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Effect of irrigation scheduling and NK fertigation on productivity of garden peas (*Pisum sativum* var. *hortense* L.)

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Abstract

A field experiment was conducted for three consecutive *rabi* seasons (2011-12 to 2013-14) to evaluate the effect of irrigation depth (0.4, 0.6, 0.8 and 1.0 CPE) and NK fertigation (50 and 100% of adjusted recommended dose) along with a control (basal application of soil test based adjusted recommended NPK fertilizer and surface irrigation of 5 cm) on the productivity of garden pea at Palampur. Result revealed that irrigation and fertigation with micro-sprinkler led to 60.9% less use of water and 10.0% higher green pod yield. Consequently, water use efficiency was increased by 3.12 times over the recommended practices. Every fifth day irrigation with 80% CPE (CPE 0.8) resulted in significantly higher green pod yield than every fifth day irrigation with either 60% CPE (13.74%) or 40% CPE (19.96%). Irrigation with minimum depth of water (0.4 CPE) resulted in maximum water use efficiency of 6.51 kg green pods m^{-3} of irrigation water used for crop production. Fertigation of sprinkler irrigated crop either with 50 or 100% of recommended soil-test based NK had no effect on green pod yield, gross return and water use efficiency.

Key words: Irrigation scheduling, fertigation, water use efficiency

India has made considerable progress in developing irrigation infrastructure which leads to substantial improvement in production of vegetables crops. Vegetable production increased from 12.06 lakh tonnes in 2009-10 to 12.69 lakh tonnes in 2010-11 with growth rate of 5.2% (Anonymous 2012). Despite this development the productivity of irrigated area has not reached the desired level. This is due to lower water use efficiency of traditional methods of surface irrigation, which is mainly due to higher water conveyance losses, excess or deficit application of irrigation water and deep losses. This necessitates adoption of such method of irrigation where losses are minimum. Pressurized micro sprinkler is one of such methods where controlled irrigation is possible with minimum losses of irrigation water. In India, due to special emphasis on micro-irrigation during 10th plan, the area under micro-irrigation increased up to 2352477 ha including 1270145 ha under micro sprinklers (Singh *et al*. 2012).

In Himachal Pradesh, area under micro-irrigation in poly-houses is 133.634 ha. Under open fields, it is 4461.519 ha with maximum area in Kangra district (842.56 ha) (Anonymous 2010). Micro-irrigation has an added advantage in undulating topography with poor soil water retention and transmission characteristics and small and scattered land holdings with small amount of water stored from rainfall at the farm. Among micro irrigation systems, sprinklers are favoured in comparison to drip as the time required in cleaning the blockages of emitters is eliminated considerably and water is delivered more uniformly to the crop. Micro and mini sprinklers are very reliable with a CV of <10%. They provide regular and targeted distribution of the irrigation water, valuable as a protection against damage from frost (Guidoboni 2006).

Application of water soluble fertilizer through venturi is an important feature of micro-irrigation systems. Fertigation increases the fertilizer use efficiency as the nutrients are supplied as per the demand of the crop. The availability of water and nutrient simultaneously improves the uptake.

Under such situation crop may need much less quantity of nutrient as it needs under conventional method of irrigation and fertilization. Sprinkler irrigation along with fertigation through water soluble fertilizers especially nitrogen and potash will optimize nutrient use and ultimately will increase water and nutrient use efficiency.

Pea (*Pisum sativum* var. *hortense* L.) is a cool-season, nutritious legume widely cultivated throughout the world. It is a rich source of protein (25%), amino acids, sugars (12%), carbohydrate, vitamins A and C, calcium and phosphorus, apart from having a small quantity of iron. Over years with steady increase in acreage and production, it has occupied the position of leading cash crop in Himachal Pradesh especially in the higher and mid hill zones of Himachal Pradesh. The area under pea crop in Himachal Pradesh is 22,800 ha with an annual production of 2,54,200 metric tonnes (Anonymous 2011). In low and mid – hill region of Himachal Pradesh, it is mostly grown as rainfed crop which is strongly influenced by low availability of soil moisture especially during initial growth and pod – formation/development stage as there is no rains from October-December and March-June. Inadequate soil moisture is usually a limiting factor in ensuring proper germination and early growth not only in rain-fed areas but also in *kuhl* (Snow fed gravity stream) irrigated areas where tail end farmers receive sub optimal irrigation water. In recent year's trend has been changed from more productivity per unit land to more productivity per unit water, as water is becoming increasingly scarce even in those areas where it was plentiful in recent past. It may be possible to maximize water productivity in pea by proper scheduling of irrigation. In the light of above a study was planned to study the effect of irrigation depth and NK fertigation through micro-sprinkler on crop productivity and water use efficiency.

