Vegetable Science (2018) 45 (1) : 97-101

Effect of drip irrigation and fertigation on growth and yield of garden pea

Sunil Garg*, Angrej Singh and Rakesh Sharda

Received: April 2018 / Accepted: May 2018

Abstract

A field experiment was conducted during 2014-15 and 2015-16 on loamy sand soil to study the effect of drip irrigation and fertigation as compared to surface (check basin) irrigation on the pod yield, water use efficiency of garden pea (*Pisum sativum var.* Punjab 89). The treatments comprised of three levels of drip irrigation in combination with three levels of fertigation and surface irrigation (check basin) was considered as control treatment. The I_2F_2 (drip irrigation at 80% ET crop along with 80% application of recommended dose of fertilizer produced (183.4 q/ha) green pod yield which was 34.2 percent higher as compared to check basin method of irrigation (136.7 q/ha). Drip irrigation resulted in 42.8 % saving of irrigation water as compared to check basin method of irrigation.

Key words: Drip irrigation, Fertigation, Garden pea and Water use efficiency

Introduction

Garden pea is an important vegetable in Punjab. It contains very low quantity of saturated fat, cholesterol and sodium. It is a good source of Vitamin A, niacin, vitamin B_6, folate, phosphorus, copper and a very good source of dietary fibre, vitamin C, vitamin K, thiamine and manganese. Fresh pea contains 75 g water, 6.2 g protein, 0.4 g fat, 17 g carbohydrates, 2.4 g crude fibre, 1.0 g ash, 32.0 mg phosphorus, 1.2 mg iron, 6 mg sodium, 350 mg potassium, 450 mg ß-carotene, 0.28 mg thiamin, 11 mg riboflavin, 2.8 mg niacin and 27 mg ascorbic acid per 100 g (Dhaliwal, 2010). In Punjab pea was grown on an area of 20,540 ha with production of 2.11 lakh tonne with average green pod yield of 10.3 t/ha during 2013-14 (Anonymous 2015). The improved varieties of Pea can result in further enhancement in yield of this crop with the adoption of scientific technology in management of irrigation and fertilizers. Drip irrigation and fertigation technology has proved its superiority over conventional methods of irrigation particularly in fruits and vegetable crops. Most of the vegetable crops are sensitive to both excess as well as low moisture content. Precise and localized application of water and fertilizer in the root zone of the crop results in increased yield of this crop (Raina et al. 1998). Singh et al. (2006) evaluated the effect of various levels of water and N application through drip irrigation on yield and water use efficiency of green pea crop. The highest yield (154.3 q/ha) was observed when 100 % of recommended N was applied through drip at lower level of irrigation (0.5 E_{pan}). Rao et al. (2017) concluded that the performance of pea crop was found to be better under micro sprinkler irrigation, considering the crop growth parameters, crop yield and water productivity in comparison with drip and conventional irrigated pea. Sharma (2011) studied the effect of different irrigation and fertilizer management systems on soil properties in pea taking three different management systems and six of fertilizer levels and sources. Fertigation has become an attractive method of fertilization in modern intensive agriculture systems. Water and nutrient are the main factors of production in irrigated agriculture and are major inputs in contributing higher productivity and quality of the produce. The method of irrigation and fertilizer application affects the efficiency of these costly inputs in arid and semi arid regions. Improvement in the water and nutrient use efficiency is of utmost importance because these are costly and scarce (Biswas 2010). Keeping these points in view an experiment was planned to study the effect of drip irrigation and fertigation on the pod yield in pea.

Materials and Methods

A field experiment was conducted during *rabi* season of 2014-15 and 2015-16 at the research farm department of Soil and Water Engineering (30°-56¹ N, 75°-56¹ E

Punjab Agricultural University, Ludhiana, Punjab 141004

*Corresponding author; Department of Soil and Water Engineering, PAU, Ludhiana, Punjab; Email: sunil1765@pau.edu

and 247 m above mean sea level) Punjab Agricultural University, Ludhiana, India. The region is characterized by a sub tropical and semi arid climate. The average annual rainfall is approximately 700 mm of which about 70% is received during monsoon season. The rainfall received during crop growing period (October to March) was 136.5 mm for 2014-15 and 79.2 mm during 2015-16, respectively (Table 1). The soil of the experimental site was loamy sand in texture with soil pH (7.9) and

Table 1: Total monthly rainfall during pea crop growing season in 2014-15 and 2015-16

