



Assessment of growth parameters and yield of pea (*Pisum sativum*) under different irrigation methods

NEHA SINGHAL^{1*}, POONAM SHARMA¹, RAKESH SHARDA¹, MUKESH SIAG¹ and
NIKHIL GLADWIN CUTTING¹

Punjab Agricultural University, Ludhiana, Punjab 141 004, India

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ABSTRACT

Field experiment for pea (*Pisum sativum* L.) (PB-89) crop was conducted during *rabi* 2016–17 and 2017–18 at Punjab Agricultural University, Ludhiana. The objective of the experiment was to study the impact of different irrigation methods, viz. drip, furrow and flood irrigation on crop growth parameters and yield of the crop. Better growth parameters, viz. plant height, leaf area index, dry weight of root and shoot and the chlorophyll content were recorded under drip irrigation. Plant height and leaf area index had a positive correlation to yield of the crop. Weight of grain was also positively correlated with the grain yield. There was increase in yields in 2017–18. Yield was found significantly higher under drip irrigation treatments.

Keywords: Growth, Irrigation methods, Leaf area index, Pea, Yield

India is amongst the leading countries in the production of pulses. Pea (*Pisum sativum* L.) is a winter season legume crop widely grown in India. Asia is the largest green pea producing continent in the world amounting to 68% on average in the last 40 years. India, with 2.34 million tonnes of average production, is the second largest green pea producer after China (FAOSTAT 2019). The method of irrigation is very important for the optimization of moisture content in the soil and efficient crop production. Different soil moisture regimes may have an impact on the growth and yield of the legumes. In legumes, more vegetative development and less flowering and pod formation are caused by the excess application of water resulting in lower yield, hence optimum irrigation is crucial for legumes. Significantly higher values of fruit quality parameters are obtained at low irrigation levels (Bicer *et al.* 2004, Ya-dan *et al.* 2017). Drip irrigation can be quite beneficial for increasing legume productivity as it provides maintenance of an optimum moisture regime, the potential for improved yields and crop quality, greater control on applied water resulting in less water and nutrient loss (Maisiri *et al.* 2005).

Plant growth is largely dependent on the optimality of available moisture in the root zone which depends on the method of irrigation application. The chickpea yield per unit area increases with increased supplemental irrigation (Oweis

et al. 2004). According to Biçer *et al.* (2004) height of the plant, yield per plant, pods per plant, leaf size, seed size and pod size, etc. increase with the application of irrigation. The chlorophyll content is a good indicator of plant health as it is directly correlated to the photosynthesis activity of the plant. Leaf area index is the indicator of the ratio of the area of the leaf to the ground area and is also a good indicator of plant growth. The objective of this study was to assess the response of different irrigation treatments on the plant growth and crop yield.

MATERIALS AND METHODS

The experiment was conducted during winters (2016–17 and 2017–18) at the research farm of Department of Soil and Water Engineering, Punjab Agricultural University (PAU), Ludhiana in the Indian state of Punjab. The soil texture of the experimental site is sandy loam and the climate of Ludhiana is subtropical semi-arid type. Pea crop variety PB-89 was sown at a row to row spacing of 30 cm in 3 replications under randomized block design. Seeds of pea crop were treated with bacterial culture (*Rhizobium leguminosarum*) to ensure nodule formation and quick growth. There were five treatments- drip irrigation on crop grown on level field (T₁) and on ridges (T₂), flood irrigation (T₃), furrow irrigation (T₄) and one treatment under rainfed condition (T₅). Irrigation was applied at 100% evapotranspiration (ET) and ET was calculated by the Modified Penmen Method using meteorological data collected from the School of Climate Change and Agricultural Meteorology, PAU, Ludhiana.

Plant height, dry weight of root and shoot, chlorophyll content and leaf area index (LAI) were recorded at flowering

Present Address: ¹Indian Agricultural Research Institute, New Delhi. *Corresponding author e-mail:- singhal.n96@gmail.com.

stage of the crop in both the years. Plant height (cm), dry weights of root and shoot (g) were taken as an average of five randomly selected plants. Leaf area index (LAI) values were measured with the help of the LAI ceptometer instrument.

