Irrigation methods and fertilizer application effects on growth and yield parameters, yield, economics and water use efficiency in groundnut

Abstract

The present investigation was carried out at Agricultural Research Station, Bhavanisagar, Erode district of Tamil Nadu to study the effect of irrigation methods and fertilizer application effects on growth and yield parameters, yield, economics and water use efficiency in groundnut. The various irrigation methods followed were I_1 – Drip irrigation, I_2 – Drip fertigation, I_3 – Sub surface drip irrigation, I_4 – Sub surface drip fertigation, I_5 – Sprinkler irrigation and I_6 – Conventional method of irrigation as main plot treatments and the various methods of application of fertilizers were S_1 – Absolute control (No fertilizer), S_2 – Recommended dose of NPK fertilizers through normal fertilizers / Recommended dose of NPK fertilizers through water soluble fertilizers (According to the irrigation treatment) and S_3 - S_2 + Vermicompost @ 5 t ha^{-1} imposed as subplot treatments, and the treatments were replicated thrice. The experiment was laid out in strip plot design in a plot size of 15 M^2. Application of recommended dose of fertilizers (25: 50: 75 kg NPK ha^{-1})along with vermicompost @ 5 t ha^{-1} with sub surface drip fertigation recorded highest growth [plant height (49.3 cm); number of branches (7.1) and number of leaves (69.2)] and yield attributes [number of pods per plant (38.2)], yield [pod yield (3271 kg ha^{-1})] high Benefit Cost Ratio (3.03) and water use efficiency (15.16 kg ha^{-1}. mm) as compared to the other treatments in groundnut (var. VRI 3).

Key words: Irrigation, Fertilizer, Growth, yield parameters, Yield, Economics, Water use efficiency, Groundnut

Introduction

Groundnut (*Arachis hypogaea* L.) is an important oilseed and food legume crop of the tropical and subtropical world. The peanut kernels contain 45–55% oil and 25–34% protein and are the fourth most important source of edible oil and the third most important source of protein in the world (Abbas Manthiri *et a*l, 2017; Snehal

Datarkar *et al*, 2015). Though high in fat, peanut primarily contains good fat (unsaturated and free from trans types) and helps to maintain blood cholesterol levels and therefore friendly to heart. Peanut oil is good from both nutritive and culinary point of views as it contains good quantities of monounsaturated fatty acids (MUFA) (oleic acid, 40–50%) and polyunsaturated fatty acids (PUFA) (linoleic acid, 25–35%). With this high oleic/linoleic ratio, peanut oil has a relatively longer shelf-life. The tocopherol (approx. 0.9 mg g^{-1} oils) and antioxidant present in peanut oil prevent the development of rancidity (Prabhu, 2018; Jain and Meena, 2015)

In India, peanut is one of the important oilseed crops and occupies an area of 5.86 M ha with the production of 8.27 M tonnes and productivity of 1411 kg ha^{-1} (2010–11) which is quite low as compared to other countries. Among the various factors that limit the productivity of peanut, efficient use of available water and fertilizer is highly critical for improving the crop productivity (Jain *et al.,* 2018).

A review on the use of fertigation by Jat *et al.* (2011) from ICRISAT, Hyderabad, suggested that to make agriculture sustainable and economically viable, there is a need to promote fertigation on a large scale by the concerned stakeholders/farmers. Over and above, fertigation by means drip irrigation clearly assures the saving of two important resources, water, and nutrient, and thus economically viable for farmers by one-time cost investment of drip system installation. Therefore, the present investigation was carried out to study the effect of irrigation methods and fertilizer application on growth and yield parameters, yield, economics and water use efficiency in groundnut.

