Original Research Article

Impact of Drip Irrigation Regimes and Fertigation Levels on Yield and Economics of Summer Sesame (Sesamum indicum)

Abstract

Aims: To study the effect of differential levels of drip irrigation and fertigation schedules on yield and economics of summer sesame.

Study design: Randomized Block Design

Place and Duration of Study: College farm, Water Technology Centre, Professor Jayashankar Telangana State Agriculture University (PJTSAU), Rajendranagar, Hyderabad, during 2018 to 2019.

Methodology: The experiment was framed with ten treatments *viz.,* two irrigation levels (0.8 and 1.0 Epan), two fertigation levels (75% and 100% recommended dose of Nitrogen and Potassium), two schedules (Equal and differential) and two treatments with soil application of 100% RDF with Drip irrigation (1.0 Epan) and conventional furrow irrigation (1.0 IW/CPE) and were replicated thrice.

Results: The results revealed that, application of 100% recommended dose of Nitrogen and Potassium (RDNK) through drip irrigation @ 0.8 or 1.0 Epan either in differential dosages based on crop growth stage or in equal splits recorded significantly superior yields (1011, 971, 977 and 990 kg/ ha, respectively) compared to the other treatments. These treatments recorded 13.5 and 26.7% higher yields, obtained from soil application of recommended dose of fertilizer (RDF) with drip irrigation at 1.0 Epan (882 kg/ha) and furrow irrigation at a 1.0 IW/CPE ratio (774 kg/ha). Further, the highest water productivity of 0.24 kg/m^3 was recorded with differential application of 100% RDNK under a drip irrigation regime of 0.8 Epan. This treatment also recorded the highest gross returns (₹ 96,489 /ha), net returns (₹ 53,604 /ha) and B:C ratio (2.95).

Conclusion: The results revealed that summer sesame grown under 100% RDNK in differential dosages or in equal splits through drip irrigation at 0.8 Epan recorded higher seed yield and water productivity with 425 mm of water.

1. INTRODUCTION

Oilseed crops play the second important role in the Indian agricultural economy next to food grains. Indian climate is suitable for the cultivation of oilseed crops. Sesame is one of the important summer oil crop having immense export potential. India ranks first in both area and production of sesamum with 25.8% (0.81 Mt) production, from 29.8% of the area (1.78 M ha) productivity of 455 kg/ha and shares 40% of the exports in the world. Among the oilseed crops cultivated, sesamum is known for its high nutritional value, medicinal properties, cooking quality and also has high demand in the cosmetic industry. Hence, it is referred as 'the Queen of oilseed crops'. In recent years, the international demand and market for sesame have experienced remarkable growth. Enhancing the contribution of agriculture to the Indian GDP can be achieved through the strategic selection of crops and the precise application of irrigation water (Champaneri *et al*., [3]).

In Telangana, sesamum is majorly cultivated in Jagityal, Nirmal and Nizamabad districts with a total area 3,328 ha and productivity of 765.7 t ha^{-1} during 2021-22 (Anonymous, [2]). It is a preferred contingent crop under rainfed conditions and can also be grown as an irrigated crop during summer (January or February months) after harvest of turmeric, *rabi* groundnut, cowpea and in rice fallows. In Telangana, approximately 98% of the total sesame cultivation takes place during the summer season. This region benefits from a favorable thermal regime, which contributes to high productivity levels of sesame crops.

Irrigation water is one of the most basic factor that restrict the development and yield of crops grown in summer. However, due to insufficient water supply, the productivity of summer sesame can be reduced. The conventional method of irrigation leads to enormous losses of water and fertilizers. The adoption of modern irrigation techniques can meet the high evaporative demand besides improving Water Use Efficiency (WUE) (Pandya and Rank, [23]). Surface drip irrigation is defined as application of water on the surface of soil near the root zone of crop through emitters with uniform discharge rate (Gilbert et al., [8]). It offers several advantages i.e., precise placement and efficient management of water, improved nutrient use efficiency, uniform application of water, reduced evaporation loss, reduced weed growth, better water productivity and many more (Hassanli et al., [10] and Koech et al, [13]). Drip irrigation can achieve 90-95% efficiency by reducing evaporation and deep percolation (Malam and Solanki, [16]) and to obtain higher net returns (Lavanya *et al.* [14]).