Material and methods

A field experiment was conducted at Water Management Farm, CSK HPKV, Palampur during *rabi* 2011-12 to 2013-14 to optimize micro sprinkler irrigation and NK fertigation in garden pea. The area lies in Palam Valley (32^{o} 06' 39.1" N latitude and 76^{o} 32' 10.5" E longitude) perched in the lap of majestic snow clad Dhauladhar range of Himalayas at an elevation of 1290 m above mean sea level in Kangra district of Himachal Pradesh. The soil of the experimental field was silty clay loam in texture; acidic in reaction (pH 5.1); high in organic carbon (16.1 g/kg); medium in available nitrogen (246.5 kg/ha); high in available phosphorus (38.08 kg/ha) and low in available potassium (141.4 kg/ha). The experiment was laid out in factorial randomized block design with three replications. There were nine treatments, comprising of all the possible combinations of four irrigation depths (0.4, 0.6, 0.8 and 1.0 CPE) and two NK fertigation levels (50 and 100% of adjusted recommended dose) plus one control (basal application of soil test based adjusted recommended NPK fertilizer and surface irrigation of 5 cm).

The irrigation was applied through micro-sprinkler system at an interval of 4 days. The system consists of three micro-sprinklers per plot each having wetting diameter of 0.90 m. Mean evaporation rate of preceding 10 cropping seasons was calculated for estimation of irrigation water requirement. Irrigation requirement was calculated by taking into account the difference of average evaporation and rainfall (only positive values) and multiplying the cumulative average evaporation minus actual rainfall value with CPE ratio. In 'recommended practice', 5 cm deep flood irrigation was applied at 10 days interval. To ensure uniform crop stand, technique of water seeding of pea seeds in furrows was followed by application of water at 0.7 l m^{-1} furrow length before closing them.

The fertilizer dose was calculated by adjusting the recommended dose of NPK (50:60:60 kg/ha) based on soil test. Since, soil available P was in higher range, its dose was lowered by 25%. K was in lower range, so its dose was increased by 25%. The level of available N in soil was medium and therefore its dose was not altered. Thus, NPK dose used in present study was 50:45:75 kg/ha. In NK fertigation treatments, $1/3^{rd}$ dose of NK was applied as basal. The remaining $2/3^{rd}$ NK was applied through water soluble fertilizers *viz*., urea for nitrogen and 0:0:50 for potassium in different calculated proportions through venturi system in 6 equal splits at an interval of 9 days starting at 3-leaf stage of crop. In 'recommended practice', 50:45:75 kg NPK/ha was applied as basal at the time of sowing through urea, SSP and MOP.

'Palam Priya' cultivar of garden pea was sown in October at 40 cm x 8 cm spacing in 4.96 m x 2 m (9.92 m^2) plots. The seeds were pre-soaked in water overnight before sowing. Observations on productivity and water use were recorded every year. Yield attributes were recorded during r*abi* 2012-13. Economics of treatments was worked out based on the prevalent market prices of inputs and output.

Results and Discussion

Conventional Fertilizer application v/s fertigation

During first year, fertigation with micro-sprinkler resulted in 56.05% water saving and statistically similar

pea pod yield and gross return as in case of recommended fertilizer application under conventional irrigation system (Table 1 & 2). Owing to huge amount of water saved fertigation resulted in 2.41 times higher WUE than the general practice of applying fertilizers. On the contrary, fertigation with micro-sprinklers resulted in significantly lower net return (18.84%) and B: C ratio (43.03%) than recommended practice mainly due to the higher cost of cultivation in former treatment.

During second and third and thereby on pooled basis, irrigation and fertigation with micro-sprinkler led to less use of water (66.23, 59.9 and 60.89%) and significantly higher green pod yield (10.75, 30.05 and 10.02%). Consequently, water use efficiency was significantly increased (3.67, 3.59 and 3.12 times) as compared to recommended practices (Table 1). Significant increase in green pod yield due to fertigation with micro-sprinkler was reflected in gross return (Table 2), which was also increased by 10.84 and 30.04% during second and third year, respectively. On an average, fertigation increased WUE by 11.59% over the conventional method of fertilizer and irrigation application. Kumar *et al*. (2015) also reported significant improvement in WUE with improved practices in blackgram.

In spite of statistically similar net return, B: C ratio was significantly lower (29.05 and 29.78%) in fertigation with micro-sprinklers than recommended practice during second year and on mean basis (Table 2). During third year, fertigation with micro-sprinklers though resulted in significantly higher net return (25.27%) than recommended practice but had significantly lower B:C ratio (10.05%).