Materials and methods

A field experiment was conducted at Agricultural Research Station, Bhavanisagar, Erode district of Tamil Nadu. The soil type of the experimental site was red sandy loam, neutral (pH 7.7) with low organic carbon (0.12 %) and available nitrogen (252 kg ha^{-1}), and medium in available phosphorus (13.0 kg ha^{-1}), and high in potassium (535 kg ha^{-1}). The experiment consisted of six irrigation methods, *viz.*, I_1 – Drip irrigation, I_2 – Drip fertigation, I_3 – Sub surface drip irrigation, I_4 – Sub surface drip fertigation, I_5 – Sprinkler irrigation and I_6 – Conventional method of irrigation as main plots and three fertilizer schedules, *viz.*, S_1 – Absolute control (No

fertilizer), S_2 – Recommended dose of NPK fertilizers through normal fertilizers / Recommended dose of NPK fertilizers through water soluble fertilizers (According to the irrigation treatment) and S_3 - S_2 + Vermicompost @ 5 t ha^{-1} as subplots, allotted in strip plot design using three replications. The recommended dose of fertilizer was 25: 50: 75 kg NPK ha^{-1} (treated as 100% NPK) and supplied through urea, single superphosphate, and muriate of potash, respectively. In surface method of irrigation, the recommended doses of NPK were applied in furrows at the time of sowing. Whereas in drip irrigation, phosphorus (P) was applied as per treatments in furrows as basal dose, and N and K were applied as per treatments through fertigation through drip. Groundnut variety VRI was the test crop. The intercultural operations like spraying herbicides, gap filling, hand weeding, gypsum application, earthing up and plant protection measures were followed as per crop production guide. The irrigation and fertilizer application were followed as per the treatment schedule. The growth and yield parameters *viz.,* the plant height, number of branches, number of leaves, leaf length and leaf breadth, number of pods $plant^{-1}$ and pod yield were recorded during harvest of the crop.

Results and Discussion

Growth parameters

The growth parameters *viz.,* plant height, number of branches, number of leaves, leaf length and leaf breadth were recorded and reported in table 1 and 2. The data indicated that, among the main plot treatments I_4 (sub surface drip fertigation) recorded the highest plant height (45.2 cm) and it is on par with I_3 (sub surface drip irrigation). There was significant difference between the main plot treatments. Among the subplot treatments the highest plant height (44.4 cm) was recorded by S_3 (recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1}) followed by S_2 and S_1. Among the interactions, sub surface drip fertigation with recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1} (I_4S_3) recorded the highest plant height. The interaction effect was not significant.

The data on number of branches and number of leaves of groundnut indicated that, among the main plot treatments I_4 (sub surface drip fertigation)

recorded the highest number of branches (6.7) and number of leaves (64.5). The main plot treatments not significantly influenced the number of leaves and number of branches. Among the subplot treatments the highest number of branches (7.1) and number of leaves (67.4) were recorded by S_3 (recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1}). The number of branches and number of leaves were significantly influenced by subplot treatments. Among the interactions, sub surface drip fertigation with recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1} (I_4S_3) recorded the highest number of branches and number of leaves. The interaction effect was not significant.

Table 1. Growth parameters of groundnut as influenced by treatments

Treatments	Plant height (cm)				Number of branches				Number of leaves			
	S_1	**S_2**	**S_3**	**Mean**	**S_1**	**S_2**	**S_3**	**Mean**	**S_1**	**S_2**	**S_3**	**Mean**
I_1	38.4	40.9	43.4	**40.9**	6.0	6.6	7.2	**6.6**	55.5	61.2	67.9	**62.0**
I_2	37.4	42.2	43.0	**40.9**	6.1	6.5	7.2	**6.6**	57.9	64.9	69.1	**63.9**
I_3	42.4	43.9	48.1	**44.8**	5.4	6.4	7.8	**6.6**	58.0	64.2	71.2	**64.4**
I_4	42.2	44.2	49.3	**45.2**	6.3	6.6	7.1	**6.7**	65.6	58.7	69.2	**64.5**
I_5	39.6	41.1	41.4	**40.7**	6.3	5.3	5.9	**6.5**	54.2	57.5	65.4	**59.0**
I_6	38.0	39.5	41.1	**39.6**	5.5	6.0	6.7	**6.0**	50.6	53.8	61.4	**55.3**
Mean	**39.7**	**42.0**	**44.4**		**5.8**	**6.3**	**7.1**		**57.1**	**60.0**	**67.4**	
	SED		CD (0.05)		SED		CD (0.05)		SED		CD (0.05)	
I	1.37		3.05		0.75		NS		3.7		NS	
S	0.92		1.9		0.16		0.35		2.4		4.9	
I at S	2.30		4.9		0.82		1.81		6.1		12.9	
S at I	2.25		NS		0.41		NS		5.9		NS	

With respect to leaf length of groundnut, the main plot treatments not significantly influenced the parameter. The treatment I_4 (sub surface drip fertigation) recorded the highest leaf length (5.93 cm). Among the subplot treatments the highest leaf length (5.9 cm) was recorded by S_3 (recommended dose of NPK fertilizers +

vermicompost @ 5 t ha^{-1}) and the treatments S_1 and S_2 were on par with each other. The interaction effect was not significant.

