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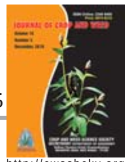

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Water productivity and economics of *rabi* sunflower as influenced by nitrogen and potassium fertigation schedules

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ABSTRACT

The present study was conducted to identify the optimum nitrogen and potassium fertigation schedules for rabi sunflower (variety DRSH-1) under semi-arid climate of Hyderabad in 2017-18. The experiment was conducted in a randomized block design with nine treatments replicated thrice. The nine treatments were combinations of N (75 kg ha^{-1}) and K (30 kg ha^{-1}) fertilizers applied by fertigation through ventury at different intervals viz., 3 days and 4 days. Drip irrigation was scheduled once in 2 days at 0.8 E pan. Fertigation was imposed at 16 DAS to 88 DAS and completed in 19 and 10 splits in 4 and 8 days interval, respectively. The sources of N and K fertilizers were urea and potassium sulphate, respectively. The amount of total irrigation water applied was 3188 m^3 and 4666 m^3 in drip irrigation and furrow irrigation treatments, respectively. Application of 75 kg N and 30 kg K_2O ha^{-1}, at 4 days interval (T_7) has recorded higher seed yield (2623 kg ha^{-1}), water productivity (0.82 kg m^{-3}) and was at par with (T_8) 75 -30 kg N-P_2O_5 kg ha^{-1} applied at 8 days interval (0.76 kg m^{-3}), Significantly lower water productivity (0.38 kg m^{-3}) was noticed in furrow irrigation with conventional manual application of fertilisers (T_9). The highest net returns (Rs. 66,103 ha^{-1}) and benefit cost ratio (2.59) were recorded in N and K at 4 days interval (T_7) followed by N and K at 8 days interval (T_8) (2.44).

Keywords : Economics, fertigation schedule, seed yield, sunflower and water productivity

Sunflower (*Helianthus annuus* L.) is an important oilseed crop in India. It was cultivated over an area of about 0.29m ha with a production of 0.21m tonnes and productivity of 738 kg ha^{-1} (DoES, 2018). In Telangana, sunflower is being grown in an area of 11547 ha, producing 13,330 tonnes with an average yield of 1154 kg ha^{-1} (DoES, 2017). The projected population of India was expected to be around 1.48 billion by 2030 and the required oil seeds production will be around 102.3 million tonnes by 2030 (DRMR, Vision 2030). With the increasing population the demand for vegetable oil in the country is increasing at the rate of about 4-6 per cent. Therefore there is an urgent need to improve the productivity of oilseed crops to bridge up the current demand-supply gap. Till now there is no major breakthrough to increase the production of vegetable oil through traditional crops. Water is becoming a limiting resource due to the multi-various demand from sectors like agriculture, livestock, industries, power generation and increased urban and rural domestic use. It is estimated that by2050; total water withdrawal will be 1180 BCM. Out of which irrigation will be accounted for nearly 68% followed by domestic use 9.5%, industries 7%, power development 6% (CWC, 2014). The demand for water is increasing day by day and the availability of water for agriculture is getting reduced. To increase productivity and resource use efficiency, it is necessary to bring most of the area under drip irrigation. It can save water up to 40 to 70% as well as increase the crop production to the extent of 20 to 100% (Reddy and Reddy, 2003). Water productivity of drip irrigation is three times higher than the furrow irrigation (Kadasiddappa, 2015). Application of fertilizers along with irrigation water through drip fertigation throughout the crop growing season can improve sunflower yield, water productivity and net returns. Earlier studies (Himaja, 2017) indicated the optimum NPK level as 75-90-30 kg N-P_2O_5-K_2O ha^{-1} by fertigation for sunflower in Southern Telangana Zone. The present study was planned to study the schedule of N and K fertilizers by fertigation.

The experiment was conducted during *rabi*, 2017-18 with sunflower (Variety DRSH-1) at Water Technology Centre, College farm, College of Agriculture, Rajendranagar, Professor Jayashankar Telangana State Agricultural University, Hyderabad on a sandy clay loam soil. The soil was alkaline in reaction, non saline, low in available nitrogen, medium in available phosphorus and potassium. The bulk density of soil at 0-15 cm depth is 1.46 mg m^{-3} with available soil moisture 32.6 mm. The irrigation water was alkaline (pH=8.1) and categorized under Class II (C_3S_1) suggesting that it is suitable for irrigating the crop by following good management practices. The RSC indicated that there was no carbonate hazard. The drip system specifications

