Int.J.Curr.Microbiol.App.Sci (2021) *10*(10): 212-220

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 10 Number 10 (2021)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2021.1010.025

Effects of Irrigation and Nutrient Management on Summer Sesame (*Sesamum indicum* L.)

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Keywords

Summer sesame, Irrigation, Nutrient management, Yield, Water use efficiency and Economics

Article Info

Accepted:
10 September 2021
Available Online:
10 October 2021

A B S T R A C T

Sesame (*Sesamum indicum* L.) plays a vital role in the Indian agriculture, industry and export trade. It commonly known as til and also called as "queen of oilseeds" has been known to be one of the earliest domesticated edible oilseeds used by mankind. It is grown in wide range of environments extending from semi-arid tropics and subtropics to temperate regions. A field experiment entitled "effects of irrigation and nutrient management on summer sesame (*Sesamum indicum* L.)",was conducted at the Agricultural Research Station, Brinjhagiri, Chatabar of Faculty of Agricultural Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar (Odisha) during summer season of 2021. 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 sowingand 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 @250l/ha and N_4: 75% RDF + 2 t/ha FYM + Jeevamrut @250l/ha) are treated in sub plot were experimented in split plot design replicate thrice. The experiment was conducted with the variety of TKG-21 followed the spacing of 30 cm × 10 cm. The experimental soil was sandy loam in texture with the pH of 5.65 and EC of 7.33 ds/m. The recommended dose of NPK was given 30:15:15 kg ha^{-1}. From the experiment, 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 @250l/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. Hence, it can be conclude that cultivation of sesame under75% RDF + 2 t/ha FYM + Jeevamrut @250l/ha with 2 irrigations at 21 and 42 days after sowing proved better in terms of yield, economics and water use efficiency.

Introduction

Oilseed crops play a vital role in the Indian agriculture, industry and export trade. In India, oilseed crops occupy an area of about 26.53 million hectares with the production of 31.01 million tonnes and average productivity of 1169 kg/ha (Anon., 2014). Sesame is cultivated on 15.98 lakh hectares and production of 8.20 lakh tonnes with average productivity of 420 kg/ha (Anonymous, 2014). In Odisha, sesame is cultivated in about 51.53 lakh hectares area with an annual production of about 11.45 million tones (Anon., 07). Sesame produces high quality edible oil which is used for cooking and salad. Generally white sesame mixed with jaggery is used to make sweets like ladoos and til, chikkis. Generaly, summer sesame requires 3-4 irrigations on its growing period. Integrated use of organic manure along with chemical fertilizers in sesame helps maintaining stability in crop production as well as improving soil physical and fertility conditions (Deshmukh *et al.*, 2002). Higher seed yield of sesame can be obtained by integrated use of fertilizer along with FYM, vermicompost and Azospirillum (Purushottam, 2005 and Jaishankar and Wahab, 2005). Application of bionutrients (panchgavya and jeevamrut) at branching and flowering stages recorded significantly the highest pod yield (1482 kg/ha) as compared to single application either at branching or flowering stage. 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 Mishra (2010) and Maravi (2010). Application of irrigation at branching, flowering and seed development stages increased yield attributing characters and yield of summer sesame (Dutta *et al.*, 2000). Keeping these view in mind, a field experiment entitled "effects of irrigation and nutrient management on summer sesame (*Sesamum indicum* L.)", was conducted at the Agricultural Research Station, Brinjhagiri, Chatabar of Faculty of Agricultural Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar (Odisha) during summer sesason of 2021 to evaluate the performance of summer sesame under different irrigation and nutrient management.

