0.92	1.02	0.25	1.17
N₄ (75%RDF+2 t/ha FYM+jeevamrut@250l/ha)	2.98	2.15	0.89	0.99	0.23	1.15
SEm(±)	0.05	0.03	0.02	0	0	0.01
CD(0.05)	0.15	0.9	0.05	0.01	0.01	0.02

Table 10: Effect of irrigation and nutrient management on NPK uptake (kg ha^{-1}) by seed and haulm on summer sesame

Treatments	NPK uptake by seed			NPK uptake by haulm		
	N uptake(kg ha^{-1})	P uptake(kg ha^{-1})	K uptake(kg ha^{-1})	N uptake(kg ha^{-1})	P uptake(kg ha^{-1})	K uptake(kg ha^{-1})
I₁ (2irrigations at 21 and 63 days after sowing)	17.34	12.40	5.27	17.62	3.86	20.15
I₂ (2irrigations at 21 and 42 days after sowing)	18.35	13.06	5.56	18.41	4.09	21.41
I₃ (3irrigations at 21, 42 and 63 days after sowing)	21.51	14.46	6.04	19.34	5.00	22.31
SEm(±)	0.6	0.4	0.3	0.4	0.2	0.3
CD(0.05)	1.8	1.3	1	1.1	0.5	0.8
N₁ (100%RDF)	17.57	12.30	5.21	17.45	3.88	20.14
N₂ (100% RDF+ 2t/ha FYM)	19.21	13.13	5.62	18.50	4.42	21.26
N₃ (100%RDF+2 t/ha FYM+jeevamrut@250l/ha)	20.56	14.15	6.03	19.29	4.67	22.19
N₄ (75%RDF+2 t/ha FYM+jeevamrut@250l/ha)	18.92	13.64	5.64	18.59	4.31	21.58
SEm(±)	0.4	0.3	0.1	0.4	0.2	0.2
CD(0.05)	1.2	0.9	0.2	1.1	0.5	0.6

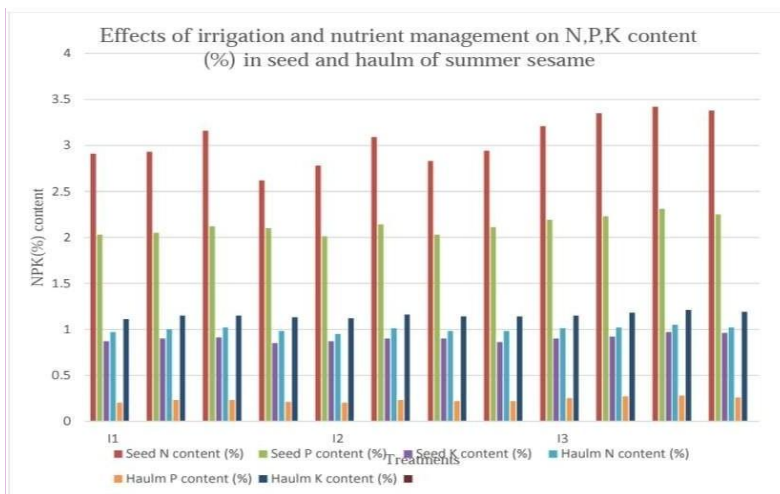


Fig. 2 : Effects of irrigation and nutrient management on NPKcontent(%) of summer sesame

Comment [Anon12]: No need to include figure title. This is mentioned in the figure caption. If you have the source files recorrect.

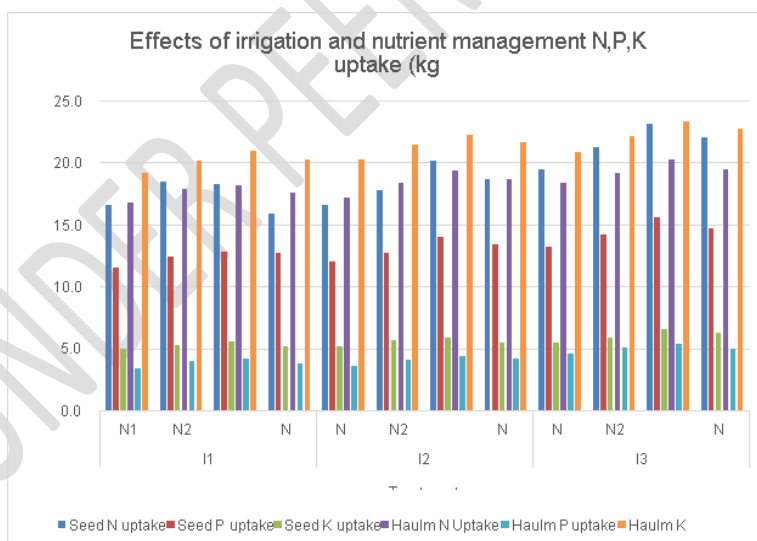


Fig. 3 : Effects of irrigation and nutrient management on NPKuptake(kgha⁻¹)of summer sesame