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include, laterals of 16 mm diameter laid at 1.2 m apart with spacing of 0.5 m distance between two inline emitters. The emitter discharge was 4.0 lph.The experiment was laid out in a randomized block design with three replications and nine treatments at 100% RDF *viz.*, no application of N and K_2O fertilizers + drip irrigation (T_1), manual application of N and K fertilizers + drip irrigation (T_2), application of N (75 kg ha^{-1}) through fertigation at 4 days interval (T_3), application of N (75kg ha^{-1}) through fertigation at 8 days interval (T_4), application of K (30 kg ha^{-1}) through fertigation at 4 days interval (T_5), application of K (30 kg ha^{-1}) through fertigation at 8 days interval (T_6), application of N and K (75 kg N - 30 kg K_2O ha^{-1}) through fertigation at 4 days interval (T_7), application of N and K (75 kg N - 30 kg K_2O ha^{-1}) through fertigation at 8 days interval (T_8) and manual application of N and K fertilizers + furrow irrigation (T_9).The recommended dosage 100% RDF (75-90-30 N-P2O5-K2O kg ha^{-1}) was applied in the form of urea, single super phosphate (SSP), and murate of potash (manual application) /sulphate of potash (fertigation). A common dose of phosphorus was applied to all the treatments including control (T_1). Nitrogen and Potassium were applied through drip fertigation at different growth stages as per treatments and 10 % N was applied as basal before sowing. For manual application treatments (T_2 and T_9) the N was applied in three equal splits at basal, 30 and 50 DAS through urea and potassium was applied through MOP in a single basal dose. Fertigation was given at 4 and 8 days intervals starting from 16 DAS to 88 DAS. The total fertigation given are 19 for 4 days interval and 10 for 8 days interval. The fertigation schedule followed is indicated in table- 1.

The water source for irrigation was from an open well. Irrigation scheduling was done as per the treatments. Scheduling of irrigation for treatments T_1 to T_8 (except T_9) were fixed for once in two days based on daily evaporation data recorded from USWB class ‘A’ pan evaporimeter in agro-meteorological station, ARI Farm, Rajendranagar, Hyderabad at 0.8 Epanandfurrow irrigation (T_9) was at 1.0 IW/CPE ratio with 50 mm irrigation depth in furrows in between paired rows (80 cm/40 cm).The total pan evaporation during crop growth period was 401.2 mm. There was no rainfall during the crop growth period. The amount of water applied under drip irrigation was 318.8 mm and under surface irrigation was 466.6 mm. Fertigation was given at 4 and 8 days intervals starting from 16 DAS to 88 DAS. Sunflower hybrid DRSH-1 was sown by a paired row system on 16th November, 2017 by adopting a spacing of 80/40 cm between the rows and 25 cm between the plants to maintain a desired plant population of 66,666 plants ha^{-1}.

The water productivity (kg m^{-3}) was calculated as the ratio of seed yield (kg ha^{-1}) to the applied water (m^3) to sunflower crop. The crop water requirement in L kg^{-1} was calculated as the ratio of amount of water applied (L) to the yield (kg ha^{-1}). For economics, the cost of drip irrigation system was computed considering the longer life span of the system (10 years) and including the present government subsidy of 90 per cent of system cost (Rs. 90500 ha^{-1}). An annual depreciation cost of Rs. 9050 was included in the cost of cultivation. Cost of water was taken as @ Rs. 10 mm^{-1}. The prevailing market price of sunflower seed @ Rs. 41 kg^{-1} was multipliedwith seed yield to get gross value of the produce. The net returns were worked out after deducting the cost of cultivation including operational costs, input expenditure and other items from the gross returns ha^{-1}. Benefit: cost ratio was calculated by dividing gross returns with cost of cultivation for each treatment.

Seed yield and water productivity

The seed yield ranged from 1262 to 2623 kg ha^{-1} (Table 2, Fig. 1). Application of N and K (75-30 kg N-K_2O ha^{-1}) at 4 days interval (T_7) has produced significantly the highest seed yield which was at par with application of same dose of N and K at 8 days interval(2437 kg ha^{-1}) and the lowest value was recorded in control (T_1) where no N and K was applied.The N and K at four days interval by fertigation recorded 21.5 % higher seed yield as compared to manual application of fertilizers with drip irrigation (2158 kg ha^{-1}) (T_2) indicating the advantage of fertigation over manual application. Manual application of N and K fertilizers and drip irrigation (T_2) has recorded 20.2 % higher seed yield as compared to manual application of N and K fertilizers + furrow irrigation (1795 kg ha^{-1}) (T_9) indicating advantage of drip irrigation over furrow irrigation.

