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Research Article

EFFECT OF DIFFERENT FERTILIZER AND IRRIGATION MANAGEMENT SYSTEMS ON SOIL PHYSICO-CHEMICAL PROPERTIES AND POD YIELD OF GARDEN PEA (*PISUM SATIVUM* L)

A.B. Shakoor Khanday[1], Uday Sharma[2], *Pramod Kumar Dubey[3] and S.B. Bhardawaj[4]
[1]*Department of Soil Science, G.B. Pant University of Agriculture and Technology, Pantnagar-263145.India*
[2]*Department of Soil Science and Water Management, Dr. Y.S.P.U.H & F, Nauni-173230, Solan (H.P) India*
[3]*Department of Agronomy, G.B. Pant University of Agriculture and Technology, Pantnagar-263145 India*
[4]*Directorate of Experimental Station, G.B. Pant University of Agriculture and Technology, Pantnagar-263145*
**Author for Correspondence*

ABSTRACT
A field experiment was conducted to evaluate the effect of different irrigation systems and fertilizer levels on the physico chemical properties of the soil and pod yield of pea on gravelly loam (Typic Eutrocrept) soil of Nauni, located in the sub-humid sub-tropical zone of Himachal Pradesh. It was observed that soil physico-chemical properties responded significantly to the interactive effect of fertilizer levels and the irrigation systems. The study revealed that flood irrigation increased the pH (from 5.86 to 6.34 in surface soil and from 6.33 to 6.51 in sub surface soil) and EC (from 0.13 to 0.15 dSm^{-1} in surface soil and from 0.14 to 0.17 dSm^{-1} in sub surface soil) but decreased the CEC from 9.73 to 9.27 cmol(p^+) kg^{-1} in surface soil and from 9.72 to 9.63 cmol(p^+) kg^{-1} in subsurface soil. Double of the recommended dose of FYM resulted in maximum organic carbon percentage in the soil (1.26 and 1.13% in surface and subsurface soil respectively). Significant increase in the availability of N, P and K in soil was recorded with increase in the fertilizer dose. Drip irrigation+ fertigation resulted in increased content of exchangeable Ca, Mg and S in the soil. Application of the recommended dose of NPK through fertigation gave significantly higher pod yield than all other interactions.

Key Words: *Irrigation Systems, Fertilizer Levels, Drip Irrigation, Fertigation, Physico-Chemical Properties of Soil, Pod Yield*

INTRODUCTION
Pea occupies a position of considerable value because of its importance in the agricultural economy of the country and is one of the main cash crops of the Sub-Himalayan region. Since it is grown as an off season crop for the plains, it contributes substantially to the economy of the farmers in this region. In addition to the adoption of the improved varieties by the farmers, use of scientific technology in management of fertilizers and irrigation for achieving optimum and sustainable yield is a necessity. Irrigation management is of special importance as the proper irrigation may bring 100-150 percent increase in the yield depending upon the soil type, winter rains and depth of the water table (Sheveleva, 1974)) and (Singh, 2001)). Application of recommended dose of K_2O (60 kg ha^{-1}) produced highest yield of pea. It has been reported that the application of recommended dose of NPK with trash incorporation recorded higher cane and commercial cane sugar yields, the beneficial effects of integrated use of organic manure and inorganic fertilizers on the soil physico-chemical properties and crop yield have also been observed (Bhalarao *et al*, 2001). Drip irrigation treatments decrease pH, ESP, EC and exchangeable sodium and increased CEC and organic carbon of the soil as compared to the conventional methods of irrigation (Dubey *et al*, 2003)). Since the fertilizer and irrigation management have a direct role in quantity and quality of yield, so the present study was carried out to find the effect of different fertilizer and irrigation management systems on soil physico-chemical properties and pod yield of garden pea (*Pisum sativum* L.) in the sub-humid sub-tropical zone of Himachal Pradesh.