Month	Monthly rainfall (mm)	
	2014-15	2015-16
October	8.1	9.0
November	0.0	0.0
December	42.2	1.7
January	19.2	19.4
February	39.0	8.8
March	28.0	40.3
Total	136.5	79.2

electrical conductivity (0.20 dSm^{-1}), low in organic carbon (0.37%) & available N (262 kg/ha) and very high in available P (38.0 kg ha^{-1}) and medium in available K (260.5 kg ha^{-1}). The experiment was laid out in randomized block design with three replications and a plot size of 24 m^2 (10 m × 2.4 m). The Punjab-89 variety of garden pea was sown on 16th October 2014 and 20th October 2015 at row to row spacing of 30 cm and plant to plant spacing of 7.5 cm. The Pea seed was inoculated with recommended *Rhizobium* culture and dried in shade before sowing. The daily ETcrop values for the crop season were calculated using Modified Penman method based upon daily meteorological data. The lateral lines were placed parallel to the crop rows and one drip lateral (16 mm dia) with inline emitters placed at 30 cm distance, with discharge rate of 2.2 litres per hour (when operated at pressure =1.5 kg/cm^2) was placed between the two crop rows. Drip irrigation to different plots was given every 3rd day as per treatments for the whole season. The recommended dose of 50 kg nitrogen (N) and 62.5 kg phosphorous (P_2O_5) per ha, was applied though fertigation in 100 percent RDF, the fertilizer dose in other plots were reduced according to treatment as per recommended Package and Practices, PAU, Ludhiana. Fertigation was done with every alternate drip irrigation throughout the crop season. The 20% of the fertilizers was applied during the first month in 5 equal splits after germination. Remaining amount of the fertilizer was applied in 9 equal splits. Thus, in total 14 split doses as fertigation were applied starting from 15 days after sowing of the crop, with every alternate irrigation. N fertilizer was applied in the form of Urea and P_2O_5 in the form of Mono Ammonium Phosphate (MAP) by using fertilizer tank. In the conventional (check basin) irrigation plot whole of N and P fertilizer were applied by broadcast method before sowing of the crop. The observations on plant height were recorded at periodic interval. The pod length, number of pods per plant, shelling percentage and number of grains/seeds per pod were recorded in the field at different intervals of time up to the harvesting and average value was taken for these parameters. The pods were picked in four pickings during 2015 and first picking was done on 8th January 2015 and last picking was done on 7th March 2015. During the second year first picking was done on 20th January 2016 and last picking was done on 6th March 2016. The total number of treatments was ten comprising combination of three levels of drip irrigation at 0.6, 0.8 and 1.0 times crop evapo-transpiration (ET_{crop}) i.e. I_1, I_2 and I_3respectively and three fertigation levels (60%, 80% and 100% of the recommended dose of N and P i.e. F_1, F_2 and F_3 respectively). The tenth treatment of surface/check basin irrigation with broadcast application of fertilizer (basal) was considered as conventional treatment (CT). The detailed treatment combinations are as: T_1: ET_{crop} 0.6 and 60% RDF fertigation (I_1F_1); T_2: ET_{crop} 0.6 and 80 % RDF fertigation (I_1F_2); T_3: ET_{crop} 0.6 and 100 % RDF fertigation (I_1F_3); T_4: ET_{crop} 0.8 and 60 % RDF fertigation (I_2F_1); T_5: ET_{crop} 0.8 and 80 % RDF fertigation (I_2F_2); T_6: ET_{crop} 0.8 and 100 % RDF fertigation (I_2F_3); T_7: ET_{crop} 1.0 and 60 % RDF fertigation (I_3F_1); T_8: ET_{crop} 1.0 and 80 % RDF fertigation (I_3F_2); T_9: ET_{crop} 1.0 and 100 % RDF fertigation (I_3F_3); and T_{10}: Check basin irrigation with fertilizer application by broadcasting.

Results and Discussion

Growth Parameter: Plant height is an important growth parameter as it gives an indication about dry matter production leading to ultimate yield. It was observed that plant height increased consistently throughout the crop season for all the treatments. The pooled analysis of data (Table 2) revealed that plant height of garden pea crop at harvest exhibited non significant differences due to different combinations of irrigation and fertigation treatments. At harvest, the highest plant height (66.5cm) was registered in the I_2F_3 treatment as compared to other drip fertigated combinations. It was closely followed by the treatments I_3F_2 (65.8 cm), I_2F_2 (65.6 cm). The highest plant height in I_2F_3 treatment might be due to the reason that there was no water stress either due to water shortage or due to excess water in the root zone. Crop grown under drip irrigation in all the treatments had more plant height compared to conventional check