Comment [Anon13]: Use the same format for all the figures and tables.

4.5. Cost of cultivation:

The cost of cultivation, gross return, net return and benefit: cost ratio are represented in Table 11. Highest net return (Rs.19966.00 /-) as well as benefit cost ratio(1.68) calculated in (I₃N₃). Though the treatment I₂N₃ found same benefit cost ratio(1.68) but the second highest net return (Rs.19269.00 /-) obtained from this treatment. The lowest net return (Rs.15251.00/-) as well as benefit cost ratio (1.55) calculated in treatment I₁N₂.

Table 11: Cost of cultivation of summer sesame influenced by irrigation and nutrient management

Treatments	Cost of cultivation (Rs./-)	Gross return (Rs./-)	Net return (Rs./-)	B:Cratio
I ₁ N ₁	26175.00	41610.00	15435.00	1.59
I ₁ N ₂	27575.00	42826.00	15251.00	1.55
I ₁ N ₃	28515.00	45667.00	17152.00	1.60
I ₁ N ₄	27895.00	44317.00	16422.00	1.59
I ₂ N ₁	26175.00	43723.00	17548.00	1.67
I ₂ N ₂	27575.00	45853.00	18278.00	1.66
I ₂ N ₃	28515.00	47784.00	19269.00	1.68
I ₂ N ₄	27895.00	46552.00	18657.00	1.67
I ₃ N ₁	27075.00	44301.00	17226.00	1.64
I ₃ N ₂	28475.00	46461.00	17986.00	1.63
I ₃ N ₃	29415.00	49381.00	19966.00	1.68
I ₃ N ₄	28795.00	47754.00	18959.00	1.66

4. CONCLUSION

From the experiment, it is concluded that the application of 2 irrigations at 21 and 42 days after sowing produced significantly higher yield (629.84 kg ha⁻¹) compared to highest in 3 irrigations at 21, 42 and 63 days after sowing (643.49 kg ha⁻¹). 75% RDF, 2 t/ha FYM and Jeevamrut @250 l/ha recorded significantly higher yield (632.99 kg ha⁻¹) comparison with 100% RDF, 2 t/ha FYM and Jeevamrut @250 l/ha (652.21 kg ha⁻¹). It is further inferred that the summer sesame recorded significantly higher seed yield (676.5 kg ha⁻¹), net return (Rs. 19966.00/- /ha) and benefit : cost ratio (1.68) in 3 irrigations at 21, 42 and 63 days after sowing with 100% RDF, 2 t/ha FYM and Jeevamrut @250 l/ha application. However, significantly no

yield loss occurred in 2 irrigations at 21 and 42 days after sowing with 75% RDF, 2 t/ha FYM and Jeevamrut @250 l/ha application (654.2 kg ha⁻¹) and highest water use efficiency calculated (2.72 kg ha⁻¹ mm⁻¹) in 2 irrigations at 21 and 42 days after sowing with 100% RDF, 2 t/ha FYM and Jeevamrut @250 l/ha application.

REFERENCES

Abbate PE, Dardanelli JL, Maturano MGM., Melchiori RJM. and Suero EE. 2004. "Climatic and water availability effects on water use efficiency in wheat", *Crop Science*, 4(2):474–483.

Adeyemo MO, Ojo AO and Gungula DT. 1992. Effects of plant population density on some agronomic traits and seed yield of sesame (*Sesamum indicum* L.) in a Southern Guinea savannah environment, *Tropical Oilseeds Journal*, 1(1): 35-42.

Anonymous, 2006. Package of Organic Practices for Brinjal, Rice, Sesame and Taro.

Development Research Communication and Services Centre.

Anonymous, 2014. Status Paper on Oilseeds, Oilseeds Division, Department of Agriculture and Cooperation Ministry of Agriculture, Govt. of India.