Materials and Methods

The field experiment was carried out at the University Farm of Agricultural Research Station, Brinjhagiri, Chatabar of Faculty of Agricultural Sciences, Siksha O Anusandhan (Deemed to be University), Bhubaneswar (Odisha) during summer sesason of 2021. The location situated in the South east coastal plain Zone of India. The field where the experiments was conducted is located at Latitude is 20.46^{o} N and Longitude 85.67^{o} E. The soil was sandy loam in texture, slidely acidic in reaction (pH 5.65), medium in organic carbon 0.30%, with 137.98-20.29-194.16 kg ha^{-1}available N-P-K. The experimental sesame 'TKG-21' used in the study is a white seeded variety with duration of 85–95 days was sown at 30 cm × 10 cm spacing at 1 cm depth. The experiment was laid out in a split plot design having three levels of irrigation (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 four nutrient management N_1 = 100% RDF, N_2 = 100% RDF + 2 t/ha FYM, N_3 = 100% RDF + 2 t/ha FYM + Jeevamrut @250l/ha and N_4 = 75% RDF + 2 t/ha FYM + Jeevamrut @250l/ha as sub-plot treatments. Sesame was sown on 6^{th} February in the year of 2021. A considerable amount of rainfall (109.2 mm) occurred during cropping season. A common pre-sowing irrigation was given to all plots and later on irrigation was given as per treatments. The N, P and K were supplied through urea, single super phosphate and

mutate of potash, respectively. Half of N along with full dose of P kg /ha and K were applied as basal and mixed with the soil of the individual plots. The rest of the N dose (half of recommendation) was top dressed at flowering stage according to the treatment. Crop was harvested at 105 DAS (31st May). The biometric data like, plant height (cm), dry matter accumulation (g m^{-2}**)** and number of branches/plant and yield related data like, number of capsules/plant, test weight (g), seed yield (kg ha^{-1}) and haulm yield (kg ha^{-1}) was taken during maturity period. Harvest index, water use efficiency (kg ha^{-1} mm^{-1}) and economics of cultivation were calculated.

Results and Discussion

Biometric Parameters

Observations of entire study proved that, at maturity, irrespective of different nutrient management, I_3 treatment produced tallest plant (111.3 cm) and shortest plant observed in I_1 treatment (104.4 cm). 100% RDF + 2 t/ha FYM + Jeevamrut @250 l/ha (N_3) attained tallest plant height (110.3 cm at maturity) followed by 75% RDF + 2 t/ha FYM + Jeevamrut @250 l/ha (109.0 cm) applied treatment. Whereas, smallest plant height recorded 104.9 cm on 100% RDF treatment (table 2). Mondal *et al.,* (1992) concluded that the plant height increased as irrigation frequency and nitrogen fertilizer rates were increased. Sahu *et al.,* (2017) also observed that the plant height found highest in combined application of inorganic and organic fertilizers. There was significant variation of number of branches count per m^2 in different irrigation levels are presented in table 2. I_3 produced statistically highest number of branches per m^2 (4.4) at maturity, where as lowest was founded in I_1 (3.9). The number of branches is found highest in combined application of inorganic and organic fertilizers was also found by Sahu *et al.,* (2017). Observation revealed that, irrespective of nutrient management, I_3 produced highest dry matter (527.55 g m^{-2}) followed by I_2 (508.93 g m^{-2}). In different nutrient management, at maturity stage 100% RDF + 2 t/ha FYM + Jeevamrut @250 l/ha (N_3) produced highest amount of dry matter (540.44 g m^{-2}) followed by N_4 (513.22 g m^{-2}) (table 2). Accumulation of dry matter in plants is important in producing a plant capable of high grain yield due to difference of irrigation (De *et al.,* 2002) and different integrated nutrient management (Imayavaramban *et al.,* 2002). Beneficial effects of FYM have also been advocated by Mishra(2010) and Maravi (2010).

Yield and yield attributes

Highest number of capsules/plant (42.2) counted in I_3 treatment. Among different nutrient management, 100% RDF + 2 t/ha FYM + Jeevamrut @250 l/ha (N_3) produced maximum number of capsule/plant (41.4) and number of seeds/capsule (53) represented in table 3.

