Original Research Article

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

ABSTRACT

Aim: To study the effect of Irrigation and nutrient management studieson 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 kg ha^{-1}), haulm yield (1820.13 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 kg ha^{-1}), haulm yield (1882.07 kg ha^{-1}) and harvest index (25.74%) which is at per with N_3. Highest water use efficiency (2.72 kg ha^{-1} m^{-1}) was calculated in I_2N_3.

Conclusion:cultivation of sesame under75% 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 highlys 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 industryis 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 [SSK1]: Italic

Comment [SSK2]: environment

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 a 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 combinationcan 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 theobjectives 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., 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 and in sub plot 4 doses of nutrients are applied i.e., N_1- 100% RDF, N_2- 100% RDF + 2t/ha FYM, N_3- 100% RDF + 2t/ha FYM + Jeevamrut @250l/ha, N_4- 75% RDF + 2t/ha FYM + Jeevamrut @ 250l/hawhereasRDF = 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.

Table1:Effectsofirrigationandnutrientmanagementoncropgrowthrate(gm-^{2}day-^{1})of summersesame

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

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.

Table2:EffectsofirrigationandnutrientmanagementonnumberofBranches/plantofsummersesame

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**
$N_1$100%RDF	3.6	3.7	3.9
N_2(100% RDF+ 2 t/ha FYM)	3.9	4.0	4.1
N_3(100%RDF+2 t/haFYM+ jeevamrut@250l/ha)	4.2	4.3	4.4
N_4(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:Effectsofirrigationandnutrientmanagementonnumberofcapsules/plants, length of capsule (cm), number of seeds/capsule and test weight (g) ofsummersesame

Treatments	Number ofcapsules/plant	Length ofcapsule(cm)	Number ofseeds/capsule	Test weight (g)
I_1(2 irrigationsat 21and 63 days aftersowing)	36.1	2.6	47	3.27
I_2(2 irrigationsat 21and 42 days aftersowing)	40.1	2.8	51	3.37
I_3(3irrigationsat21,42and63day saftersowing)	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/haFYM +jeevamrut @250l/ha)	41.4	2.8	53	3.45
N_4(75%RDF+2 t/haFYM +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 ofcapsules/plantof summersesame

Irrigation	Nutrientmanagement				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 =

2.4Nutrientmanagementat sameirrigation =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 4showed 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.Higheryieldobtainedinincreasedirrigationareassociatedwithhigherharvestindex found byLin*et al.,* 2007.

Table5:Effectsofirrigationandnutrientmanagementonseedyield(kgha^{-1}),haulmyield (kg ha^{-1}) andharvest index (%) of summersesame

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**
$N_1$100%RDF	591.94	1786.71	24.89
N_2(100% RDF+ 2 t/ha FYM)	617.08	1837.85	25.14
N_3(100%RDF+2 t/haFYM+ jeevamrut@250l/ha)	652.21	1882.07	25.74
N_4(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:Interactioneffectsofirrigationandnutrientmanagementonseedyield(kgha^{-1}) on summersesame

Irrigation	**Nutrientmanagement**				**Mean**
	N_1	**N_2**	**N_3**	**N_4**	
I_1	570.00	586.7	625.6	607.1	**597.34**
I_2	598.96	628.1	654.6	637.7	**629.85**
I_3	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 =

28.7Nutrientmanagementat sameirrigation =24.2

Table7:Interactioneffectsofirrigationandnutrientmanagementonhaulmyield(kg ha^{-1}) ofsummersesame

Irrigation	**Nutrientmanagement**				**Mean**
	N_1	**N_2**	**N_3**	**N_4**	
I_1	1732.00	1752.1	1820.8	1795.8	**1775.19**
I_2	1808.33	1880.2	1919.8	1903.1	**1877.87**
I_3	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
Nutrientmanagementat sameirrigation =9.5

4.2.3.Oilcontent:

Oilcontentunderdifferentirrigationlevelsandnutrientmanagementarepresented in Table 8. I_3 resulted the statistically highest oil content of 51.44% andlowest oil content was found in I_1 (46.05%). Among the different nutrient management,in 100% RDF + 2 t/ha FYM + Jeevamrut @250 l/ha (N_3) found the highest oil

content50.04%(Table8).Thereisnosignificantdifferenceamongthetreatmentcombinationon oil content.Oil content differences among the irrigation levels may be due to water stress wasalso reported by Boydak*et al*., 2007. Increased oil content and oil yield may be due toapplicationofnitrogen was also reportedbyDasand Das, (1995).