Anonymous. 2007. Economic Intelligence Service (Centre for Monitoring Indian Economy).

Boydak E, Karaaslan D, Simsek M, Gercek S, Kirnak H, Kasap Y and Ozturk I. 2007. Effects of irrigation methods and irrigation intervals on yield and some yield components of sesame growing in semi-arid area, *Journal of Agronomy*, 6(3) : 439-443.

Cakir R. 2004. Effect of water stress at different development stages on vegetative and reproductive growth of corn, *Field Crops Research*, 89 (1): 1–16.

Carlsson A, Linder A, Svensson MY, Davidsson J, Schick S, Horion S and Hell W. 2008. Female volunteer motion in rear impact sled tests in comparison to results from earlier male volunteer tests. In 2008 Int. IRCOBI Conference on the Biomechanics of Injury, Bern, Switzerland, 17-19 September through: 461-464.

Chamorro AM, Tamagno LN, Bezus R and Sarandon SJ. 2002. Nitrogen accumulation, partition, and nitrogen-use efficiency in canola under different nitrogen availabilities. *Communication of Soil Science and Plant Analysis*, 33:493-504.

Chaubey AK, Kaushik MK and Singh S.B. 2003. Response of sesame (*Sesamum indicum*) to nitrogen and sulphur in light – textured entisol, *New Agriculturist*, 14: 61–64.

Cheema MA, Malik MA, Hussain A, Shah SH and Basra SMA. 2001. Effects of time and rate of nitrogen and phosphorus application on the growth and seed and oil yields of canola (*Brassica napus* L.), *Journal of Agricultural Crop Science*, 186:103-110.

Choradia RK and Gaur BL. 1986. Effect of irrigation and mulch on seed yield of sunflower. *Indian Journal of Agronomy*, 31(3): 298- 299.

Das KN and Das K. 1995. Effect of sulphur and nitrogen fertilizer on growth and yield of toria (*Brassica campestris* sub sp. *oleifera* var. *toria*), *Indian Journal of Agronomy*, 40: 329-331

Comment [Anon14]: Kindly include the declarations after the conclusion before the references. This can be found in the author guidelines
<https://peerreviewcentral.com/page/general-guideline-for-authors>

Acknowledgments

Competing Interests

AUTHORS' CONTRIBUTIONS

CONSENT (WHERE EVER APPLICABLE)

ETHICAL APPROVAL (WHERE EVER APPLICABLE)

Comment [Anon15]: Kindly number all literature and include citation in the introduction.

De P, Majumdar DK and De GC. 2002. Studies on the effect of irrigation and intercropping of summer sesame and mung in the lateritic belt of West Bengal, *Journal of Interacad.*, 6: 272-79.

Deshmukh MR, Jain HC, Duhoon SS and Goswami U. 2002b. Integrated nutrient management in sesame (*Sesamum indicum* L.) for Kymore plateau zone of Madhya Pradesh, *Journal of Oilseeds Research*, 19(1):73-75.

Dotaniya CK, Niranjana RK, Kumar U, Dotaniya RK, Mohbe S, Khandagle A and Jadon Priyanka. 2019. Quality, Yield and Nutrient Uptake of Fenugreek as influenced by Integrated Nutrient Management, *International Journal of Plant & Soil Science*, 29(3): 1-7.

Dotaniya ML, Sharma MM, Kumar K and Singh PP. 2013. Impact of Crop Residue Management on nutrient balance in rice-wheat cropping system in an Aquic hapludoll, *The Journal Rural Agricultural Research*, 13:122-123.

Dutta D, Jana PK, Bandyopadhyay P and Maity D. 2000. Response of summer sesame (*Sesamum indicum* L.) to irrigation. *Indian Journal of Agronomy*, 45(3): 613– 616.

FAO. 2013. FAOSTAT database, Food and Agriculture Organization of the United Nation, Rome, Italy.

FAOSTAT F. 2008. Agricultural Organization.

FAOSTAT. 2011. and FAO Statistics Division 2011, Sesame seed. In: Food and Agriculture Organization of The United Nation.

Fereres E and Soriano MA. 2007. "Deficit irrigation for reducing agricultural water use", *Journal of experimental botany*, 58(2):147–159,.