These data shows that the number of capsules/plant is found highest in combined application of inorganic and organic fertilizers (Sahu *et al.,* 2017). The significant differences in seed yield due to the different water management treatments (table 3) where the lowest seed yield (597.33 kg ha^{-1}) were recorded for I_1. Three irrigations at 21, 42 and 63 days after sowing (I_3) resulted the highest seed yield of 643.49 kg ha^{-1} followed by I_2 (629.84 kg ha^{-1}). The maximum amount of seed yield in I_3 may be due to producing maximum number of capsule per plant on account of higher availability of water.

Table.1 Physico-chemical properties of the experimental soil

Sl.	Properties	Value	Method used
1.	Mechanical composition Sand (%) Silt (%) Clay (%)	72.8% 21.2% 6%	International pipette method (Jackson, 1973)
2.	Soil texture	Sandy loam soil	USDA system (Brady, 1974)
3.	pH	5.65	(Jackson, 1973)
4.	Electrical conductivity (ds m^{-1})	7.33	(Jackson, 1973)
5.	Organic carbon (%)	0.30	Walkley and Black method (Jackson, 1973)
6.	Available nitrogen (kg/ha)	137.98	Alkaline permanganate method (Jackson, 1973)
7.	Available phosphorus (kg/ha)	20.29	Olsen's method (Olsen *et al.*, 1954)
8.	Available potassium (kg/ha)	194.16	Flame photometric method (Jackson, 1973)

Table.2 Influence effects of irrigation level and nutrient management on plant height (cm), number of branches/plant, dry matter accumulation (g m^{-2}), number of capsules/plant, test weight (g) of summer sesame

Treatment	Plant height (cm)	Number of branches/plant	Dry matter accumulation (g m^{-2})	Number of capsules/plant	Test weight (g)
I_1	111.3	4.4	392.03	36.5	3.39
I_2	109.3	4.2	424.94	40.2	3.30
I_3	111.3	4.4	430.25	42.3	3.48
SEm (±)	**0.7**	**0.1**	**19.49**	**0.9**	**0.02**
CD (0.05)	**2.8**	**0.4**	**76.53**	**2.8**	**0.05**
N_1	109.0	4.3	423.52	40.1	3.46
N_2	104.9	3.7	391.65	37.6	3.35
N_3	107.8	4.1	414.09	39.5	3.42
N_4	110.3	4.4	433.70	41.4	3.49
SEm (±)	**0.7**	**0.1**	**32.31**	**0.4**	**0.09**
CD (0.05)	**2.7**	**0.3**	**126.83**	**1.3**	**0.36**

Table.3 Effects of irrigation and nutrient management on seed and haulm yield (kg ha^{-1}), harvest Index (%) and water use efficiency (kg $ha^{-1}mm^{-1}$) of sesame

Treatment	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest Index (%)	Oil content (%)
I_1	597.33	1775.19	25.18	46.05
I_2	629.84	1794.27	25.98	47.99
I_3	643.49	1828.13	26.04	51.44
SEm(±)	**3.84**	**7.42**	**0.04**	**0.5**
CD(0.05)	**15.03**	**29.45**	**0.15**	**2.04**
N_1	591.94	1786.71	24.89	46.69
N_2	617.08	1837.85	25.14	48.01
N_3	652.21	1882.07	25.74	50.04
N_4	632.99	1878.82	25.20	49.24
SEm(±)	**6.16**	**6.46**	**0.15**	**0.8**
CD(0.05)	**24.66**	**25.30**	**0.56**	**3.1**

Table.4 Cost of cultivation of summer sesame influenced by irrigation and nutrient management

Treatments	Cost of cultivation (Rs./-)	Gross return (Rs./-)	Net return (Rs./-)	B:C ratio
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

Fig.1 Meteorological data during cropping season of summer 2021.

