International Journal of Ecology and Environmental Sciences
www.ecologyjournal.in
Online ISSN: 2664-7133; Print ISSN: 2664-7125; Impact Factor: RJIF 5.28
Received: 20-07-2020; Accepted: 05-08-2020; ; Published: 21-08-2020
Volume 2; Issue 2; 2020; Page No. 178-182

Optimization of nitrogen and potassium Fertigation schedules on nutrients uptake of sunflower

K Preethika Reddy[1], M Uma Devi[2], V Ramulu[3], M Madhavi[4]
[1-4] Water Technology Centre, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, India

Abstract
A field experiment was conducted at Water Technology Centre, College farm, Rajendranagar, Hyderabad during *rabi* 2017-18 with sunflower (var. DRSH-1). The experiment was conducted in a randomized block design with three replications in a sandy clay loam soil, alkaline in reaction, non saline, low in available nitrogen, medium in available phosphorus and potassium. The treatments were nine with 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 Epan. Fertigation was imposed at 16 DAS to 88 DAS and completed in 19 and 10 splits in 4 and 8 days interval respectively. The source of N and K fertilizers was urea and potassium sulphate respectively. At harvest, the total N content ranged from 0.59 to 0.89 % and 1.37 % to 1.84 % in sunflower stalk and shoots respectively. The total P content ranged from 0.12 to 0.21, 0.24 to 0.32% in sunflower stalk and shoots respectively. The total K content ranged from 0.91 to 1.46, 0.58 to 0.87% in sunflower stalk and shoots respectively. At harvest, the highest total uptake of N (281.6 kg N ha^{-1}), P (55.5 kg P ha^{-1}) and K (252.6 kg K ha^{-1}) was noticed in T_7 (75-30 kg N and K_2O ha^{-1} at 4 days interval). Significant correlations were noticed between uptake of N, P and K with sunflower seed yield.

Keywords: Fertigation, N, P and K contents, nutrient uptake, Sunflower

Introduction
In the present-day context, agriculture is challenged to manage water and nutrients such that production benefits are maximized, while adverse environmental effects are minimized. The right combination of water and nutrients is a prerequisite for higher yields and good quality production. The method of fertilizer application is also important in improving the use efficiency of nutrients. Fertigation enables adequate supplies of water and nutrients with precise timing and uniform distribution to meet the crop nutrient demand (Patel and Rajput, 2000 and Narda, 2000) [5, 4]. Sunflower ranks third in the area and fourth in production in the world. It is an important oilseed crop in India. In India it was cultivated over an area of about 0.29 m ha with a production of 0.21m tonnes and productivity of 738 kg ha^{-1} (DoES, 2018) [2]. 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) [1]. Nutrient uptake is a function of dry matter production, available nutrient status of the soil. Application of fertilizers along with irrigation water through drip fertigation can improve sunflower yield and fertilizer use efficiency and meets crop demand throughout the crop growing season. Such information on drip fertigation for sunflower is scanty for Telangana state. With this background, an effort was made to study the effect of fertigation scheduling in sunflower and uptake of NPK nutrients by the crop at different growth stages.

Material and methods
The field experiment was carried out at Water Technology Centre, College Farm, Rajendranagar, Hyderabad during *rabi*, 2017-18. The experiment site was situated at $17^0$19'25.2" N Latitude, $78^0$24'31" E Longitude and altitude of 534 m above mean sea level. The soil was sandy clay loam in texture, slightly alkaline in reaction (pH 7.8), non saline (EC 0.32 dS m^{-1}), high in organic carbon content (0.82 %), low in available nitrogen (188.5 kg N ha^{-1}), medium in available phosphorus (32.4 kg P_2O_5 ha^{-1}) and high in available potassium (317.18 kg K_2O ha^{-1}) contents. The experiment was laid out in a randomized block design with three replications and nine treatments at 100 % RDF *viz*., T_1 control (no application of N and K fertilizers + drip irrigation, T_2 (manual application of N and K fertilizers + drip irrigation.), T_3 (application of only N (75 kg ha^{-1}) through fertigation with 4 days interval.), T_4 (application of only N (75kg ha^{-1}) through fertigation with 8 days interval), T_5 (application of only K (30 kg ha^{-1}) through fertigation with 4 days interval), T_6 (application of only K (30 kg ha^{-1}) through fertigation with 8 days interval), T_7 (application of N and K (75 kg N and 30 kg K_2O ha^{-1}) through fertigation with 4 days interval), T_8 (application of N and K (75 kg N and 30 kg K_2O ha^{-1}) through fertigation with 8 days interval) and T_9 (manual application of N and K fertilizers + furrow irrigation).