The increase in green pod yield with fertigation may be due to improvement in yield attributes in response to better availability of moisture and nutrients during crop growth. The same is depicted by significant improvement in green pod yield through significant improvement in plants meter^{-1} row length, pods plant^{-1}, pod weight plant^{-1} by fertigation during *rabi*, 2012-13 (Table 3). Rajput and Patel (2012), Kakhandaki *et al.* (2013) and Kumar *et al*. (2013) also recorded similar increase in crop yield by micro-irrigation as compared to irrigation with conventional method. Ramulu *et al*. (2010), Prabhakar *et al.* (2011) and Sayed and Bedaiwy (2011) reported fertigation to produce more yield as compared to conventional fertilizers.

Irrigation scheduling (depth of irrigation)

Irrigation scheduling (depth of irrigation) significantly influenced green pod yield, water use efficiency, gross and net returns and BC ratio during all the years (Table 1 and 2). Increase in irrigation depth resulted in progressive increase in green pod yield, gross returns, net returns and

Table 1. Effect of different treatments on productivity, irrigation water used and water use efficiency of green pea

Treatment	Pod yield (Mg/ha)				IWU (m^3/ha)				WUE (kg/m^3)			
	2011-12	2012-13	2013-14	Pooled	2011-12	2012-13	2013-14	Pooled	2011-12	2012-13	2013-14	Pooled
Control v/s others												
Control	10.65	8.09	7.32	8.68	6,000(12)*	6500(13)	6000 (12)	6167(12)	1.78	1.24	1.22	1.41
Others	10.17	8.96	9.52	9.55	2,637(28)	2195(27)	2406 (28)	2412(28)	4.29	4.55	4.38	4.40
LSD (P = 0.05)	NS	0.29	0.34	0.43	-	-	-	-	0.46	0.17	0.19	0.20
Irrigation schedule (depth of irrigation)												
CPE = 0.4	9.75	8.53	8.63	8.97	1,507(28)	1254(27)	1375(28)	1379(28)	6.47	6.80	6.27	6.51
CPE = 0.6	9.88	8.94	9.56	9.46	2,260 (28)	1881(27)	2062(28)	2068(28)	4.37	4.75	4.64	4.57
CPE = 0.8	11.32	9.79	11.17	10.76	3,013(28)	2508(27)	2750(28)	2757(28)	3.76	3.90	4.06	3.90
CPE = 1.0	9.72	8.60	8.71	9.01	3,767(28)	3135(27)	3437(28)	3446(28)	2.58	2.74	2.53	2.61
LSD (P = 0.05)	1.10	0.27	0.32	0.40					0.44	0.16	0.17	0.19
NK fertigation												
50 % RDF	10.06	9.02	9.44	9.51	2,637(28)	2195(27)	2406(28)	2412(28)	4.15	4.56	4.35	4.34
100 % RDF	10.27	8.90	9.59	9.59	2,637(28)	2195(27)	2406(28)	2412(28)	4.43	4.54	4.40	4.45
LSD (P = 0.05)	NS	NS	NS	NS	-	-	-	-	NS	NS	NS	NS

***** Value in the parenthesis indicate number of irrigations

Table 2. Effect of different treatments on economics of green pea

Treatment	Gross return (INR/ha)				Net return (INR/ha)				B:C ratio			
	2011-12	2012-13	2013-14	Mean*	2011-12	2012-13	2013-14	Mean*	2011-12	2012-13	2013-14	Mean*
Control v/s others												
Control	1,59,750	1,61,733	1,46,333	1,55,939	1,23,195	114323	98,923	1,12,147	3.37	2.41	2.09	2.62
Others	1,52,500	1,79,263	1,90,292	1,74,018	99,980	112894	1,23,923	1,12,265	1.92	1.71	1.88	1.84
LSD (P = 0.05)	NS	5,770	6,857	6,647	17517	NS	6,857	NS	0.34	0.09	0.10	0.12
Irrigation schedule (depth of irrigation)												
CPE = 0.4	1,46,250	1,70,667	1,72,500	1,63,139	93,730	104298	1,06,131	1,01,386	1.77	1.58	1.61	1.66
CPE = 0.6	1,48,250	1,78,700	1,91,167	1,72,706	95,730	112331	1,24,798	1,10,953	1.85	1.70	1.89	1.82
CPE = 0.8	1,69,750	1,95,700	2,23,333	1,96,261	1,17,230	129331	1,56,964	1,34,508	2.25	1.97	2.38	2.20
CPE = 1.0	1,45,750	1,71,983	1,74,167	1,63,967	93,230	105614	1,07,798	1,02,214	1.81	1.60	1.63	1.68
LSD (P = 0.05)	16,515	5,440	6,465	6,267	16515	5440	6,465	6,267	0.32	0.08	0.10	0.12
NK fertigation												
50 % RDF	1,50,938	1,80,433	1,88,833	1,73,401	1,02,548	118582	1,26,982	1,16,037	2.12	1.92	2.05	2.03
100 % RDF	1,54,063	1,78,092	1,91,750	1,74,635	97,413	107205	1,20,863	1,08,493	1.72	1.51	1.71	1.65
LSD (P = 0.05)	NS	NS	NS	NS	NS	3847	4,571	4,431	0.23	0.06	0.07	0.08