With respect to leaf breadth of groundnut, the main plot treatments were not significantly influenced the parameter. The treatment I_4 (sub surface drip fertigation) recorded the highest leaf breadth (2.93 cm). Among the subplot treatments S_3 (recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1}) recorded the highest leaf breadth (3.0 cm) when compared to S_2 (recommended dose of NPK fertilizers) and S_1 (no fertilizer). The interaction effect was significant. Among the interactions, sub surface drip fertigation with recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1} (I_4S_3) recorded the highest leaf breadth.

Table 2. Growth parameters of groundnut as influenced by treatments

Treatments	Leaf length (cm)				Leaf breadth (cm)			
	S_1	**S_2**	**S_3**	**Mean**	**S_1**	**S_2**	**S_3**	**Mean**
I_1	5.2	5.2	5.4	**5.23**	2.4	2.8	2.9	**2.70**
I_2	5.3	5.5	6.1	**5.63**	2.7	2.8	3.1	**2.86**
I_3	5.6	5.8	6.3	**5.90**	2.6	2.9	3.2	**2.90**
I_4	5.6	5.9	6.3	**5.93**	2.6	3.0	3.2	**2.93**
I_5	5.0	5.4	5.9	**5.43**	2.6	2.8	2.9	**2.76**
I_6	4.7	5.1	5.3	**5.03**	2.6	2.7	2.7	**2.66**
Mean	**5.3**	**5.5**	**5.9**		**2.6**	**2.6**	**3.0**	
	SED		**CD (0.05)**		**SED**		**CD (0.05)**	
I	0.33		NS		0.20		NS	
S	0.12		0.26		0.03		0.07	
I at S	0.41		0.91		0.21		0.47	
S at I	0.30		NS		0.08		0.17	

The pod yield of groundnut is reported in table 3. The pod yield of groundnut was not significantly influenced by the main plot treatments. The yield data indicated that, among the main plot treatments the highest pod yield of 2601 kg ha^{-1}

was recorded by sub surface drip fertigation (I_4) when compared to other methods of irrigation. Among the subplot treatments the highest pod yield was recorded by S_3 (recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1}) as 2591 kg ha^{-1}, when compared to S_2 (recommended dose of NPK fertilizers). The subplot treatments significantly influenced the pod yield. Among the interactions, sub surface drip fertigation with recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1} (I_4S_3) recorded the highest pod yield of 3271 kg ha^{-1} (Khanday and Ali, 2012). Rank *et al.,* (2003) found that pod yield of peanut at 1, 2, 3, 4, and 5 days irrigation interval (keeping total depth of irrigation water constant) in drip irrigation were statistically at par. However, maximum pod yield value was obtained at 3 days irrigation interval. The average pod yield was increasing from 1 day interval to 3 days interval at decreasing rate and after that it is decreasing at decreasing rate from 3 days interval to 5 days interval. Marked increase in economic yield appeared to be as a result of the beneficial effect of fertigation on growth and yield parameters of the crop (Tables 2 and 3). Further, increased nutrient availability and absorption by the crop at the optimum moisture supply coupled with frequent nutrient supply by fertigation and consequent better formation and translocation of assimilates from source to sink might have increase yield under fertigation (Jayakumar *et al.,* 2014). Irrigation system permits multiple small dose fertilizer applications at different intervals, reducing the risk of leaching compared to fertilizers applied in a single application. Similar were the findings of Singandhupe *et al.* (2003).