Table8:Effectsofirrigationandnutrientmanagementonoilcontent(%)ofsummersesame

Treatments	Oilcontent(%)
I_1(2irrigationsat21and63daysafter sowing)	46.05
I_2(2irrigationsat21and42daysafter sowing)	47.99
I_3(3irrigationsat21,42and63daysaftersowing)	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. Wateruseeffiency:

Crop water production functions describe the relationship of seed yield (Y)responsetovaryinglevelsofwaterinputandcanbeusefulforvariouswatermanagementapplications.Improvingagriculturalwateruseefficiency(WUE)isessential because of the demand for increased grain production in India. The resultsrevealed significant difference in seed yield due to the different water managementtreatments (Figure 1). The lowest WUE was recorded for I_3N_1 (2.02 kg ha^{-1} mm^{-1}).Because, there was not much yield increment with the increase application of water.Treatment I_2N_3 produced highest WUE of 2.72 kg ha^{-1} mm^{-1} followed by I_2N_4 (2.65 $kgha^{-1}mm^{-1}$).

Research studies show that the practice of limiting water applications to drought-sensitive growth stages aims at maximizing water productivity and stabilizing,ratherthan maximizing, yields which is supported by S. Geerts and D. Raes, (2009).Ucan,2007suggestedthattheWUEincreaseswithirrigationamount,andwater-savingtechniques such as deficit level have been improved water use efficiency (WUE) withminimumyieldreduction.Thesametrendwasobservedinthispresentstudy.Theincrease or decrease in seed yield due to different nutrient management practices insummer sesame commensurate with the corresponding water use by the crop resulting insimilar trend in water use efficiency of the crop to its consumptive use of water. This isalso established byDutta*et al*., 2000.

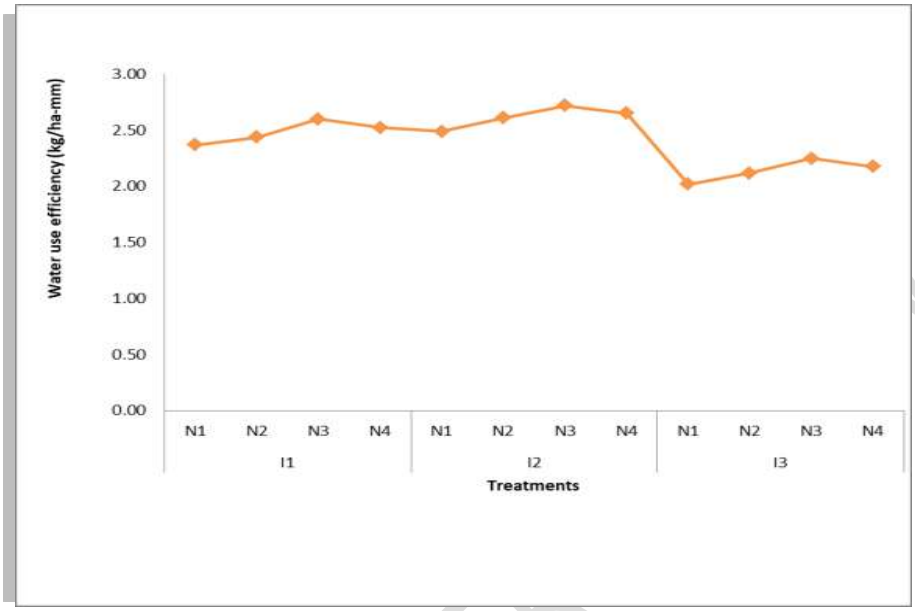

Fig. 1: Effects of irrigation and nutrient management on water use efficiency (kg ha-1 mm-1) of summer sesame.

4.4. Nutrientuptake

4.4.1 Nitrogen:

Total nitrogen content (%) in seed and haulm was obtained to be highest in I_3treatment. The observation proved that I_3 produced highest nitrogen content in seed(3.34%) and in haulm (1.03%) whereas, in I_1 found lowest nitrogen content (2.91%)followed by I_2 treatment (2.91%). Total nitrogen content was found to be highest in N_3treatment. The observation proved that (N_3) produced highest nitrogen content (3.15%)whereas in N_1lowestnitrogen content (2.97%) observed (Table 9).