Table 2: Effect of different drip irrigation and fertigation levels on plant height of garden pea

Treatments	Final Plant height (cm)			Dry matter(q/ha)		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
I_1F_1	61.4	60.1	60.8	35.7	37.6	36.6
I_1F_2	63.3	62.9	63.1	37.4	41.7	39.6
I_1F_3	65.9	63.5	64.7	41.3	43.7	42.5
I_2F_1	63.9	63.7	63.8	39.1	38.4	38.7
I_2F_2	64.0	67.7	65.6	42.1	46.3	44.2
I_2F_3	68.2	64.9	66.5	47.5	42.1	44.8
I_3F_1	62.3	64.3	63.3	38.9	41.1	40.1
I_3F_2	65.8	65.8	65.8	40.8	43.1	41.9
I_3F_3	64.7	66.1	65.4	42.9	43.6	43.2
Control	60.2	57.9	59.0	38.8	34.3	35.7
CD at 0.05%	NS	NS	NS	NS	NS	5.3

basin irrigation treatment (59.0 cm). This clearly indicated that different drip fertigation treatments had advantageous effect over conventional check basin irrigation treatment. Pooled analysis of data on dry matter production (Table 2) showed that dry matter accumulation was significantly influenced by different drip fertigation treatments. The, maximum dry matter accumulation (44.8 q/ha) was recorded in I_2F_3 treatment which was statistically at par with I_2F_2 (44.2 q/ha) and closely followed by I_3F_3 (43.2 q/ha) under drip fertigation combinations. The lowest dry matter accumulation 35.7 q/ha was recorded in surface check basin irrigated plot with broadcast (basal) application of fertilizers.

Pod yield: The number of pods/plant and green pod yield varied significantly, however other yield attributes viz. pod length, grains per pod and shelling percentage were not significantly affected due to different drip irrigation and fertigation treatments. The pooled analysis of data revealed that all the drip irrigation and fertigation treatment combinations recorded significantly higher number of pods per plant as compared to conventional irrigation i.e. check basin irrigation plot. Pooled analysis of data revealed that among all the drip fertigated treatment combinations, the highest green pod yield of 183.4 q/ha was recorded in I_2F_2 treatment which was statistically at par with I_3F_2, I_3F_3 (179.2 q/ha) and I_2F_3 (175.0 q/ha), I_1F_3 (170.1 q/ha). The I_2F_2, I_3F_2 and I_3F_3 treatment combinations recorded increase in the green pod yield to the tune of 34.2, 31.1 and 31.1 percent respectively as compared to (Check basin) conventional irrigated crop (Table 3). This might be due to the fact that soil moisture at optimum level enhanced the cell metabolism resulting in better growth and yield. Also, the fulfilment of crop nutrient requirements at various stages with minimum leaching of fertilizers in the root zone might had resulted in maximum fertilizer use efficiency, resulting in higher pod yield. In drip irrigated crop, minimum number of pods per plant (22.3) and green pod yield (144.3 q/ha) was found in the I_1F_1 treatment i.e. application of drip irrigation at 0.6 % of ET_{crop} and 60% of the recommended dose of N and P fertilizers. The lowest number of pods per plant (17.7) and green pod yield (136.7 q/ha) was recorded under

Table 3: Yield attributes and pod yield of garden pea as influenced by different treatments

Treatments	Pod length (cm)		Pods/plant			Grains/pod		Shelling (%)		Green pod yield (q/ha)			Water use efficiency (q/ha-cm)		
	2014-15	2015-16	2014-15	2015-16	Pooled	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
I_1F_1	10.1	10.1	21.5	23.1	24.8	7.9	8.4	50.0	48.3	139.9	148.5	144.3	13.29	11.0	12.15
I_1F_2	9.5	9.4	28.5	26.3	27.4	7.5	7.3	55.0	51.4	168.6	166.8	167.7	16.02	12.36	14.19
I_1F_3	9.8	9.7	30.3	28.5	29.4	7.7	7.5	51.7	50.1	169.2	171.0	170.1	16.08	12.67	14.38
I_2F_1	9.6	9.4	27.9	24.3	26.1	7.3	7.3	53.3	50.8	165.9	156.4	161.2	14.62	10.86	12.74
I_2F_2	9.4	9.2	32.3	30.9	31.6	8.0	6.9	53.3	49.9	186.5	180.4	183.4	16.44	12.53	14.49
I_2F_3	9.4	9.1	31.2	30.1	30.7	7.4	7.2	52.0	50.7	173.4	176.6	175.0	15.29	12.26	13.78
I_3F_1	9.3	9.5	26.4	27.5	28.4	7.2	6.7	50.0	51.7	170.9	161.1	166.1	13.54	10.33	11.94
I_3F_2	9.1	9.5	32.7	29.5	30.9	7.7	7.1	55.0	48.4	187.1	171.4	179.2	14.82	10.99	12.91
I_3F_3	9.3	9.1	29.4	28.5	25.0	6.9	7.1	53.3	51.3	178.9	179.5	179.2	14.17	11.51	12.84
Control	8.8	9.0	15.2	20.3	17.7	6.8	6.7	58.3	49.0	126.2	147.3	136.7	5.61	6.55	6.08
CD at 0.05%	NS	NS	6.6	3.24	2.44	NS	NS	NS	NS	27.0	19.1	15.4	--	--	--