The recommended dose of fertilizer (RDF) was 75, 90 and 30 kg N, P_2O_5 and K_2O ha^{-1}, respectively was applied in the form of urea, single super phosphate (SSP), and muriate of potash (MOP). 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. For manual application treatments (T_2 and T_9), N was applied in three equal splits at basal, 30 and 50 days after sowing (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. Plant samples for dry matter estimation at 30, 60, 90 DAS and at harvest and

seed samples at 90 DAS and harvest were collected and oven-dried , finely ground and used for estimating N, P and K content as per the standard procedures. The nutrient content uptake values obtained as percentage in the analysis were multiplied by the respective dry matter content for computing N, P and K uptake expressed in kg ha^{-1}. The fertigation schedule followed is indicated in Table 1.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%) x Dry matter (kg ha}^{-1}\text{)}}{100}$$

Results and discussion

Nutrient contents (N, P and K)

Data on nutrient contents of sunflower is presented in Table 2. The nitrogen content ranged from 0.12 to 0.20 % at 30 DAS, 0.29 to 0.47 % at 60 DAS, 0.38 to 0.61 % in stalk and 0.81 to 1.26 % in seed at 90 DAS, 0.59 to 0.89 % in stalk and 1.37 to 1.84 % in seed at harvest. The total nitrogen content in stalk at all the growth stages was not significantly influenced by different treatments. However, it was significantly influenced at 90 DAS and at harvest in sunflower seed. The highest total nitrogen content at 90 DAS was noticed in T_3 (only N at 4 days interval) and the least content was noticed in T_1 (control). At harvest the highest was noticed in T_8 (N and K at 8 days interval) and least content was noticed in T_1 (control).

Phosphorus (P) content ranged from 0.19 to 0.27 % at 30 DAS, 0.17 to 0.22 % at 60 DAS, 0.13 to 0.20 % in stalk and 0.19 to 0.26 % in seed at 90 DAS, 0.12 to 0.21 % in stalk and 0.24 to 0.32 % in seed at harvest. The total P content in stalk at 60 DAS and in seeds at 90 DAS was not significantly influenced by different treatments. Whereas, in stalk at 30, 90 DAS and at harvest and in seed at harvest was significantly influenced by different treatments. The highest total P content at 90 DAS and at harvest was noticed in T_7 (N at 4 days interval) and the least content was noticed in T_1 (control).

Potassium content ranged from 0.22 to 0.32 % at 30 DAS, 0.56 to 0.92 % at 60 DAS, 1.30 to 1.83% in stalk and 0.69 to 1.07 % in seed at 90 DAS, 0.91 to 1.46 % in stalk and 0.58 to 0.87 % in seed at harvest. At 30 DAS the highest content was noticed with T_2 (manual application of N and K fertilizers + drip irrigation). At 60 DAS the highest content was noticed in T_7 (N and K at 4 days interval). At 90 DAS in stalk the highest content was noticed in T_5 (only K at 4 days interval) and in seed it was noticed in T_7 (N and K at 4 days interval). At harvest in stalk the highest content was noticed in T_5 (K at 4 days interval) and in seed it was noticed in T_7 (N and K at 4 days interval). At all the growth stages least content was noticed in control (T_1).

Nitrogen uptake

Data on nutrient uptake of sunflower is presented in Table 3. Nutrient uptake was significantly affected by fertigation schedules at different crop growth stages. At 30 DAS, the highest nitrogen uptake (2.6 kg ha^{-1}) was recorded with T_7 (N + K at 4 days interval) and the lowest nitrogen uptake was observed with T_6 (K at 8 days interval) (1.5 kg ha^{-1}). At 60 DAS, the highest nitrogen uptake was recorded with T_7 (N + K at 4 days interval) (33.8 kg ha^{-1}) and the lowest was observed with T_1 (Control) (6.0 kg ha^{-1}). N + K at 4 days interval (T_7) has recorded 15.7, 32.6, 34.1% higher N uptake over T_3 (N at 4 days interval), T_8 (N + K at 8 days interval) and T_4 (N at 8 days interval). Manual application of N and K fertilizers + drip irrigation treatment (T_2) has recorded 30% higher N uptake over manual application of N and K fertilizers + furrow irrigation treatment (T_9).