Chlorophyll content of fresh green leaves of five randomly selected plants from all the treatments was measured using the method proposed by Witham *et al.* (1971).The chlorophyll content was calculated based on mg of chlorophyll per gram of leaf tissue extracted:

$$\text{mg chlorophyll total/g tissue} = [20.2 (\text{OD})_{645} + 8.02 (\text{OD})_{663}] \times \frac{V}{1000 \times w}$$

where, OD, Optical density of chlorophyll extract at the specific indicated wavelength; V, Final volume of 80% acetone chlorophyll extract; w, Fresh weight of tissue extracted.

Yield analysis was done for all the treatments at the time of harvesting. Number of pods per plant, number of grains per pod, weight of 100 seeds and grain yield (kg/ha) of crop were recorded. For number of pods per plant and number of grains per pod, five plants were randomly selected from each plot and the average was taken. For yield evaluation, crop from the 2 × 2 m² area from within the plot was harvested and grain yield was converted into kg/ha. The data collected from the present field experiment was subjected to the statistical analysis using analysis of variance (ANOVA) techniques at 5% level of significance.

RESULTS AND DISCUSSION

Growth parameters: The plant height varied significantly with irrigation treatment (Table 1). Greater plant height was recorded under T₁ and T₂ treatments which in the year

2016–17 were significantly different from those under T₃ and T₄ but not significantly different in 2017–18. Minimum plant heights were recorded under T₅ which were significantly less than all other treatments in both the years. The plant height in 2017–18 was almost 15–25% more than the year 2016–17. This may be due to improvement in soil condition in the second year due to previous year pea crop as also observed by Singhal *et al.* (2018) for chickpea crop in the year 2017–18. The dry weight of root was not significantly different among treatments in both the years. In the first year, dry weight of shoot was significantly less in T₅ as compared to the irrigation treatments, whereas there was no significant difference in the second year. There was no significant difference in chlorophyll content among treatments but the least values were observed in T₅ treatment. There was no significant difference in leaf area index except under T₅ in the year 2017–18 which was significantly less than under irrigation treatments. However, there was a significant increase of 10–35% in leaf area index in the second year (2017–18) as compared to first year (2016–17). Among the growth parameters of pea crop studied, only plant height was significantly impacted by the irrigation treatment. Better plant height under drip irrigation treatments may be attributed to better soil moisture regime due to frequent irrigation and favorable microclimate. This implies that the legume seedlings require consistently moist root zone environment and favorable microclimate (Henson *et al.* 2007, Agele *et al.* 2017).

Yield parameters: There was non-significant difference in number of pods per plant and number of grains per pod in first year 2016-17 (Table 2). The number of pods per plant was maximum under drip irrigation (T₂) treatment and significantly higher as compared to flood and furrow

Table 1 Growth parameters of pea crop

Treatment	Plant height (cm)		Leaf area index		Dry weight of root (g)		Dry weight of shoot (g)		Chlorophyll content (mg/g)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
T ₁	45.67	55.78	0.89	1.2	0.39	0.42	3.71	4.09	1.14	1.17
T ₂	43.67	55.56	1	1.13	0.4	0.34	3.46	4.5	1.15	1.16
T ₃	43.83	54.33	0.86	0.97	0.35	0.31	3.14	3.73	1.13	1.15
T ₄	43.94	53.78	0.93	1.13	0.39	0.39	3.79	4.74	1.15	1.16
T ₅	34.78	43.11	0.7	0.77	0.3	0.35	1.81	2.05	1.08	1.12
CD (*P=0.05)	1.478	5.214	NS	0.28	NS	NS	1.03	NS	NS	NS

Table 2 Yield parameters of pea crop

Treatment	Number of pods per plant		Number of grains per pod		Weight of 100 grains (g)		Yield (kg/ha)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
T ₁	5.13	8.70	5.02	6.49	22.68	24.60	2789.04	3545.37
T ₂	5.27	9.43	5.13	6.35	20.52	22.10	2408.79	3153.58
T ₃	6.33	6.80	4.80	5.38	19.62	21.30	1966.25	2957.50
T ₄	4.80	7.33	4.91	5.33	21.20	21.12	1945.13	2493.83
T ₅	5.33	4.93	3.83	4.39	18.36	19.50	1194.67	1653.17
CD (*P=0.05)	NS	2.03	NS	1.38	1.51	2.2	203.91	533.58