Filho JGM, Araujo CV, Borrego AG, Cook A, Flores D, Hackley P, Hower JC, Kern ML, Kommeren K, Kus J, Mastalerz M, Mendonca JO, Menezes TR, Newman J, Ranasinghe P, Souza IV, Suarez-Ruiz I and Ujjiie Y. 2010. Effects of concentration of dispersed organic matter on optical maturity parameters : Interlaboratory results of the organic matter concentration working group of the ICCP, *International Journal of Coal Geology*, 84 (3-4) : 154-165.

Frederick JR, Wooly JT, Hesketh JD and Peters DB. 1991. "Seed yield and agronomic traits of old and modern soybean cultivars under irrigation and soil water deficit," *Field Crops Research*, 27(1-2):71–82.

Garai AK. and Datta JK. 2002. Effect of different moisture regimes and growth retardants on consumptive use and water use efficiency in summer sesame, *Agricultural Science Digest*, 22: 96-98.

Geerts S and Raes D. 2009. "Deficit irrigation as an on-farm strategy to maximize crop water productivity in dry areas", *Agricultural water management*, 96(9):1275– 1284,.

Ghosh DC and Biswas SK. 1984. Influence of irrigation and straw mulch on the growth and yield of sesame grown in summer season, *Indian Agriculturist*, 28(4) : 275- 280.

Golestani M and Pakniyat H. 2015. "Evaluation of traits related to drought stress in sesame (*Sesamum indicum* L.) Genotypes", *Journal of Asian Scientific Research*, 5(9): 465–472,.

Gopinath KA, Venkateswarlu B, Venkateswarlu S, Srinivasa Rao CS, Palloli SS, Yadav SK. and Prasad YG. 2011. Effect of organic management on agronomic and economic performance of sesame and on soil properties. *Indian Journal of Dryland Agril. Research and Development*, 26: 16-20

Heidari M, Galavi M and Hassani M. 2011. Effect of sulfur and iron fertilizers on yield, yield components and nutrient uptake in sesame (*Sesamum indicum* L.) under water stress, *African Journal of Biotechnology*, 10(44): 8816-8822.

Imayavaramban V, Thanunathan K, Singaravel R and Manickam G. 2002. Studies on the influence of integrated nutrient management on growth, yield parameters and seed yield of sesame (*Sesamum indicum* L.). *Crop Research*. 24(2): 309-313.

Jain HC, Deshmukh MR, Goswami U and Hegde DM. 2000. Response of sesame to NPK, Mg and Zn with or without organic manure in different soil types, *Journal of Oilseeds Research*, 17: 66-69

Jaishankar S and Wahab K. 2005. Effect of integrated nutrient management on the growth, yield components and yield of sesame. *Sesame and Safflower Newsletter*, 20 : 732.

Latif S. and Anwar F. 2011. Aqueous enzymatic sesame oil and protein extraction, *Food Chemistry*, 125(2): 679-684.

Lin L, Xu BC and Li FM. 2007. Effects of limited irrigation on yield and water use efficiency of two sequencereplaced winter wheat, *African Journal of Biotechnology*, 6 (13): 1493-1497.

Lokanath HM, Parameshwarappa KG. 2006. Effect of organics on the productivity of Spanish bunch groundnut under rainfed farming situation. In proceeding of 18th world congress of Soil Science, Philadelphia, Pannsylvania, USA, 62-63.

Majumdar S.K, Barik, K.C., Bera, P.S. and Ghosh, D.C. 1978. Growth and yield of sesame (*Sesamum indicum* L.) as influenced by N and K nutrition. *Fertilizer News*, 33(3): 41- 43.

Malik, M.A., Saleem MF, Cheema MA and Ahmed Shamim. 2003. Influence of different nitrogen levels on productivity of sesame (*S. indicum* L.) under varying patterns, *International Journal of Agricultural and Biology*, 5(4) : 490-492.

Mandal SS, Das SK, Goswami SB, Pradhan BK. 1990. Yield and yield attributes of sesame as influenced by potassium nutrition and plant density, *Indian Agriculture*, 34 : 99-102.

Maravi Preeti . 2010. Development of organic nutrient management for sesame (*Sesamum indicum* L.) M.Sc. (Ag.)Thesis (Unpublished), JNKVV. Jabalpur, 84.

Mishra, P. 2010. Effect of nutrient management on growth and yield of sesame (*Sesamum indicum* L.), M.Sc.(Ag.)Thesis (Unpublished), JNKVV. Jabalpur, 76.