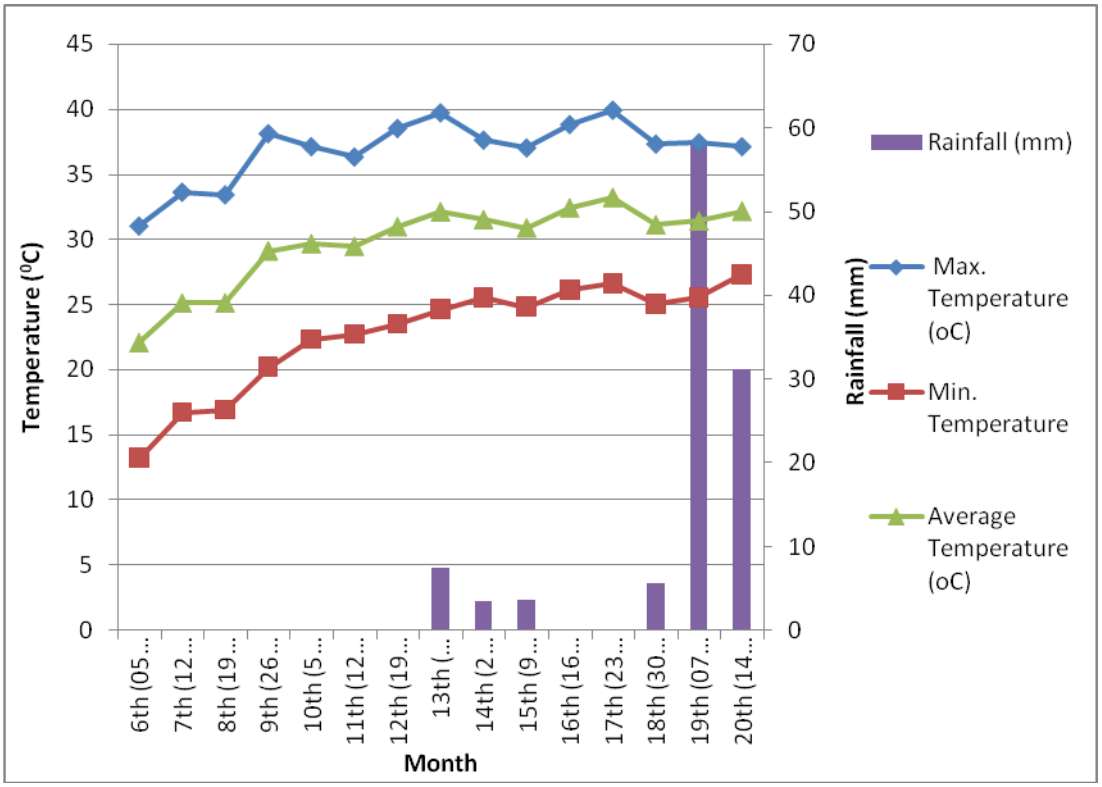
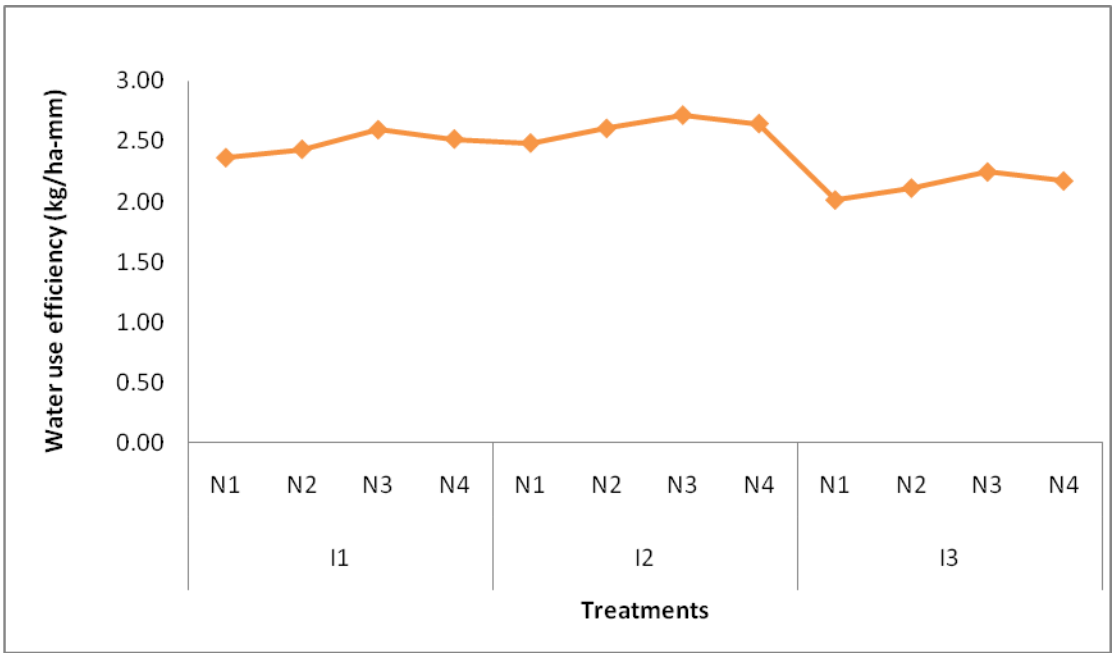