Fertigation enables application of optimum dose of fertilizer in accordance with the plant development (Couch *et al*., [5]). N is the most limiting nutrient for agricultural production and is an important input to maximize the yield of non-legume crops. (Qui *et al.,* [28]). Supply of N through fertigation is also expected to reduce N leaching in sandy soils, therefore, minimizing environmental contamination (Zenawi and Mizan, [31]).

Drip irrigation is the fastest growing segment of micro irrigation in the state of Telangana and its benefits are many. Now a days, it is used in a wide variety of crops with the increasing shortage of water. However, this technology needs to be standardized as information on drip irrigation and fertigation for summer sesame is very scarce. Hence, this study on “Response of *summer Sesame* (*Sesamum indicum*) to different of drip irrigation regimes and fertigation levels” was taken up.

2. MATERIAL AND METHODS

The experiment was conducted at the College farm, Water Technology Centre, Professor Jayashankar Telangana State Agriculture University (PJTSAU), Rajendranagar, Hyderabad. The site is located at latitude of 17°19'25.00"N and longitude of 78°24'31.03"E at 549 m above the mean sea level for two summer seasons of 2018 and 2019 in order to find out the optimum irrigation and fertigation schedules for sesame (Swetha). Swetha is white seeded variety released in the year 1997 with yield potential of 750-800 kg/ha and matures in 82-86 days. It is resistant to diseases like powdery mildew, stem rot, leaf curl, phyllody and macrophomina. The design was laid out in Randomized Block Design with eight treatments *viz.,* three factors such as Irrigation regimes, Fertigation levels and dosage schedules and another two treatments with soil application of 100% RDF through drip and furrow irrigation. The crop was sown during february first fortnight and harvested in May, during both the years of study. The soil of the research site is sandy clay loam soil in texture with a gross plot size was 7.0 m X 4.0 m and net plot size of 5.4 x 3.2 m. The crop was sown at 40 cm x 10 cm spacing under in - line drip (16 mm laterals placed at 0.8 m with emitter spacing of 0.4 m, having discharge of 2 LPH).

The treatments include drip irrigation scheduled at 0.8 and 1.0 Epan and fertigation scheduled at 75 and 100% N and K with Equal and Differential dosages. The recommended dose of N, P and K for sesame was 60:60:40 N, P_2O_5 and K_2O kg / ha. The drip fertigation (Urea and SOP) was scheduled to the crop through Venturi at three days interval from 10 DAS to 70 DAS in 21 splits. The differential N dose was 1.5, 4.5 and 3 kg N / ha (3.26, 9.78 and 6.52 kg urea ha^{-1}) and differential K_2O dose was 0.9, 1.8 and 3.0 (1.5, 3.0 and 5.0 kg white MOP or 1.8, 3.6 and 6.0 kg sulphate of potash) was applied during 10 to 30 DAS, 30 to 50 DAS and 50 to 70 DAS (days after sowing) (Table 1). For equal dosage, 1 kg N/ha and 0.66 kg K / ha was applied from 10 DAS to 70 DAS. A common dose of 60 kg P_2O_5 / ha through SSP was applied to soil as basal. In T9 and T10 treatments, the entire RDF was applied as basal. The data was subjected to statistical analysis and CD values were used to compare the treatments and drawn valid.

Table 1: Physical and chemical properties of experimental soil

Particulars	Value	Methods
Sand(%)	72.1	Bouyoucos hydrometer method (Piper, [25])
Silt (%)	6.6	
Clay(%)	21.3	
pH (1:2.5:: Soil: Water)	8.02	Glass electrode pH meter(Jackson, [11])
Organic Carbon (g kg/ ha)	0.61	Walkley and Black's modified method (Jackson, [11])
Available N (kg/ha)	210.5	Alkaline permanganate method using Kelplus (Subbiah and Asija, [29])
Available P_2O_5 (kg/ha)	36.7	Olsens method for extraction and ascorbic acid method for estimation Spectrophotometer at 420 mm (Olsens et al. [22])
Available K (kg/ha)	321.7	Neutral normal ammonium acetate method using Flame photometer(Piper, [25])

Table 2: Fertigation Schedule applied to summer sesamum during 2018 and 2019.