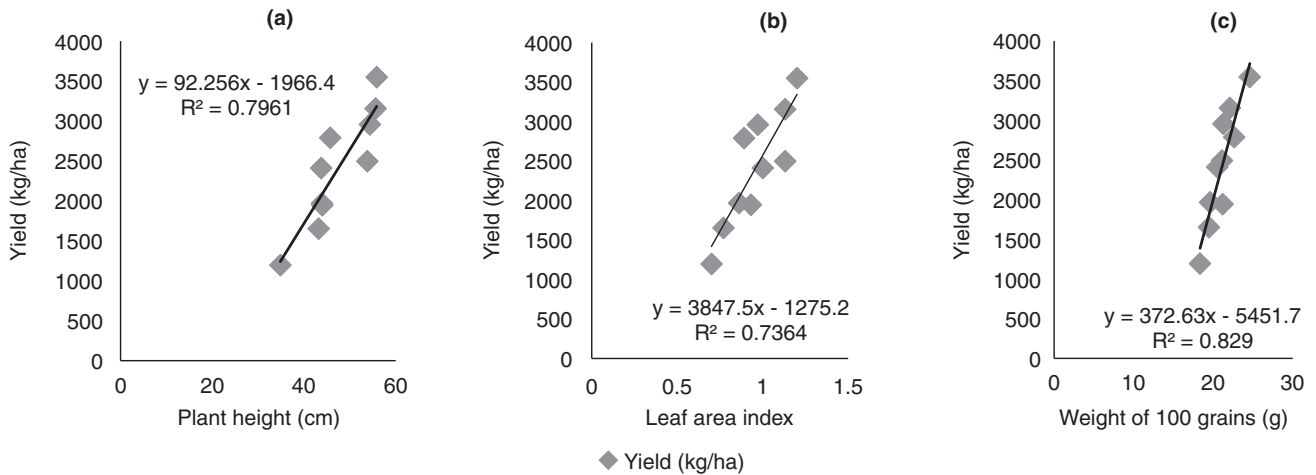


Fig 1 Co-relation of yield (kg/ha) with (a) Plant height (cm), (b) Leaf area index and (c) Weight of 100 grains (g).

irrigation treatments, whereas for the number of grains per pod there was non-significant difference between irrigation treatments but was significantly less under rainfed (T_5) treatment as compared to drip irrigation treatments. There was significant difference in weight of 100 grains among treatments, with generally higher values being recorded under drip irrigation treatments. It may be inferred that grain development was better under drip irrigation system which provides a more conducive soil moisture regime than other irrigation methods. The results are at par with the findings of Biçer *et al.* (2004).

Maximum yield of the crop was recorded under T_1 treatment. There were significantly higher yields under both drip irrigation treatments (T_1 and T_2) as compared to flood and furrow irrigation treatments with CD value of 203.91 and 533.58 at 5% level of significance for both years respectively. Least yields were recorded under rainfed conditions (T_5). The results of the study were found similar to El-Adel (2000), Singh H (2016), Agele *et al.* (2017) and Singhal *et al.* (2018).

Co-relation of plant growth and yield parameters: Higher yields under drip irrigation system may be attributed to better plant growth (as reflected by plant height), better grain development (as reflected by weight of 100 grains). Also there was significant increase in yields, increase in leaf area index in nodule formation in the second year. Therefore to better understand the interaction of these various factors some co-relation of plant growth and yield parameters has been developed by taking the data of both the years together. There were positive linear co-relations between plant height versus yield (Fig 1(a)) and between leaf area index versus yield (Fig 1(b)). Positive linear co-relations was also observed between weights of 100 grains versus yield (Fig 1(c)). From all these inter co-relations it may be inferred that higher plant height and canopy cover as Leaf area Index have a positive bearing on plant growth and yield because in drip irrigation systems, increase water and nutrient uptake efficiency (Schumann *et al.* 2009). Since drip irrigation significantly increases the number of pods and

weight of grains, maximum yield of pea was obtained under drip irrigation. The results are in agreement with the findings of Schumann *et al.* (2009) and Waghmare *et al.* (2016).