surface/check basin treatment and was found to be significantly less than all the drip-fertigation treatments. The results confirm the findings of Raina *et al.,* (1998) where it was reported that drip irrigation at volume V and 0.8V volume of water applied resulted increase in pea pod yield to the tune of 49.5 and 37.0 percent as compared to check basin method of irrigation.

Water use and its efficiency: The total depth of irrigation water applied in I_1 treatment was 10.52 & 13.50 cm which was less than I_2 (11.34 & 14.40 cm) and I_3 (12.62 & 15.60 cm) during 2014-15 and 2015-16 crop seasons, respectively. Further, in conventional (Check basin) treatment, the depth of irrigation water applied was 22.5 cm during both the years (Table 4). The percentage of water saving over check basin (conventional) irrigation i.e. in I_1 treatment (53.2 & 40.0 %) followed by I_2 (49.6 & 36.0 %), I_3 (43.9 & 30.6%) during 2014-15 and 2015-16 crop seasons, respectively. Also, pooled analysis of water use efficiency as presented in Table 3 was recorded higher in I_2F_2 treatments (14.49 q/ha-cm). The higher water use

Table 4: Comparison of irrigation water applied in different irrigation treatments

Irrigation treatments	Total depth of irrigation water applied (cm)				Percentage of saving water over conventional irrigation	
	Drip irrigation		Check basin irrigation (Conventional)			
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
I_1	10.52	13.50	22.5	22.5	53.24	40.0
I_2	11.34	14.40			49.60	36.0
I_3	12.62	15.60			43.91	30.6

Table 5 Economic analysis of drip irrigation system in garden pea with subsidy and conventional method

S. No	Description	Drip irrigation	Conventional method
1	Main, submain & venturi etc.		
	a) Fixed cost (Rs)	41,898.00	
	b) Accessories [10% of a] (Rs)	4189.80	
	c) Total (Rs)	46,087.80	
	d) Life in years	20	
	e) Depreciation on capital by taking two crops per year (c/40)	1152.19	
	f) Interest @ 8% per crop taking two crops per year (c × 0.08/4)	921.76	
	g) Total (e + f)	2073.95	
2	Pump		
	a) Fixed cost (Rs)	20,000	20,000
	b) Life in years	20	20
	c) Depreciation on capital by taking two crops per year (a/40)	500	500
	d) Interest @ 8% per crop taking two crops per year(a x 0.08/4)	400	400
	e) Total (c + d)	900	900
3	Laterals and installation		
	a) Cost of laterals with inbuilt emitters @ Rs10.45 per meter for 1 ha (approx.16670m)	1,74,201.5	
	b) Cost of installation (Rs)	17,420.0	
	c) Total (Rs)	1,91621.5	
	d) Total cost with subsidy (With maximum subsidy of Rs.80812.0 based upon the maximum subsidy provided by the government on vegetable crops per hectare)	110809.5	
	e) Life in years	8	
	f) Depreciation on capital by taking two crops per year (d/16)	6925.5	
	g) Interest @ 8% per crop taking two crops per year (c x 0.08/4)	3832.43	
	h) Total (f + g)	10757.93	
4	Cultivation cost of garden pea (Rs)	73,308.00	74,108.00
5	Total cost of production (Rs)	87,039.88	75,008.00
6	Produce (q/ha)	183.4	136.7
7	Selling price (Rs. /q)	1300	1300
8	Gross income (Rs)	2,40,020	1,77,710
9	Net income (Rs)	1,55,970.31	1,02,702
10	Benefit cost ratio (8/5)	2.75	2.36

efficiency in I_2F_2 could be attributed to relatively higher yield and lower depth of irrigation water applied. The pooled analysis of water use efficiency (6.08 q/ha-cm) under conventional treatment was found to be less than all the treatments under drip irrigation and fertigation.