At 90 DAS highest nitrogen uptake was recorded with T_7 (N + K at 4 days interval) (158.1 kg ha^{-1}) and the lowest N uptake was recorded with T_1 (control) (50.5 kg ha^{-1}). N + K at 4 days interval (T_7) has recorded 40.3% higher N uptake over T_2 (manual application of N and K fertilizers + drip irrigation treatment). The T_2 (manual application of N and K fertilizers + drip irrigation) has recorded 22.6% higher N uptake over T_9 (manual application of N and K fertilizers + furrow irrigation). At harvest, the highest nitrogen uptake was recorded with T_7 (N + K at 4 days interval) (281.6 kg ha^{-1}) and the lowest N uptake was recorded with T_1 (control) (108.8 kg ha^{-1}). N + K at 4 days interval (T_7) has recorded 28.3 % higher N uptake over T_2 (manual application of N and K fertilizers + drip irrigation treatment). The T_2 (manual application of N and K fertilizers + drip irrigation) has recorded 22.16% higher N uptake over T_9 (manual application of N and K fertilizers + furrow irrigation). The results corroborate with the findings of Himaja (2017) [3], Sheker (2014) [7] and Sanju (2013) [6].

Phosphorus Uptake

At 30 DAS, the highest uptake (3.8 kg ha^{-1}) was recorded with T_9 (manual application of N and K fertilizers + furrow irrigation) and the lowest content was observed with T_6 (K at 8 days interval) (2.4 kg ha^{-1}). Manual application of N and K fertilizers + furrow irrigation (T_9) has recorded 15.1% higher P uptake over manual application of N and K fertilizers + drip irrigation (T_2). Manual application of N and K fertilizers + drip irrigation treatment has recorded 10 % higher P uptake over T_7 (N and K at 4 days interval). At 60 DAS, the highest uptake was recorded with T_7 (N + K at 4 days interval) (15.2 kg ha^{-1}) and the lowest was observed with T_1 (control) (3.5 kg ha^{-1}). N + K at 4 days interval (T_7) has recorded 43.4 % higher P uptake over T_2 (manual application of N and K fertilizers + drip irrigation treatment). Manual application of N and K fertilizers + drip application irrigation treatment (T_2) has recorded 21.8 % higher P uptake over T_9 (manual application of N and K fertilizers + furrow irrigation treatment).

At 90 DAS highest uptake was recorded with T_7 (N + K at 4 days interval) (40.3 kg ha^{-1}) followed by T8 (35.0 kg ha^{-1}) and T_2 (27.2 kg ha^{-1}) and the lowest P uptake was observed with T_1 (control) (13.4 kg ha^{-1}). N + K at 4 days interval (T_7) has recorded 48.1 % higher P uptake over T_2 (manual application of N and K fertilizers + drip irrigation treatment). Manual application of N and K fertilizers + drip irrigation treatment (T_2) has recorded 30.8 % higher P uptake over T_9 (manual application of N and K fertilizers + furrow irrigation treatment).At harvest highest uptake was recorded with T_7 (N + K at 4 days interval) (55.5 kg ha^{-1}) and the lowest P uptake was observed with T_1 (control) (19.9 kg ha^{-1}). N + K at 4 days interval (T_7) has recorded 56.3 % higher P uptake over T_2 (manual application of N and K fertilizers + drip irrigation treatment). Manual application of N and K fertilizers + drip irrigation treatment (T_2) has recorded 25 % higher P uptake over T_9 (manual application of N and K fertilizers + furrow irrigation treatment).