Table 3.Yield and yield attributes of groundnut as influenced by treatments

Treatments	Pod yield (Kg ha^{-1})				Number of pods $plant^{-1}$			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
I_1	1433	1752	2422	**1937**	17.2	24.1	30.9	**24.1**
I_2	1489	1945	2675	**2188**	21.8	30.0	31.4	**27.1**
I_3	1845	2433	2889	**2237**	17.0	28.6	39.8	**28.4**
I_4	1978	2555	3271	**2601**	23.1	28.7	38.2	**30.0**
I_5	1380	1687	2366	**1798**	14.9	20.9	30.9	**22.2**
I_6	1050	1278	1922	**1679**	18.7	20.3	24.5	**21.2**

Mean	**1554**	**2075**	**2591**		**18.8**	**25.1**	**32.6**	
	SED		CD (0.05)		SED		CD (0.05)	
I	90		192		5.51		NS	
S	29		60		1.86		3.84	
I at S	107		233		6.65		14.5	
S at I	71		147		4.56		NS	

The number of pods plant^{-1} of groundnut showed similar trend as that of pod yield. Sub surface drip fertigation with recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1} (I_4S_3) recorded the highest number of pods (30) when compared to other methods of irrigation with various fertilizer treatments. Efficient and greater partitioning of metabolites and adequate translocation and accumulation of photosynthates, amino acids, vitamins etc. to developing reproductive structures under adequate and increased nutrient use efficiency seems to have resulted in increase in the yield attributing characters. The fertigation provided better conducive conditions for better uptake of nutrients and in turn helped the plants to boost their growth leading to the development of yield attributes through supply of more photosynthates towards the reproductive sink compared to conventional method of soil application of nutrients (Jayakumar, *et al.,* 2014).

Economics

Irrigation regimes and fertilizer treatments increased the net return. Sub surface drip fertigation with recommended dose of NPK fertilizers + vermicompost @ 5 t ha^{-1} (I_4S_3) recorded the highest B : C ratio of 3.03, followed by sub surface drip fertigation with recommended dose of NPK fertilizers (I_4S_2) as 2.90. The lowest B : C ratio of 1.81 was recorded with conventional method of irrigation with no fertilizer (I_6S_1).

Table 4 : **Comparing Income, Cost of cultivation, Net return and B: C ratio for different treatments**

Groundnut					
Treatments	**Yield (kg ha^{-1})**	**Gross return (Rs.)**	**Cost of cultivation (Rs.)**	**Net return (Rs.)**	**B: C ratio**
I_1S_1	1433	35825	18500	17325	1.94
I_1S_2	1752	43800	20000	23800	2.19
I_1S_3	2422	60550	25000	35550	2.42
I_2S_1	1489	37225	18500	18725	2.01
I_2S_2	1945	48625	20000	28625	2.43
I_2S_3	2675	66875	25000	41875	2.56
I_3S_1	1845	46125	20500	25625	2.15
I_3S_2	2433	60825	22000	38825	2.76
I_3S_3	2889	72225	27000	45225	2.68
I_4S_1	1978	49450	20500	28950	2.30
I_4S_2	2555	63875	22000	41875	2.90
I_4S_3	3271	81775	27000	54775	3.03
I_5S_1	1380	34500	18500	16000	1.86
I_5S_2	1687	42175	20000	22175	2.00
I_5S_3	2366	59150	25000	34150	2.28
I_6S_1	1050	26250	14500	11750	1.81
I_6S_2	1278	31950	16000	15950	2.00
I_6S_3	1922	48050	21000	27050	2.28

Cost of groundnut seed = Rs. 25.00/ kg

Water use efficiency

The water use efficiency was worked out and furnished Table 5. The results showed that, the highest total water used was noticed in conventional method of irrigation as 667.9 mm and 839.1 mm for maize and groundnut respectively. The water use efficiency of treatments indicated that, the highest water use efficiency

values was noted with sub surface drip fertigation as 15.163 kg ha^{-1}mm 6.176 kg ha^{-1}mm for maize and groundnut respectively and the lowest value was noted with conventional method of irrigation as 5.240 kg ha^{-1}mm and 1.251 kg ha^{-1}mm for maize and groundnut respectively.