From	Days	Splits	N kg/day	K kg/day
Equal dosage				
10-30 DAS	20	7	1	0.66
30-50 DAS	20	7	1	0.66
50-70 DAS	20	7	1	0.66
Differential dosage				
10-30 DAS	20	7	1	0.3
30-50 DAS	20	7	1	0.6
50-70 DAS	20	7	1	1.0

3. RESULTS AND DISCUSSION

3.1 EFFECT OF IRRIGATION, FERTIGATION LEVELS AND DOSAGE SCHEDULE ON YIELDS OF SUMMER SESAMUM

3.1.1 Seed and stalk yield

Irrigation and fertigation levels significantly influenced the seed yield of sesamum (Table 3). Higher seed yield was recorded in the treatment in which 100% RDNK was applied either with differential dosages according to the crop growth stages or in equal splits with drip irrigation scheduled at 0.8 or 1.0 Epan (1011, 971, 990 and 977 kg/ha, respectively) over soil application of RDF with drip irrigation at 1.0 Epan (882 kg/ha) and furrow irrigation at 1.0 IW/CPE ratio (774 kg/ha). The yield improvement was 26.7 % and 13.5 % over the treatments where soil application of 100% RDF was irrigated through conventional furrow @ 1.0 IW/CPE ratio and drip irrigation @ 1.0 Epan. Further, soil application of 100% RDF with drip irrigation at 1.0 Epan recorded significantly higher sesame seed yield (882 kg/ha) than furrow irrigation at 1.0 IW/CPE (774 kg/ha).

Increased seed yields of sesamum crop might be due to adequate amount of irrigation water received during the crop growth stages in comparison to the water lost through evapotranspiration (Chauhan *et al*., [4]), 50% of the daily crop evapotranspiration (Papastylianou et al. [24]), scheduling irrigation at 75% Epan (Malla Reddy et al. [17]) and uninterrupted soil moisture availability during entire crop growth period (Neeshma et al. [21]). Similar results were reported by Damdar et al. [6], Hailu et al. [9], Moursi et al.[20] and Abdelraouf and Anter [1].

Lower seed yields were recorded in the treatment applied with 75% RDNK either with differential dosages according to the crop growth stages or in equal splits with drip irrigation scheduled at 0.8 or 1.0 Epan (904, 877, 909 and 815 kg/ha, respectively) than the 100 % RDNK applied either with drip irrigation @ 0.8 or 1.0 Epan. Increase in growth and yield attributes with higher level of nitrogen is because of the balanced nutrient supply, increased adsorptive power of soil for cation and anion exchange and favored higher uptake of NPK by plant. These absorbed ions are released slowly during the entire growth period and resulted in better nutrient availability to the crop and enhanced growth parameters. The increase in yield with increased N-fertilizer level are in close conformity with the findings of Thanki et al. [30].

Higher stalk yield was recorded in the treatment applied with 100% RDNK either with differential dosages according to the crop growth stages or in equal splits with drip irrigation scheduled at 0.8 or 1.0 Epan (2429, 2325, 2495 and 2341 kg/ha, respectively). (Table 3). Appropriate combination of water and nutrients might have hastened physiological processes including cell division and expansion, leading to favorable growth conditions and higher dry matter production according to

Chauhan et al. [4]. Mathew and Kunju et al. [19] supported the results by reporting that water management practices and N levels significantly influenced the seed and stalk yields.

Table 3: Grain yield (kg /ha), Straw yield(kg/ha) and Total Dry matter (kg/ha) of summer sesamum to drip fertigation of nitrogen and potassium on during 2018 and 2019.