*Based on prices prevailing in 2013-14

B:C ratio up to 0.8 CPE. However, increases in green pod yield, gross return, net return and B:C ratio with increase in irrigation depth from 0.4 to 0.6 CPE were not significant during first year (Table 1 and 2). Irrigation every fifth day with 80% CPE (0.8 CPE) resulted in significantly higher green pod yield than every fifth day irrigation with either 60% CPE (14.57, 9.51, 16.84 & 13.74 %) or 40% CPE (16.10, 14.77, 29.43 & 19.96%). This progressive increase in green pod yield with increase in irrigation depth may be due to progressive increase in yield attributes as indicated by observations made during second year of study, where, plants/meter row length, pods/plant, pod weight plant attributed to progressive increase in green pod yield (Table 3). Sarkar *et al*. (2008) also reported progressive and significant increase in bulb yield of garlic with increase in pan evaporation factor. Results are in conformity with Hundal *et al*. (2003) and Kadam *et al*. (2005), Kassab *et al*. (2012) and Patel *et al*. (2012).

During first, second and third year as well as on mean basis, with increase in irrigation depth to 0.8 CPE from 0.6 CPE, the respective increase in gross return was 14.50, 9.51, 16.83 & 13.64%; in net return 22.46, 15.13, 25.77 & 20.82% and in BC ratio 21.62, 15.88, 24.89 & 21.23%. Increase in irrigation depth also resulted in significant and progressive decrease in WUE in all the years due to progressive increase in irrigation water used. Irrigation with minimum depth of water (CPE 0.4) resulted in maximum water use efficiency of 6.47, 6.80, 6.27 and 6.51 kg green pods/m^3 of irrigation water used (IWU) (Table 1).

NK fertigation

Fertigation of sprinkler irrigated crop either with 50 or 100% of recommended soil-test based NK had no effect on green pod yield, gross return and water use efficiency in all the years. It is may be due to improvement of nutrient use efficiency. Teixeira *et al*. (2011) also reported 36% increase in nutrient use efficiency with NK fertigation as compared to conventional fertilization. NK fertigation did not significantly affect green pod weight/plant, shelling percentage and seed weight/pod during *rab*i 2012-13 (Table 3). Fertigation with 50% of recommended NK resulted in higher net return (5.27, 10.61, 5.06 & 6.95%) and B: C ratio (23.25, 27.15, 19.88 & 23.03%) than fertigation with 100% of recommended NK; however, difference in net return was not significant during the first year (Table 1 and 2). Since NK fertigation had no significant effect on green pod yield that mean NK fertigation can be safely reduced to half without sacrificing green pod yield. It is may be due to improvement of nutrient use efficiency.

Table 3. Effect of irrigation depth and NK fertigation on yield attributes and green pod yield of pea

Treatment	Plants/ m row length (cm)	Pods/plant	Pod weight/ plant (g)	Shelling (%)	Seed weight/pod (g)	Green pod yield (Mg/ ha)
Control v/s others						
Control	8.41	21.44	92.08	40.17	5.03	8.09
Others	8.71	23.57	94.88	43.31	5.62	8.96
LSD (P=0.05)	0.27	0.85	2.71	2.01	0.43	0.28
Irrigation depth						
0.4 CPE	8.55	22.40	92.79	41.46	5.25	8.53
0.6 CPE	8.71	24.00	95.93	44.42	5.68	8.94
0.8 CPE	8.97	24.56	97.06	45.44	6.21	9.79
1.0 CPE	8.60	23.33	93.75	41.94	5.35	8.60
LSD (P=0.05)	0.25	0.80	2.55	1.89	0.40	0.26
NK fertigation						
50% of Rec.	8.68	23.28	94.60	43.11	5.59	9.02
100% of Rec.	8.73	23.86	95.16	43.52	5.66	8.90
LSD (P=0.05)	NS	0.57	NS	NS	NS	NS

Conclusively it may be inferred that for saving irrigation water (about 40%) and increasing productivity as well as WUE, garden pea should be fertigated with micro-sprinklers as compared to recommended practices of surface irrigation and fertilization. For maximizing production and economics micro-sprinkler irrigated pea crop should be irrigated every fifth day with water depth of 0.8 cumulative pan evaporation. For obtaining higher net returns and B: C ratio, pea crop should be fertigated with 50% of recommended NK. Irrigation with minimum depth of water (CPE 0.4) resulted in maximum water use efficiency of 6.51 kg green pods/m^3 of irrigation water used.

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