Likewise nitrogen content,totalnitrogen uptake(kg ha^{-1}) by seed and haulmwas observed to be highest in I_3 treatment. The observation proved that I_3 producedhighestnitrogenuptakebyseed(21.51kgha^{-1})andbyhaulm(19.34kgha^{-1})whereas,I_1 showed the lowest nitrogen uptake by seed (17.34kg ha^{-1}) and by haulm (17.62 kgha^{-1}) . Total nitrogen uptake was found to be highest in N_3 treatment. The observationprovedthat100%RDF+2t/haFYM+Jeevamrut@250l/haproducedhighestnitrogen uptake by seed (20.56 kg ha^{-1}) and by haulm (19.29 kg ha^{-1}) whereas, (N_1)produced lowest nitrogen uptake byseed (17.57 kg ha^{-1}) and byhaulm(17.45 kg ha^{-1})(Table10).

An excessive N rate or an inadequate amount of N application could increase Ncontentin seeds.Ourresult isalso similarwiththefindingofChamorro*etal.,* 2002.

4.4.2 Phosphorus:

Total phosphorus content (%) in seed and haulm was analyzed and presented inTabl11. It was observed that 3 irrigations at 21, 42 and 63 days after sowing showedhighest phosphorus content (%) in seed (2.25%) and in haulm (0.27%) where as in I_1foundlowestphosphoruscontentinseed(2.08%)andinhaulm(0.22%).Totalphosphorus content (%) was found to be highest in N_3 treatment. The observationprovedthat100%RDF+2t/haFYM+Jeevamrut@250l/haproducedhighestphosphorus content in seed (2.17%) and in haulm (0.25%) The lowest phosphoruscontentwas found in seed (2.08%)and in haulm (0.22%) in N_1.

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, (I_1) produced lowest phosphorus uptake by seed (12.40 kg ha^{-1}) and by haulm(3.86kgha^{-1}). Total phosphorus contentwasfound highest in100%RDF+2 t/haFYM+Jeevamrut@250l/haapplicationinbothseed(10.12kg ha^{-1})andhaulm(2.95kgha^{-1}).The increases with irrigation frequency lead to higher phosphorus uptake due tothe higher average moisture content in root zone of the crop. This result is in concurrentwith Xu *et al*., 2004.

4.4.3 Potassium:

AnalyzeddataofseedandhaulmshowedhighestpotassiumcontentinI_3(0.94%) and (1.18 %). Irrespective of irrigation levels, N_3 (0.92%) in seed and (1.17%)inhaulm found significantlyhighest potassium content.

Potassium uptake by both seed (6.04 kg ha^{-1}) and haulm (22.31 kg ha^{-1}) foundhighestinI_3.100%RDF+2t/haFYM+Jeevamrut@250l/hashowedhighestpotassium uptakebyseed (6.03kgha^{-1}) and haulm (22.19kgha^{-1}) (Table11).

UptakeofN,PandKwasthehighestwhenthecropwasirrigatedwithappropriate quantity water. The uptake pattern mostly followed the biomass yield trenddue to different irrigation regimes, (Dutta *et al.*, 2000). Uptake of nutrients by the plantswas more efficient with the integrated use of inorganic and organic fertilization than thatof using all organic sources alone. Beneficial effects of FYMhave also been advocatedbyDeshmukh (2003),Mishra(2010)and Maravi (2010).

Table9:EffectsofirrigationandnutrientmanagementonNPKcontent(%)inseedand haulmofsummersesame

Treatments	NPKcontentinseed			NPKcontent in haulm		
	N content (%)	**P content (%)**	**K content (%)**	**N content (%)**	**P content (%)**	**K content (%)**
I_1(2 irrigationsat 21and 63daysaftersowing)	2.91	2.08	0.88	0.99	0.22	1.14
I_2(2 irrigationsat 21and 42daysaftersowing)	2.91	2.07	0.88	0.98	0.22	1.14
I_3(3 irrigations at 21, 42and63daysaftersowing)	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**

N_1(100%RDF)	2.97	2.08	0.88	0.98	0.22	1.13
N_2(100% RDF+ 2t/ha FYM)	3.11	2.13	0.91	1.01	0.24	1.16
N_3(100%RDF+2 t/ha FYM+jeevamrut@250l/ha)	3.15	2.17	0.92	1.02	0.25	1.17
N_4(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**

Table10:Effectsofirrigationandnutrientmanagementon NPKuptake(kgha^{-1})byseed and haulmon summersesame

	NPKuptakeby seed			**NPKuptakeby haulm**		
Treatments	**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})**
I_1(2irrigationsat21 and63daysafterso wing)	17.34	12.40	5.27	17.62	3.86	20.15
I_2(2irrigationsat21and4 2 daysafter sowing)	18.35	13.06	5.56	18.41	4.09	21.41
I_3(3irrigationsat21, 42and63daysafterso wing)	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**
N_1(100%RDF)	17.57	12.30	5.21	17.45	3.88	20.14
N_2(100% RDF+ 2t/ha FYM)	19.21	13.13	5.62	18.50	4.42	21.26
N_3(100%RDF+2 t/haFYM+jeevamrut@2 50l/ha)	20.56	14.15	6.03	19.29	4.67	22.19
N_4(75%RDF+2 t/ha FYM+jeevamrut@2 50l/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**