Potassium uptake

At 30 DAS, the highest uptake (4.2 kg ha^{-1}) was recorded with T_2 (manual application of N and K fertilizers + drip irrigation) and the lowest uptake was observed with T_1 (control) (2.8 kg ha^{-1}). Manual application of N and K fertilizers + drip irrigation treatment has recorded 27.3 % higher K uptake over T_7 (N and K at 4 days interval). Manual application of N and K fertilizers + drip irrigation (T_9) has recorded 10.5 % higher P uptake over manual application of N and K fertilizers + furrow irrigation (T_2). At 60 DAS highest uptake was recorded with T_7 (N + K at 4 days interval) (67.0 kg ha^{-1}) and the lowest uptake was recorded with T_1 (control) (11.4 kg ha^{-1}). N + K at 4 days interval (T_7) has recorded 74.5 % higher P uptake over T_2 (manual application of N and K fertilizers + drip irrigation treatment). Manual application of N and K fertilizers + drip irrigation treatment (T_2) has recorded 62.7 % higher P uptake over T_9 (manual application of N and K fertilizers + furrow irrigation treatment).

At 90 DAS, the highest uptake was recorded with T_7 (N + K at 4 days interval) (243 kg ha^{-1}) and the lowest K uptake was observed with T_1 (control) (79.0 kg ha^{-1}). N + K at 4 days interval (T_7) has recorded 42.0 % higher K uptake over T_2 (manual application of N and K fertilizers + drip irrigation treatment). Manual application of N and K fertilizers + drip irrigation treatment (T_2) has recorded 25.4 % higher P uptake over T_9 (manual application of N and K fertilizers + furrow irrigation treatment). At harvest, the highest uptake was recorded with T_7 (N + K at 4 days interval) (252.6 kg ha^{-1}and the lowest P uptake was observed with T_1 (control) (86.3 kg ha^{-1}). N + K at 4 days interval (T_7) has recorded 34.8 % higher K uptake over T_2 (manual application of N and K fertilizers + drip irrigation treatment). Manual application of N and K fertilizers + drip irrigation treatment (T_2) has recorded 22.3 % higher P uptake over T_9 (manual application of N and K fertilizers + furrow irrigation treatment).

Correlations and Regression between nutrient uptake and seed yield

Total nitrogen uptake was significantly correlated with seed yield and the highest correlation was noticed at harvest (0.892) followed by 90 DAS (0.882) and no significant correlation was noticed at 30 and 60 DAS as presented in Table 3. Total phosphorus and potassium uptake was not significantly correlated with seed yield at 30 DAS and were significantly correlated at 60, 90 DAS and harvest. In phosphorus uptake the highest correlation was noticed at harvest (0.842) followed by 90 DAS (0.835) and 60 DAS (0.770). In potassium uptake the highest correlation was noticed at 60 DAS (0.869) followed by 90 DAS (0.842) and harvest (0.841). The dependence of seed yield on total NPK uptakes was evident from significant (p=0.01) and positive correlation between yield and N uptake, P uptake and K uptake data. The determination coefficient (R^2) was noticed as 0.79 for total N uptake at harvest, 0.71 for total P uptake at harvest and 0.75 for total K uptake at 60 DAS which showed a linear increase in the nutrient uptakes with the corresponding increase in yield.

Table 1: Fertigation schedule of N and K (kg ha^{-1}) 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
Seed development	66-88 DAS	14-19	8.1	6	10.3	4.5
Total	88 days	19	75	30	75	30

Table 2: Nitrogen, Phosphorus and Potassium content of *rabi* sunflower as influenced by N and K fertigation schedules.