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	TDM (kg/ha)
T1: Drip irrigation at 1.0 Epan - fertigation of 75% RD N&K - Equal splits	815	2077	2892
T2: Drip irrigation at 1.0 Epan - fertigation 75% RD N&K - differential dosage based on growth stage(D)	909	2041	2950
T3: Drip irrigation at 1.0 Epan - fertigation 100% RD N&K - Equal splits	977	2341	3318
T4: Drip irrigation at 1.0 Epan - fertigation 100% RD N&K - D	990	2495	3485
T5: Drip irrigation at 0.8 Epan - fertigation of 75% RD N&K - Equal splits	877	2099	2975
T6: Drip irrigation at 0.8 Epan - fertigation of 75% RD N&K - D	904	2311	3214
T7: Drip irrigation at 0.8 Epan - fertigation of 100% RD N&K - Equal splits	971	2325	3295
T8: Drip irrigation at 0.8 Epan - fertigation of 100% RD N&K – D	1011	2429	3439
T9: Drip irrigation (1.0 Epan) - soil application of 100% RDF to soil	882	2130	3012
T10: Conventional method furrow irrigation (IW/CPE=1.0) application of 100% RDF to soil.	774	2026	2800
SEm ±	15	66	70
C.D (P=0.05)	46	196	208

3.1.2 Effect of irrigation, fertigation levels and dosage schedule on total dry matter of summer sesamum

Total dry matter was significantly higher due to differential application of 100% RDN&K in combination with drip irrigation at 1.0 Epan (3485 kg/ha) and was on par with T7 (3295 kg/ha), T3 (3318 kg/ha) and T4 (3485 kg/ha) but significantly superior over other treatments, on the other hand conventional furrow irrigation with soil application of 100% RDF recorded least dry matter (2800 kg /ha) (Table 2). Higher dry matter production in differential application of 100% RDNK was due to increase in N supply and associated with increase in leaf area, carboxylases, and chlorophyll content, all of which determine the photosynthetic activities of leaf, ultimately dry matter production and allocation to the various organs of a plant (Maqsood *et al.,* [18]). Similar results were reported by Fadadu and Shrivastava [7] and Madhavi *et al.* [15].

3.1.2 Effect of irrigation, fertigation levels and dosage schedule on harvest index of summer sesamum

The harvest index (HI) ranged between 30-34%. However, HI was not significantly influenced by irrigation, fertigation levels and dosage schedules (Table 4). Maximum harvest index (34%) was reported in Drip irrigation at 1.0 Epan with differential fertigation of 75% RD N&K based on growth stage, while least was recorded in Drip irrigation at 0.8 Epan with fertigation of 75% RD N&K applied in differential dosages (30 %) and conventional method furrow irrigation (IW/CPE=1.0) application of 100% RDF to soil (30 %).

3.1.3 Effect of irrigation, fertigation levels and dosage schedule on water productivity of summer sesamum

The total amount of water applied through drip @ 0.8 and 1.0 Epan of water was 425 and 531 mm respectively (Table 3). However, application of irrigation water through drip @ 0.8 and 1.0 Epan could save 31% and 14% of the irrigation water as compared to the conventional irrigation with 1.0 IW/CPE (619.8 mm). Significantly higher water productivity (0.24) was recorded in summer sesamum with drip irrigation at 0.8 Epan along with 100% RDNK in differential dose which was on par with same irrigation and fertigation applied in equal splits (0.23) and significantly superior to other treatments. Conventional method of furrow irrigation (IW/CPE=1.0) along with soil application of 100% RDF recorded lowest water productivity of 1.2 with 619.8mm. Chauhan et al. [4] reported higher water use efficiency of 3.83 kg/ha/mm with drip irrigation scheduled at 100% Epan and lowest under surface irrigation of 1.0 IW/CPE (2.58 kg/ha).

Table 4: Harvest index, water applied (mm) and water productivity (kg/m^3) of summer sesamum to drip fertigation of nitrogen and potassium on during 2018 and 2019.