Table 5. Total water used and water use efficiency

Particu. / Treat.	Maize			Groundnut		
	Yield (kg ha^{-1})	Total water used (mm)	WUE (kg ha^{-1} mm)	Yield (kg ha^{-1})	Total water used (mm)	WUE (kg ha^{-1}mm)
I_1S_1	4330	432.5	10.012	1433	529.6	2.706
I_1S_2	5096	432.5	11.783	1752	529.6	3.308
I_1S_3	5567	432.5	12.872	2422	529.6	4.573
I_2S_1	4456	432.5	10.303	1489	529.6	2.812
I_2S_2	5232	432.5	12.097	1945	529.6	3.673
I_2S_3	5952	432.5	13.762	2675	529.6	5.051
I_3S_1	4870	432.5	11.260	1845	529.6	3.484
I_3S_2	5560	432.5	12.855	2433	529.6	4.594
I_3S_3	6364	432.5	14.714	2889	529.6	5.455
I_4S_1	5032	432.5	11.635	1978	529.6	3.735
I_4S_2	5868	432.5	13.568	2555	529.6	4.824
I_4S_3	6558	432.5	15.163	3271	529.6	6.176
I_5S_1	4260	432.5	9.850	1380	529.6	2.606
I_5S_2	4715	432.5	10.902	1687	529.6	3.185
I_5S_3	5368	432.5	12.412	2366	529.6	4.468
I_6S_1	3500	667.9	5.240	1050	839.1	1.251
I_6S_2	4109	667.9	6.152	1278	839.1	1.523
I_6S_3	4600	667.9	6.887	1922	839.1	2.291

Conclusions

Application of recommended dose of fertilizers + vermicompost @ 5 t ha^{-1} with sub surface drip fertigation recorded the growth and yield attributes and yield of groundnut, high Benefit Cost Ratio and water use efficiency when compared to the other treatments.

References

Abbas Manthiri A., Mohamed Sali A. and Sulthan Mohideen A. 2017. **Intercontinental Journal of Marketing Research Review**, 5, 11-25.

Jain, N. K., H. N. Meena, Debarati Bhaduri and R. S. Yadav. 2018. Drip fertigation and irrigation interval effects on growth, productivity, nutrient, and water economy in summer peanut. Communications In Soil Science And Plant Analysis. ISSN: 0010-3624 (Print) 1532-2416 (Online) Journal homepage: http://www.tandfonline.com/loi/lcss20

Jat, R. A., S. P. Wani, K. L. Sahrawat, P. Singh, and B. L. Dhaka. 2011. Fertigation in vegetable crops for higher productivity and resource use efficiency. **Indian Journal of Fertilisers 7 (3**):22–37.

Jayakumar, M., U. Surendran, and P. Manickasundaram. 2014. Drip fertigation effects on yield, nutrient uptake and soil fertility of Bt Cotton in semi arid tropics. **International Journal of Plant Production 8 (3):**375–90.

Jain, N. K., and H. N. Meena. 2015. Improving productivity of groundnut (Arachis hypogaea) by using water soluble fertilizer through drip irrigation. **Indian Journal of Agronomy 60 (1):**109–15.

Khanday, A.S. and Ali, N. 2012. Effect of different fertilizer and irrigation management systems on soil physico-chemical properties and pod yield of garden pea (*Pisum sativum* L.**). Annals of Horticulture 5(1),** 34-40.

Prabu P.C. 2018. **International Journal of Advances in Agricultural Science and Technology, 5,** 17 - 24.

Rank, H. D., R. H. Chaghada, V. K. Saradhara, H. V. Parmar, and D. K. Vyas. 2003. Optimal irrigation scheduling for summer groundnut crop under hot arid climate. International Seminar on Downsizing Technology for Rural Development, held at Regional Research Laboratory, Bhubaneswar during 7–9 October, 2003, pp.254–57.

Singandhupe, R. B., G. G. S. N. Rao, N. G. Patil, and P. S. Brahmanand. 2003. Fertigation studies and irrigation scheduling in drip irrigation system in tomato crop (Lycopersicon esculentum L.). **European Journal of Agronomy 19(2):** 327–40. doi:10.1016/S1161-0301(02)00077-1.

Snehal Datarkar , Pagire B V, Ashwini Darekar and Hile R. B. (2015). Regionwise Compound Growth rate in Area, Production and Productivity of Kharif Groundnut in Maharashtra. International Journal of Tropical Agriculture. 33:1101-1106