Treatments	Nitrogen content (%)						Phosphorus content (%)						Potassium content (%)					
	30 DAS	60 DAS	90 DAS		Harvest		30 DAS	60 DAS	90 DAS		Harvest		30 DAS	60 DAS	90 DAS		Harvest	
			Stalk	Seed	Stalk	Seed			Stalk	Seed	Stalk	Seed			Stalk	Seed	Stalk	Seed
T_1	0.15	0.29	0.38	0.81	0.63	1.37	0.22	0.17	0.13	0.19	0.12	0.24	0.23	0.56	1.30	0.69	0.91	0.58
T_2	0.14	0.38	0.50	1.06	0.73	1.73	0.25	0.21	0.15	0.23	0.14	0.26	0.32	0.76	1.62	0.97	1.15	0.76
T_3	0.18	0.44	0.53	1.26	0.86	1.74	0.25	0.20	0.16	0.24	0.18	0.31	0.24	0.70	1.56	0.87	1.07	0.68
T_4	0.17	0.41	0.50	1.09	0.74	1.81	0.21	0.20	0.14	0.22	0.15	0.29	0.22	0.60	1.53	0.85	1.07	0.67
T_5	0.13	0.34	0.44	0.93	0.66	1.63	0.25	0.19	0.15	0.23	0.18	0.31	0.26	0.88	1.83	1.04	1.46	0.84
T_6	0.12	0.30	0.40	0.85	0.59	1.52	0.19	0.18	0.14	0.21	0.15	0.25	0.25	0.80	1.63	0.98	1.23	0.81
T_7	0.20	0.47	0.61	1.19	0.89	1.78	0.23	0.21	0.20	0.26	0.21	0.32	0.27	0.92	1.81	1.07	1.44	0.87
T_8	0.19	0.38	0.58	1.06	0.78	1.84	0.23	0.20	0.17	0.25	0.19	0.29	0.25	0.82	1.78	1.04	1.21	0.86
T_9	0.16	0.38	0.50	1.04	0.73	1.71	0.27	0.22	0.14	0.21	0.13	0.26	0.27	0.60	1.62	0.93	1.11	0.77
SEm ±	0.03	0.05	0.05	0.23	0.08	0.08	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.05	0.07	0.06	0.07	0.05
CD (p=0.05)	NS	NS	NS	0.23	NS	0.25	0.04	NS	0.04	NS	0.03	0.04	0.05	0.14	0.23	0.17	0.20	0.15

* 100% RDF = 75-90-30 N- P2O5-K2O kg ha-1

* A common dose of phosphorus was applied as basal to all the treatments

Table 3: Plant nutrient uptake (kg ha-1) of rabi sunflower as influenced by N and K fertigation schedules.

Treatments	Nitrogen uptake (kg ha^{-1})				Phosphorus uptake (kg ha^{-1})				Potassium uptake (kg ha^{-1})			
	30 DAS	60 DAS	90 DAS Seed+ Stalk	Harvest Seed+ Stalk	30 DAS	60 DAS	90 DAS Seed+ Stalk	Harvest Seed+ Stalk	30 DAS	60 DAS	90 DAS Seed+ Stalk	Harvest Seed+ Stalk
T_1 - Control (N_0K_0)	1.8	6.0	50.5	108.8	2.7	3.5	13.4	19.9	2.8	11.4	79.0	86.3
T_2 - Manual application of N and K + drip	1.9	19.5	112.7	219.4	3.3	10.6	27.2	35.5	4.2	38.4	171.1	187.4
T_3 - Fertigation of N at 4 days interval	2.3	29.2	108.8	212.2	3.2	13.2	25.1	40.2	3.1	46.0	140.9	152.3
T_4 - Fertigation of N at 8 days interval	2.1	25.2	93.5	201.3	2.7	12.4	20.9	34.9	2.8	37.2	134.1	142.9
T_5 - Fertigation of K at 4 days interval	1.6	12.4	73.0	166.8	3.2	6.9	20.2	35.9	3.3	31.8	161.7	167.7
T_6 - Fertigation of K at 8 days interval	1.5	10.8	60.2	143.7	2.4	6.3	16.8	27.3	3.1	28.3	124.7	139.0
T_7 - Fertigation of N and K at 4 days interval	2.6	33.8	158.1	281.6	3.0	15.2	40.3	55.5	3.3	67.0	243.0	252.6
T_8 - Fertigation of N and K at 8 days interval	2.4	25.5	137.9	257.2	2.9	13.3	35.0	47.4	3.2	54.8	202.5	237.1
T_9 - Manual application of N and K + furrow	2.3	15.0	91.9	179.7	3.8	8.7	20.8	28.4	3.8	23.6	136.4	153.2
SEm ±	0.11	1.47	5.9	8.65	0.16	0.75	1.64	1.38	0.20	2.52	4.85	8.12
CD (p=0.05)	0.34	4.45	17.9	26.15	0.49	2.27	4.98	4.19	0.60	7.63	14.69	24.58

* 100% RDF = 75-90-30 N- P2O5-K2O kg ha-1
* A common dose of phosphorus was applied as basal to all the treatments