The amount of water consumed was 318.8 mm in drip irrigation and 466.6 mm in surface furrow irrigation. Thus there was a saving of 147.8 mm of water due to drip irrigation accounting to 46%. No rain was received during crop growth period. The water productivity in terms of kg m^{-3} ranged from 0.38 to 0.82 kg m^{-3}. The highest water productivity (0.82 kg m^{-3}) was recorded by (N + K at 4 days interval) (T_7) followed by T_8 (N + K at 8 days interval) (0.76 kg m^{-3}) and the lowest with T_9 (manual application of N and K fertilizers + furrow irrigation) (0.38 kg m^{-3}). Higher yields produced by the fertigation contributed to the higher water productivity. Water productivity was higher in drip irrigated treatments over surface furrow irrigation. The results corroborate with the findings of Himaja (2017) and Sanju (2013). Water productivity in terms of L kg^{-1} indicated the amount

Table 1: Fertigation schedule of N and K as applied for *rabi* sunflower crop

Crop growth stage	DAS	No of schedules	Fertilizer dose 4 days interval		Fertilizer dose 8 days interval	
			N (kg ha^{-1})	K_2O (kg ha^{-1})	N (kg ha^{-1})	K_2O (kg ha^{-1})
At sowing 10% N applied as basal			7.5	-	7.5	-
Vegetation development	16-45 DAS	1-8	54.75	12.6	36.95	13.5
Flowering and pollination	46-65 DAS	9-13	12.15	11.4	20.25	12.0
Seed development	66-88 DAS	14-19	8.1	6.0	10.3	4.5
Total	88 days	19	75.0	30.0	75	30.0

Table 2: Seed yield (kg ha^{-1}), total water applied (mm) and water productivity (kg m^{-3}) of *rabi* sunflower as influenced by N and K fertigation schedules

Treatments	Seed yield (kg ha^{-1})	Total water applied (mm)	Water productivity (L kg^{-1})	(kg m^{-3})
T_1 - Control (N_0K_0)	1262	318.8	0.40	2526
T_2 - Manual application of N and K + drip	2158	318.8	0.68	1447
T_3 - Fertigation of N at 4 days interval	1983	318.8	0.62	1608
T_4 - Fertigation of N at 8 days interval	1918	318.8	0.60	1662
T_5 - Fertigation of K at 4 days interval	1662	318.8	0.52	1918
T_6 - Fertigation of K at 8 days interval	1602	318.8	0.50	1990
T_7 - Fertigation of N and K at 4 days interval	2623	318.8	0.82	1215
T_8 - Fertigation of N and K at 8 days interval	2437	318.8	0.76	1308
T_9 - Manual application of N and K + furrow	1795	466.6	0.38	1776
SEm (±)	**98.90**	**-**	**-**	
LSD (0.05)	**299.07**	**-**	**-**	

Table 3: Economics of *rabi* sunflower as influenced by N and K fertigation schedules

Treatments	Total cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B: C
T_1 - Control (N_0K_0)	37148	51742	14594	1.39
T_2 - Manual application of N and K + drip	40995	88478	47483	2.16
T_3 - Fertigation of N at 4 days interval	39384	81303	41919	2.09
T_4 - Fertigation of N at 8 days interval	38924	78654	39730	2.02
T_5 - Fertigation of K at 4 days interval	40078	68142	28064	1.70
T_6 - Fertigation of K at 8 days interval	39594	65682	26088	1.66
T_7 - Fertigation of N and K at 4 days interval	41440	107543	66103	2.59
T_8 - Fertigation of N and K at 8 days interval	40907	99917	59010	2.44
T_9 - Manual application of N and K + furrow	35615	73595	37980	2.07
SEm (±)	-	-	**2878**	-
LSD (0.05)	-	-	**8703**	-

*Note: * 100% RDF = 75-90-30 N- P_2O_5-K_2O kg ha^{-1} , * A common dose of phosphorus was applied as basal to all the treatments*

of water used by the crop per kg produce. It ranged from 1215 to 2526 L kg^{-1}. The least amount of water required to produce one kg of sunflower seed was recorded in T_7, followed by T_8 and higher amount of water was used by control. Fertigation (T_7) resulted in saving of 232 litres of water per kg produce as compared to manualapplication (T_2).