Economic analysis: The cost of cultivation of garden pea includes expenses incurred on land preparation, ploughing, seeds, sowing, cost of fertilizer, their application, weeding, crop protection and cost of picking and harvesting of produce. The cost of different components for the drip irrigation system and net returns from the crop is shown in Table 5. It shows that net seasonal income from garden pea was Rs.1, 55,970.31 and Rs.1, 02,702 per hectare for drip fertigation and check basin method of irrigation respectively. In garden pea, the increase in net income by drip irrigation method was 51.9 percent more as compared to check basin method of irrigation. Further, the increase in yield could be possible where water is scarce by increasing area under cultivation with saved water, by adopting drip irrigation system.

Conclusions

- The average maximum green pod yield of garden pea and water use efficiency was found to be 183.4 q/ha and 14.49 q/ha-cm respectively under drip irrigation with 0.8 times ET_{crop} and fertilized with 80% of the recommended dose of fertilizer (40 kg N and 50 Kg P_2O_5/ha) using water soluble fertilizers.
- The average increase in green pod yield was 34.2% with 0.8 times ET_{crop} drip irrigated and 80% of the recommended dose of fertilizer as compared to check basin method of irrigation.
- Drip irrigation with 0.8 times ET_{crop} saved average 42.8 % of irrigation water as compared to check basin method of irrigation.
- Drip irrigated garden pea recorded higher net returns (Rs.53, 268/ha) and benefit cost ratio (2.75) as compared to check basin method of irrigation (2.36).

Acknowledgement

Authors are grateful to ICAR, New Delhi for providing the funds and facilities under the scheme, "Plasticulture Engineering and Technology", Department of Soil & Water Engineering, Punjab Agricultural University, Ludhiana.

Lkkjk'k

सब्जी मटर (किस्म पंजाब–89) की बुआई करके टपक सिंचाई एवं फर्टिगेशन और सतही सिंचाई (चेक बेसिन) का अध्ययन इसकी उपज पर पड़ने वाले प्रभाव जानने के लिए प्रयोग वर्ष 2014–15 के दौरान बलुई दोमट मृदा में किया गया। टपक सिंचाई के तीन सतर (0.6, 0.8 तथा 1.0) एवं फर्टिगेशन के तीन सतर (60, 80 और 100 प्रतिशत) उर्वरक की अनुशसित मात्रा और सतही सिंचाई (चेक बेसिन) को नियंत्रण उपचार मान कर किया गया था। मटर की हरी फली का सबसे अधिक उत्पादन (183.4 कुन्तल/हेक्टेयर) 0.8 वाष्पन उर्त्सजन पर टपक सिंचाई और सिफारश की मात्रा का 80 प्रतिशत उपयोग करने से प्राप्त हुआ जो सतही सिंचाई विधि से प्राप्त उत्पादन 136.7 कुन्तल/हेक्टेयर) से 34.2 प्रतिशत अधिक वृद्धि दर्ज की गयी। सतही सिंचाई विधि की तुलना में टपक सिंचाई का उपयोग करने से 42.8 प्रतिशत पानी की भी बचत होती है।

References

Anonymous (2015) Package of Practices for Vegetable Crops. Punjab Agricultural University, Ludhiana, pp 1.

Biswas BC (2010) Fertigation in High tech Agriculture- A success story of a lady farmer. Fertilizer Marketing News 41: 4-8.

Dhaliwal MS (2010) Handbook of Vegetable Crops. Kalyani Publishers, New Delhi, pp237.

Raina JN, Thakur BC and Bhandari AR (1998) Effect of drip irrigation and plastic mulch on yield, water use efficiency and benefit cost ratio of pea cultivation. J Indian Soc Soil Sci 46: 562-567.

Rao KV, Gangwar S, Bajpai A, Keshri R, Chourasia L and Kumar S (2017) Performance of pea under different irrigation systems. Legume Res- An Int J 40(3): 559-561.

Sharma U (2011) Effect of irrigation and fertilizer methodologies on soil properties in pea. J Hill Agri 2(2): 227-230.

Singh KG, Siag M and Mahajan G (2006) Water and nutrient requirement of drip irrigated green pea. Haryana J Hort Sci 35 (3 & 4): 320-322.