Drip irrigation resulted in significantly higher plant height, leaf area index, dry weight of root, weight of 100 grains and yield of pea as compared to flood and furrow irrigation. But dry weight of shoot and chlorophyll content was more or less same under different irrigation treatments. Almost all the growth parameters were observed minimum under treatment T_5 , i.e. rainfed conditions except the dry weight of root in the year 2017–18. It was concluded that the overall size and health of plant under drip irrigation had a positive impact on yield of pea crop as clearly reflected by the significantly higher yields recorded under drip irrigation. Better plant height and health under drip irrigation may be attributed to the almost uniform soil moisture regime maintained due to frequent and precise irrigation. The study was aimed for the application of precision irrigation methods for improvement of plant growth and yield in legume crop. The findings of the work can be utilised for irrigation planning and management for pea crop. A cost effective system could be developed as further research for small and marginal landholdings. For adoption of this method on farm level, training programs for farmers could be conducted.

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REFERENCES

- Agele S O, Ajayi A J and Olawanle F M. 2017. Effects of watering regime and rhizobium inoculation on the growth, functional and yield traits of four legume species. *International Journal of Plant & Soil Science* 17 (4): 1–15.

- Bicer B Tuba, Kalender A Narin and Ôakar Do-an. 2004. The effect of irrigation on spring-sown chickpea. *Journal of Agronomy* **3**(3): 154–58.
- El- Adel M A. 2000. Effect of irrigation and fertilization method on pea production. *Misr Journal of Agricultural Engineering* **17**(3): 450–68.
- FAOSTAT. 2019. retrieved from <http://www.fao.org/faostat/en/#data/QC/visualize> on 13/12/2019
- Henson I E, Harun M H, Chang K C and Mohammed A T. 2007. Predicting soil water status, evapotranspiration growth and yield of young oil palm in a seasonally dry region of Malaysia. *Journal of Oil Palm Research* **19**: 398–415.
- Maisiri N, Senzanje A, Rockstrom J and Twomlow S J. 2005. On farm evaluation of the effect of low cost drip irrigation on water and crop productivity compared to conventional surface irrigation system. *Physics and Chemistry of the Earth* **30**: 783–91
- Oweis Theib, Hachum Ahmed and Pala Mustafa. 2004. Water use efficiency of winter-sown chickpea under supplemental irrigation in a Mediterranean environment. *Agricultural Water Management* **66**:163–79.
- Schumann A W, Syvertsen J P and Morgan K T. 2009. Implementing advanced citrus production systems in Florida: Early results. *Proceedings of the Florida State Horticultural Society* **122**: 108–13.
- Singh H. 2016. Impact of different irrigation methods on microbial activity in summer mungbean. M Sc thesis, Punjab Agricultural University, Ludhiana. Retrieved from <http://krishikosh.egranth.ac.in/handle/1/5810000368>
- Singhal N, Sharma P, Siag M, Sharda R and Cutting N G. 2018. Impact of different irrigation methods on microbial activity in chickpea crop. *International Journal of Current Microbiology and Applied Sciences* **7**(07): 1921–30.
- Waghmare Y M, Gokhale D N and Chavan A S. 2016. Production potential of pigeonpea [*Cajanus cajan* (L.) Millsp] as influenced by plant geometry and irrigation schedules. *International Journal of Agricultural Sciences* **8**(16): 1287–89.
- Witham P H, Dyes D F and Delvin R M. 1971. Chlorophyll absorption of spectrum and quantitative determination. *Experimental Plant Physiology*. Von Nastrand Reinhoed Company, New York.
- Ya-dan D U, Hong-xia C A O, Shi-quan L I U, Xiao-bo G U and Yu-xin C A O. 2017. Response of yield, quality, water and nitrogen use efficiency of tomato to different levels of water and nitrogen under drip irrigation in Northwestern China. *Journal of Integrative Agriculture* **16**(5): 1153–61.