Similarly drip (T_2) irrigation saved 329 litres of water per kg produce when compared to furrow method of irrigation (T_9). Frequent application of nutrients with

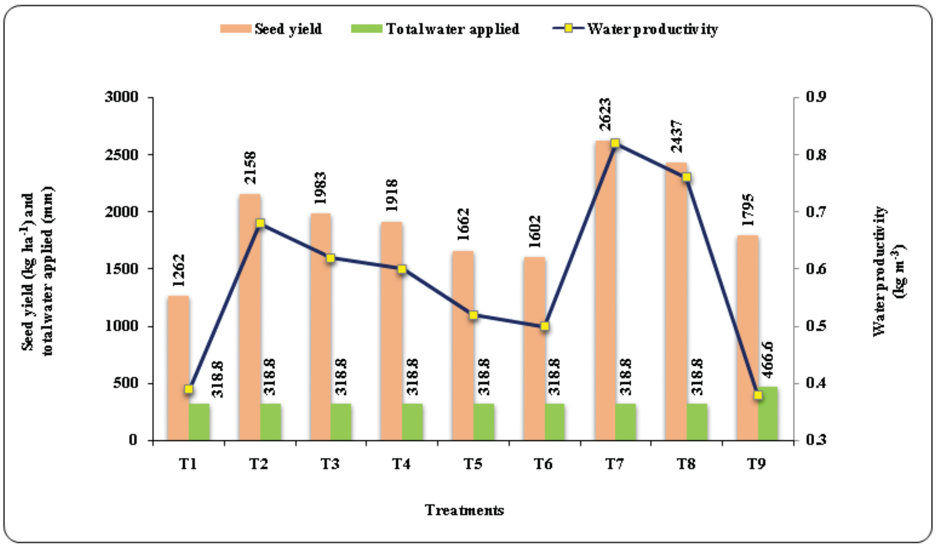

Fig. 1: Water productivity of *rabi* sunflower as influenced by N and K fertigation schedules

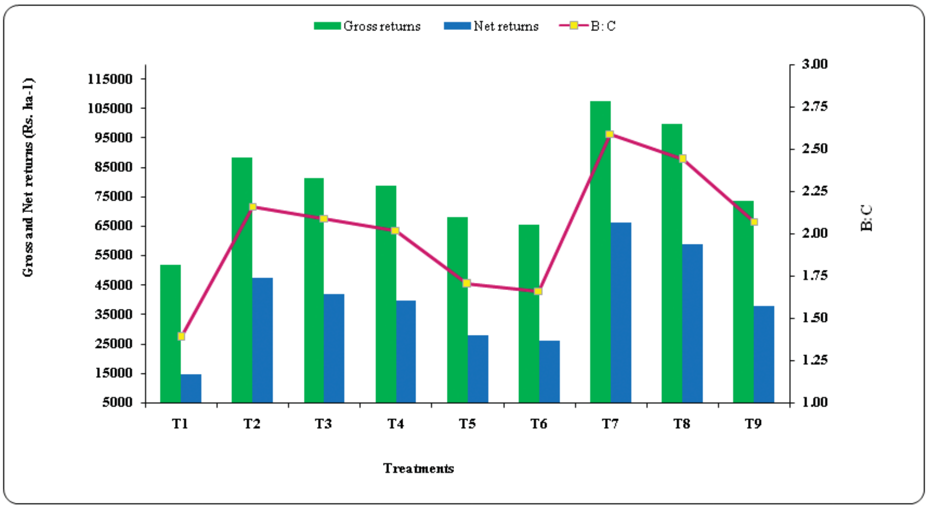

Fig. 2: Economics of *rabi* sunflower as influenced by N and K fertigation schedules

sufficient quantity of water by drip resulted in the maintenance of adequate soil moisture in the crop root zone and sufficient amount of nutrients in soil solution throughout the growth period of the crop and resulted in higher yields and more water use efficiency.

Economics

The cost of cultivation was observed to be higher (Rs. 41440 ha^{-1}) in T_7 (N + K at 4 days interval) and the lowest cost of cultivation (Rs. 35615 ha^{-1}) was under manual application of N and K fertilizers + furrow irrigation treatment (Table 3). Gross and net returns were higher (Rs. 1, 07,543 and Rs. 66,103 ha^{-1}) under T_7 (N and K at 4 days interval), followed by T_8(N + K at 8 days interval) (Rs. 99,917 and Rs. 59,010 ha^{-1}) and lower gross and net returns (Rs. 51,742 and Rs. 14,594 ha^{-1}) were recorded by T_1 (control). The benefit-cost ratio (2.59) was higher in T_7 (N + K at 4 days interval) followed by T_8(N + K at 8 days interval) (2.44) and lower with T_1 (control) (1.39). The higher returns (gross and net) and benefit-cost ratio under T_7 and T_8weredue to higher yield because of favorable soil moisture and nutrients facilitating better growth and better crop response.

Based on the results obtained in the present investigation, it can be concluded that the sunflower crop grown with drip fertigation at 100% recommended dose of N + K (75 kg N - 30 kg K_2O ha^{-1}) with 4 days interval during *rabi* under Hyderabad semi arid conditions realized higher seed yield (2623 kg ha^{-1}), water productivity (0.82 kg m^{-3}) and net returns (Rs. 66,103 ha^{-1}).

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