Table 4: Correlations and regression between seed yield of sunflower with nutrient uptake at different growth stages

Parameter	DAS	r^2 value	Regression equation	R^2
Total N uptake (kg ha^{-1})	90 (total)	0.882**	y = 11.32x + 821.6	0.78
	Harvest (total)	0.892**	y = 7.475x + 467	0.79
Total P uptake (kg ha^{-1})	60	0.770**	y = 87.69x + 1059	0.59
	90 (total)	0.835**	y = 43.29x + 880.5	0.70
	Harvest (total)	0.842**	y = 35.75x + 646.9	0.71
Total K uptake (kg ha^{-1})	60	0.869**	y = 23.63x + 1048	0.75
	90 (total)	0.842**	y = 8.164x + 673.7	0.71
	Harvest (total)	0.841**	y = 7.566x + 660.8	0.71

*=significant at 95% and **=significant at 99% of confidence level.
R2 : Equal or above of 0.381 at 95% and 0.487 at 99% level of significance

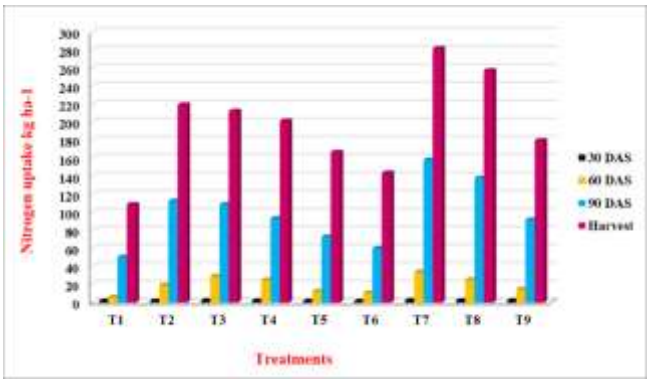


Fig 1: Nitrogen uptakes (kg ha-1) of rabi sunflower at different growth stages as influenced by N and K fertigation schedules.

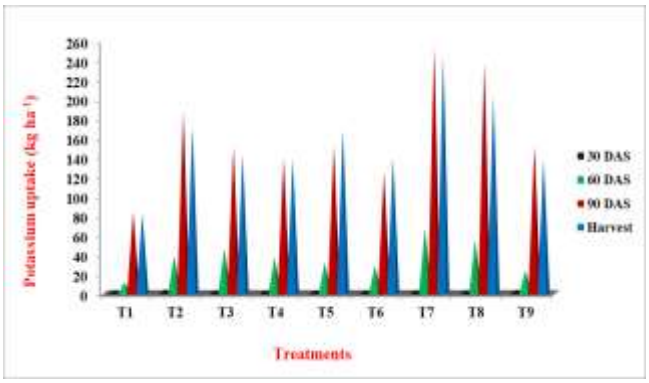


Fig 3: Potassium uptakes (kg ha-1) of rabi sunflower at different growth stages as influenced by N and K fertigation schedules.

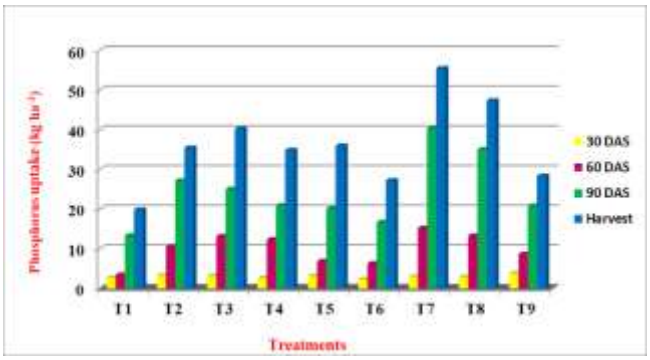
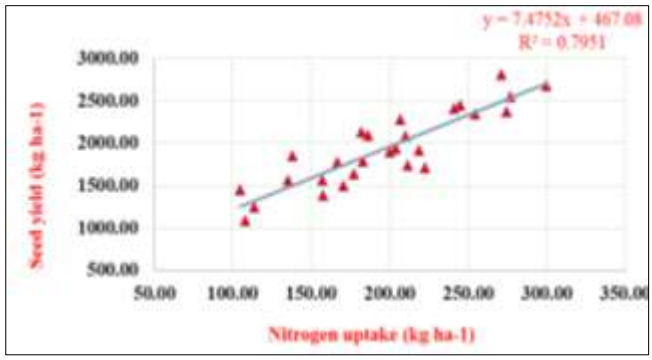


Fig 2: Phosphorus uptakes (kg ha^{-1}) of *rabi* sunflower at different growth stages as influenced by N and K fertigation schedules.