Mohbe S, Dotaniya CK, Reager ML and Dautaniya RK. 2019. Effect of organic manures on productivity of green gram (*Phaseolus radiata* L.) under rainfed condition, XXI Biennial National Symposium of Indian Society of Agronomy, 24-26 October, 2018 at MPUAT, Udaipur, Rajasthan, 520- 521.

Molden D. 1997. Accounting for Water Use and Productivity. SWMI Paper, International Water Management Institute, Colombo.

Molden D.1997. Accounting for Water Use and Productivity, IWMI, Colombo, Sri Lanka, 1

- Mondal SS, Verma D and Kulia S. 1992. Effect of organic and inorganic sources of nutrients on growth and seed yield of sesame (*Sesamum indicum* L.). *Indian Journal of Agricultural Science*, 62(4):258-262.
- Morris JB, Janick J and Whipkey A. 2002. "Food, industrial, nutraceutical, and pharmaceutical uses of sesame genetic resources," in *Trends in New Crops and New Uses*, Arlington, VA, ASHS, 153–156.
- Nambiar KKM. and Abrol IP. 1992. Long term fertilizer experiments in India-An Overview. *Fertilizer News*, 34 (4):11- 26
- Narang RS and Gill MS. 1998. Irrigation scheduling for higher WUE in oilseed and pulses. *Fertilizer News*, 43(3): 57- 67.
- Olewe VIO, Busari LD. 2007. Appropriate plant population and spacing for sesame (*Sesamum indicum* L.) in the southern Guinea Savanna of Nigeria, *Tropical Oil Seeds Journal*, 2: 18-27
- Onsaard E, Pomsamud P and Audtum P. 2010. Functional properties of sesame protein concentrates from sesame meal, *Asian Journal of Food and AgroIndustry*, 3(4): 420-431.
- Oweis T, Zhang H and Mustafa P. 2000. Water use efficiency of rain fed and irrigated bread wheat in a Mediterranean environment, *Agronomy Journal*, 92(2): 231– 238.
- Oweis T. November 1994. "Supplemental irrigation: an option for improved water use efficiency," in *Proceedings of Regional Seminar on the Optimization of Irrigation in Agriculture*, 21–24.
- Patil BV, NT. Shishode and Dahipale VV. 1992. Effect of different sowing date on growth and yield of sesame, *Journal of Maharashtra Agriculture*, 17: 349-350.
- Perin A, Cruvinel DJ, Silva JW. 2010. Sesame performance in function of NPK fertilizer and levels of soil fertility, *ActaScientiarum Agronomy*, 32: 93-98.
- Purushottam G. 2005. Integrated nutrient management in sesame (*Sesamum indicum* L.) and its residual effect on succeeding chickpea (*Cicer arietinum* L.), M.Sc.(Ag.) in Agronomy Thesis submitted to the University of Agricultural Sciences, Dharwad, Karnataka.
- Rahmato D. June 1999. *Water Resources Development in Ethiopia: Issues of Sustainability"s and Participation*, Forum for Social Studies, Addis Ababa, Ethiopia.
- Rahnama A, Bakhshandeh A. 2006. Determination of Optimum RowSpacing and Plant Density for Uni-branched Sesame in Khuzestan Province, *Journal of Agricultural Science and Technology*, 8: (25-33)
- Raman R and Suganya K. 2018. Effects of integrated nutrient management on the growth and yield of hybrid rice, *Journal of Agricultural Research*, 3(2): 156-159.
- Rathke GW, Christen O, Diepenbrock W, 2005. Effects of nitrogen source and rate on productivity and quality of winter oilseed rape (*Brassica napus* L.) grown in different crop rotations , *Field crops research*, 94(2-3): 103-113.
- Reddy BN and Sudhakarababu SN. 1996. Production potential and utilization and economics of fertilizer management in summer sunflower based crop, *Indian Journal of Agricultural Science*, 66:16–19,
- Roa V and Raju C. 1991. "Effect of soil moisture stress at different development phases on growth and yield of sesame", *Journal of Oilseeds Research*, 8(2):240–243.

Roy N, Abdullah Mamun SM and Sarwar Jahan MD. 2009. Yield performance of sesame (*Sesamum indicum* L.) varieties at varying levels of row spacing, *Research Journal of Agriculture and Biological Sciences*, 5(5): 823-827.