Fig.2 Effects of irrigation and nutrient management on water use efficiency (kg $ha^{-1}mm^{-1}$) of summer sesame.



Irrespective of irrigation levels, in different nutrient management, 100% RDF + 2 t/ha FYM + Jeevamrut @250 l/ha (N_3) produced highest yield (652.21 kg ha^{-1}) followed by N_4 (632.99 kg ha^{-1}) whereas, 100% RDF (N_1) 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 (Dutta *et al.*, 2000).

The higher haulm yield was found in I_3 (1828.13kg ha^{-1}) followed by I_2 (1794.27 kg ha^{-1}). The observed data also showed that, haulm yield differs with variation of nutrient management. It is recorded highest in N_3 (1882.07 kg ha^{-1}) followed by N_4 (1878.82 kg ha^{-1}). Haulm yield preferably increased with integrated nutrient management with fertilizer + FYM + Jeevamrut (Raman and Suganya, 2018). The observation proved that difference nutrient management at different irrigation level i.e., (I_3) produced highest harvest index (26.04%) followed by I_2 (25.98%). Irrespective of irrigation levels, highest harvest index was calculated in N_3 (25.74%) followed by N_4 (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 (Lin *et al.*, 2007).

Oil content

Three irrigations at 21, 42 and 63 days after sowing resulted the statistically highest oil content of 51.44% and lowest oil content was found in 2 irrigations at 21 and 63 days after sowing treatment (46.05%). Among the different nutrient management, in 100% RDF + 2 t/ha FYM + Jeevamrut @250 l/ha (N_3) found the highest oil content 50.04% (table 3). Oil content differences among the irrigation levels may be due to water stress (Boydak *et al.*, 2007). Increased oil content and oil yield may be due to application of more nitrogen (Das and Das, 1995).

Water use efficiency

The results revealed significant difference in seed yield due to the different water management treatments (figure 4.1). The lowest WUE was recorded for I_3N_1 (2.02 kg ha^{-1} mm^{-1}). It is due to there was not much yield increment with the increase application of water in I_3. Treatment I_2N_3 produced highest WUE of 2.72 kg ha^{-1} mm^{-1} followed by I_2N_4 (2.65 kg ha^{-1} mm^{-1}). Present research showed 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). 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 which was earlier reported by Ucan, 2007.

Cost of cultivation

The cost of cultivation, gross return, net return and benefit**:**cost ratio are presented in Table 4. Highest net return (Rs.19966.00 /-) as well as benefit cost ratio (1.68) calculated in (I_3N_3). Though the treatment I_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 in treatment I_1N_2.

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}). 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, the 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.

Acknowledgement

The authors are very much thankful to Department of Agronomy, IAS, SOADU, for providing financial and laboratory equipments for present study.

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How to cite this article:

Chakraborty, P., M. Das Bairagya, S. Sarkar, J. M. L. Gulati, G. H. Santra, N. Nayak and Sahoo, B. K. 2021. Effects of Irrigation and Nutrient Management on Summer Sesame (*Sesamum indicum* L.). *Int.J.Curr.Microbiol.App.Sci.* 10(10): 212-220.
doi: https://doi.org/10.20546/ijcmas.2021.1010.025