Treatment	Harvest index (%)	Water applied (mm)	Water productivity (kg/m^3)
T1: Drip irrigation at 1.0 Epan - fertigation of 75% RD N&K - Equal splits	31	531.2	0.15
T2: Drip irrigation at 1.0 Epan - fertigation 75% RD N&K - differential dosage based on growth stage(D)	34	531.2	0.17
T3: Drip irrigation at 1.0 Epan - fertigation 100% RD N&K - Equal splits	33	531.2	0.18
T4: Drip irrigation at 1.0 Epan - fertigation 100% RD N&K - D	31	531.2	0.19
T5: Drip irrigation at 0.8 Epan - fertigation of 75% RD N&K - Equal splits	31	425.0	0.21
T6: Drip irrigation at 0.8 Epan - fertigation of 75% RD N&K - D	30	425.0	0.21
T7- Drip irrigation at 0.8 Epan - fertigation of 100% RD N&K - Equal splits	32	425.0	0.23
T8: Drip irrigation at 0.8 Epan - fertigation of 100% RD N&K – D	31	425.0	0.24
T9: Drip irrigation (1.0 Epan) - soil application of 100% RDF to soil	31	425.0	0.21
T10: Conventional method furrow irrigation (IW/CPE=1.0) application of 100% RDF to soil.	30	619.8	0.12
SEm ±	0.7	-	0.003
C.D (*P*=.05)	NS	-	0.010

Whereas, Kassab *et al.* [12] reported that, irrigation regime of 100% Epan through sub-surface and surface drip irrigation utilized 237 mm of water and recorded water productivity of 0.943 and 0.863 kg/m^3, respectively as compared to controlled surface irrigation (0.546 kg/m^3) using 438 mm of water.

3.1.4 Effect of irrigation, fertigation levels and dosage schedule on economics of summer sesamum

The cost of cultivation was higher in the treatment where drip irrigation @ 1.0 Epan was scheduled with fertigation of 100% RDNK (₹. 33,729/ha), while conventional furrow irrigation @ 1.0 IW/CPE along with soil application of 100% RDF (₹. 28,951/ha) accrued lowest cost for cultivation (Table 5).

The gross returns (₹. 96,489 /ha), net returns (₹. 53,604 /ha) and B:C (2.95) ratio were higher when drip irrigation was scheduled @ 0.8 Epan along with 100% RDNK as differential dosages. It was on par with T3 (₹.93,329, ₹. 49,747 /ha and 2.75) and T4 treatments (₹94,537, ₹50,837 /ha and 2.8) but significantly superior over T10 (₹. 73,869, ₹.37,272 /ha and 2.59) treatment. Application of 150% RDF to summer sesamum recorded highest gross and net monetary returns and B:C ratio than 100 and 200% RDF (Sarkar et al. [27] and Shinde et al. [28]).

Table 5: Economics of sesame to drip fertigation of nitrogen and potassium during *summer*, 2018 and 2019

Treatment	Gross returns (₹/ha)	Cost of cultivation (₹/ha)	Net returns (₹/ha)	B:C ratio
T1: Drip irrigation at 1.0 Epan - fertigation of 75% RD N&K - Equal splits	77867	32969	36607	2.34
T2: Drip irrigation at 1.0 Epan - fertigation 75% RD N&K - differential dosage based on growth stage(D)	86749	33231	44378	2.61
T3: Drip irrigation at 1.0 Epan - fertigation 100% RD N&K - Equal splits	93329	33683	49747	2.75
T4: Drip irrigation at 1.0 Epan - fertigation 100% RD N&K - D	94537	33729	50837	2.8
T5: Drip irrigation at 0.8 Epan - fertigation of 75% RD N&K - Equal splits	83724	32101	42773	2.6
T6: Drip irrigation at 0.8 Epan - fertigation of 75% RD N&K - D	86271	32197	45065	2.7
T7: Drip irrigation at 0.8 Epan - fertigation of 100% RD N&K - Equal splits	92689	32632	50257	2.83
T8: Drip irrigation at 0.8 Epan - fertigation of 100% RD N&K – D	96489	32752	53604	2.95
T9: Drip irrigation (1.0 Epan) - soil application of 100% RDF to soil	84155	33037	42362	2.58
T10: Conventional method furrow irrigation (IW/CPE=1.0) application of 100% RDF to soil.	73869	28951	37272	2.59
SEm ±	1463	-	1463	0.04
C.D (P=0.05)	4347	-	4347	0.13

4. CONCLUSION

Sesame grown in summer has to be irrigated through drip @ 0.8 Epan and fertigation @ 100% RDNK either with differential dosages as per crop growth stages or in equal splits for significantly higher seed yields (1011 and 971 kg/ha), water productivity (0.24 and 0.23 kg/ha) and net returns (₹ 53604/- /ha).

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