Sahu G, Chatterjee N, Bera M, Ghosh GK, Mondal S, Biwas PK and Kundu MC. 2017. Integrated nutrient management in sesame (*Sesamum indicum* L.) in red and lateritic soils of west Bengal, *International journal of plant, animal and environmental sciences*, 7(1): 137-146

Salunkhe DK, Chavan JK, Adsule RN and Kadam SS. 1992. *World oilseeds: chemistry, technology, and utilization*. New York: Van Nostrand. Reinhold.

Sarhadi J. and Sharif M. 2014. "The effect of deficit irrigation on sesam growth, yield and yield components in drought conditions on base of sustainable agriculture", *International Journal of Farming and Allied Sciences*, 3(10):1061–1064,.

Sarkar RK and Pal PK. 2005. Effect of crop geometry, fertility level and nipping on physiological parameters in relation to productivity of sesame. *Indian Journal of Agricultural Science*, 75: 143-46.

Selvaraj J, Ramaraj B, Devarajan K, Seenivasan N, Senthilkumar S, Sakthi E., 2007. Effect of organic farming on growth and yield of thyme. In: *Articles and Abstracts of Nation. Sem. Prod. Utiliz. Med. Pl.*, 13-14, March, 2003 held at AnnamalaieUni.TamilNandu, 63.

Silva RT, Oliveira AB, Lopes MFQ, Filho FPN, Nogueira ASLP and Silva MNC. 2017. Integrated nutrient management in sesame (*Sesamum indicum* L.) in red and lateritic soils of West Bengal, *International journal of plant, animal and environment sciences*, 7(1).

Silva RT, Oliveira AB, Lopes MFQ, Guimarães MA, Dutra AS. 2016. Physiological quality of sesame seeds produced from plants subjected to water stress, *RevistaCiênciaAgronômica*, 47(4):643- 648.

Sim'ek M, Boydak E, Kirnak H, Gercek S and Kasap Y, 2003. The effect of sprinkle irrigation on water and yield product interaction in sesame as affected by different irrigation intervals and row spacing, *University of Ankara, Faculty of Agriculture, Journal of Agricultural Science*, 9: 136-142.

Singh SB. 2005. Genetic variability and relative contribution of component characters on yield of sesame, *Farm Science Journal*, 14(1): 1-3.

Sridevi S, Sriniva K and Sharma KL. 2005. Effect of sole and conjunctive application of plant residues and inorganic nitrogen on profile soil water content and mineral nitrogen in a dryland Alfisol, *Indian Journal of Dryland Agriculture Research and Development*, 20: 104-09.

Subrahmaniyan K, Dinakaran D, Kalaiselven P and Arulmozhi N. 2001. Response of root rot resistance cultivars of sesame to plant density and NPK fertilizer, *Agricultural Science Digest*, 21: 176-78.

Suja KP, Jayalekshmy A and Arumughan C. 2004. Free radical scavenging behavior of antioxidant compounds of sesame (*Sesamum indicum* L.) in DPPH system, *Journal of agricultural and food chemistry*, 52(4): 912-915

Tantawy MM, Oudu SA and Khalil FA. 2007. "Irrigation optimization for different Sesame varieties grown under water stress condition", *Journal of Applied Science Research*, 3(1):7–12,.

Thanunathan K, Thirupathi M, Leopold M and Imayavaramban V. 2006. Nutrient management for sesame under water constraint situation, *Research on Crops*, 7(2): 426–428.

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

Uçan K, Killı F, Gençođlan C, Merdun H. 2007. Effect of irrigation frequency and amount on water use efficiency and yield of sesame (*Sesamum indicum* L.) under field conditions, *Field Crop. Research*, 101: 249–258.

Verma, S, Saxena, R. and Singh, H V. 2012. Integrated nutrient management in sesame (*Sesamum indicum* L.). 9(4): 576-579.

Weiss EA. 1983. *Oilseed Crops*. Longman, London, England.

Xu G, Levkovitch, Soriano S, Wallach R and Silber A. 2004. Integrated effects of irrigation frequency and phosphorus level on lettuce, Puptake, root growth and yield, *Plant and soil*, 263: 297-309.

Comment [Anon16]: The references are not recent as of 2023. There is much research in 2021 to 2022.

UNDER PEER REVIEW