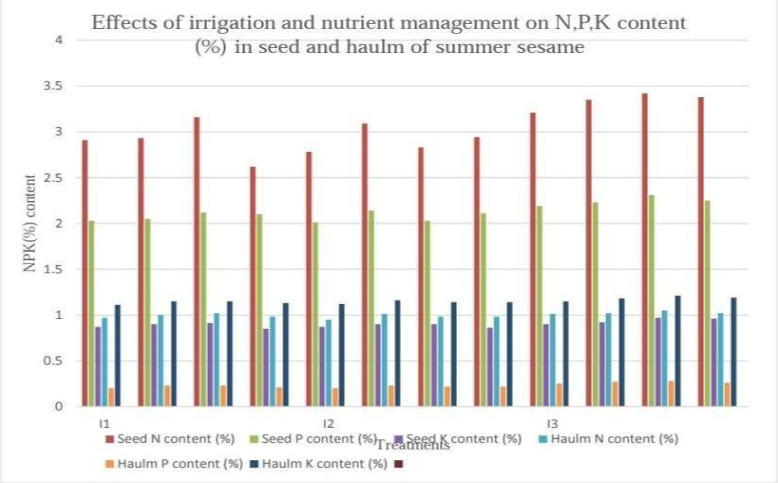

Fig. 2 : Effects of irrigation and nutrient management on NPKcontent(%) of summer sesame

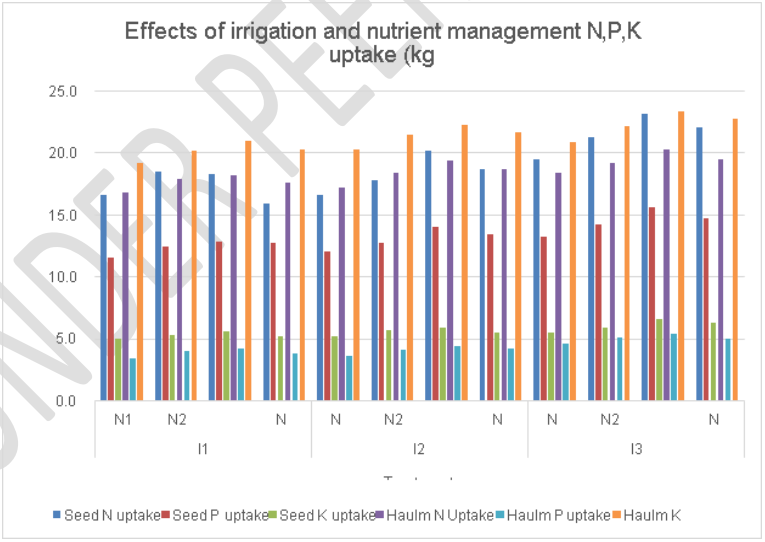

Fig. 3 : Effects of irrigation and nutrient management on NPKuptake(kgha^{-1})of summer sesame

4.5. Costofcultivation:

Thecostofcultivation,grossreturn,netreturnandbenefit:costratioarepresented in Table 11. Highest net return (Rs.19966.00 /-) as well as benefit cost ratio(1.68) calculated in (I_3N_3). Though the treatmentI_2N_3 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 intreatmentI_1N_2.

Table 11: Cost ofcultivationofsummersesame influencedby irrigationandnutrientmanagement

Treatments	Cost ofcultivation(Rs./-)	Grossreturn(Rs./-)	Netreturn(Rs./-)	B:Cratio
I_1N_1	26175.00	41610.00	15435.00	1.59
I_1N_2	27575.00	42826.00	15251.00	1.55
I_1N_3	28515.00	45667.00	17152.00	1.60
I_1N_4	27895.00	44317.00	16422.00	1.59
I_2N_1	26175.00	43723.00	17548.00	1.67
I_2N_2	27575.00	45853.00	18278.00	1.66
I_2N_3	28515.00	47784.00	19269.00	1.68
I_2N_4	27895.00	46552.00	18657.00	1.67
I_3N_1	27075.00	44301.00	17226.00	1.64
I_3N_2	28475.00	46461.00	17986.00	1.63
I_3N_3	29415.00	49381.00	19966.00	1.68
I_3N_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 infrared 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.

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