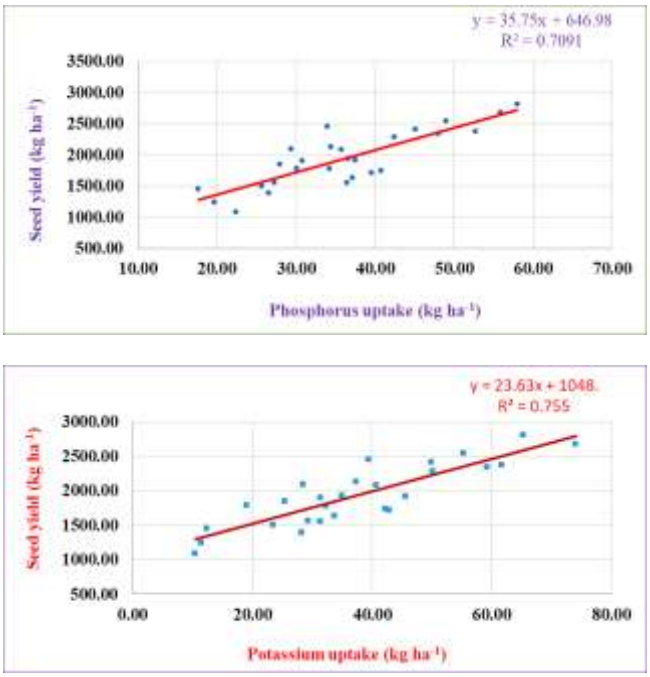


Fig 4: Regression of sunflower seed yield with nitrogen, phosphorus and potassium uptake (kg ha-1) at harvest.

Conclusion

From the above result it was observed that nutrient uptake in sunflower was highest with the application of 100% RD of N and K through fertigation over manual soil application method with drip or furrow irrigation. N+K (75 kg N and 30 kg K_2O ha^{-1}) applied by fertigation at 4 days interval has resulted in the highest total N (281.6 kg ha^{-1}), P (55.5 kg ha^{-1}) and K (252.6 kg ha^{-1}) uptakes at harvest followed by N+K (75 kg N and 30 kg K_2O ha^{-1}) applied by fertigation at 8 days interval (257.6 kg ha^{-1}, 47.4 kg ha^{-1}, 237.1 kg ha^{-1})

References

1. DoES, Statistical year book 2017. Directorate of Economics and Statistics (DoES), Government of Telangana, Hyderabad.
2. DoES, Agricultural statistics at a glance 2018. Ministry of Agriculture and Farmer's Welfare. Department of Agriculture, Cooperation & Farmers Welfare. Directorate of Economics and Statistics (DoES).
3. Himaja I. Responce of maize, sorghum and sunflower to different fertigation levels. *M.Sc* Thesis. Professor Jayashanker Telangana State Agriculture University, Hyderabad, India. 2017.
4. Narda NK, Lubana PPS. Studies on growth dynamics and yield of trickle fertigated okra. *Journal of Research, Punjab Agricultural University*, 2000; 39: 272-276.
5. Patel N, Rajput TGS. Effect of fertigation on growth and yield of onion, In: Proceedings international conference on micro and sprinkler irrigation system, 2000; 8-10 February, Jalgaon, Maharastra.
6. Sanju HR. Effect of precision water and nutrient management with different sources and levels of fertilizer on yield of groundnut. *M. Sc Thesis*. University of Agricultural Sciences, GKVK, Banglore, India. 2013.
7. Sekhar PC. Response of *rabi* pigeonpea to different nutrigation levels. *M.S.c Thesis*, Acharya NG Ranga Agricultural University, Rajendranagar, Hyderabad. 2014.