MATERIALS AND METHODS

The study entitled "Effect of different fertilizer and irrigation management systems on soil physico-chemical properties and pod yield of garden pea (Pisum sativum L.)," was carried out at the gravelly loam soil (Typic Eutrocrept) during 2006-2007. The characteristics of the soil were: gravel 22.50%, sand 42.90%, Clay 26.20%,bulk density 1.38 Mg M^{-3}, porosity 42.06%, WHC 34.90%, CEC 10.50 cmol(p^+) Kg^{-1} , texture gravelly loam, pH (1:2.5) 6.81, EC 0.09 dSm^{-1},OC 1.02%, available N 296.60 kg ha^{-1}, available P 48.7 kg ha^{-1}, available K 109.25kg ha^{-1}, exchangeable Ca 511.55 kg ha^{-1} , exchangeable Mg 159.50 kg ha^{-1} and available S 60.00 kg ha^{-1}. The experiment was laid in split plot design with three replications, where three systems of irrigation (S_1 : flood irrigation + soil application of fertilizers, S_2 : drip irrigation + soil application of fertilizers and S_3 : drip irrigation + fertigation) were tested in main plots under pea.The six fertilizer levels (F_1 : 100% recommended dose of NPK, F_2 : FYM + 50% recommended dose of NPK, F_3 : FYM +100% recommended dose of NPK, F_4 : FYM + 150% recommended dose of NPK, F_5 : 2 x FYM and F_6 : FYM + bio-fertilizer (*Rhizobium sp.*) were laid in sub plots. S_1 and F_1 were taken as control for irrigation systems and fertilizer levels respectively. Recommended doses were: FYM 200 q ha^{-1},N 25 kg ha^{-1},P_2O_5 60 kg ha^{-1} and K_2O 60 kg ha^{-1}. The sub sub-plot characteristics were: size 5m x 3m, planting distance 10 x 45 cm, inter sub sub-plot distance 0.5 m. The seed was sown in October-November. For the soil analysis two composite samples were taken from each sub sub-plot, one from each depth. The samples were air dried in shade and ground with pestle and mortar. Samples were subsequently passed through the 2mm sieve and were stored in cloth bags after labeling(Kanwar and Chopra, 1967).).Nutrient content determination was done following the standard methods recommended. The pods were hand picked from the plants in two pickings at their maturity ,were weighed and expressed as q ha^{-1}. The results obtained during the two seasons were pooled and the data thus obtained was subjected to statistical analysis as per the recommended methods (Gomez and Gomez, 1994). Critical difference at 5% level was used for testing the significant difference among the treatment means.

RESULTS AND DISCUSSION

Soil moisture content, pH, EC, CEC, organic carbon and pod yield

Changes in the soil moisture content with different types of nutrient and irrigation management systems indicate that effect of double of the recommended dose of FYM (F_5) on soil moisture was most pronounced, maintaining highest moisture content in both surface and sub-surface soils viz. 25.10 and 22.71 percent respectively. Among the irrigation systems S_3 (drip irrigation + fertigation) was found superior to S_1(flood irrigation + soil application of fertilizers) and S_2(drip irrigation + soil application of fertilizers) in conserving the soil moisture with values of 26.73 and 23.80 percent for 0-15 cm and 15-30 cm soil depths respectively. From the interactions S_3F_6 (drip irrigation+ biofertilizer + FYM application) and S_3F_5 (drip irrigation + 2xFYM) proved to be best. The observations are in line with the findings of the (Karim *et al*, 1989) and (Mahawarapa *et al*, 1998). These findings may be ascribed to the higher levels of the organics and their consequent effect in conserving the soil moisture and also to the irrigation of the crops at regular intervals directed to the root zone of the plant in case of the drip irrigation systems.

The two irrigation systems i.e. drip irrigation+ soil application of fertilizers (S_2) and drip irrigation (S_3) decreased the pH and EC of the soil, where as the CEC of the soil was found to increase (Table 1). Double the recommended dose of FYM was found to equally effective in decreasing the EC of the soil. Amongst the interactions S_1F_1 (flood irrigation + soil application of the 100% NPK) and S_2F_1 (drip irrigation + soil application of 100% NPK) resulted in the highest pH in surface and sub-surface soils respectively.S_2F_4 (drip irrigation + soil application of 150% NPK) and S_1F_6 (flood irrigation + biofertilizer and FYM) resulted in the highest EC in 0-15 and 15-30 cm. A similar effect on CEC in the surface and sub-surface soil was shown by S_2F_4 (drip irrigation + soil application of 150% NPK) and S_3F_4 (drip fertigation with 150 % NPK + FYM) respectively.

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Table 1: Effect of different fertilizer and irrigation management systems on soil moisture content, pH, EC, CEC ,organic carbon and pod yield.

Treatment	Moisture Content (%)		Soil pH		EC (dSm^{-1})		CEC($cmolkg^{-1}$)		Organic carbon (%)		Pod Yield qha^{-1}
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	
Irrigation Systems											
S_1	19.88	18.85	6.34	6.51	0.15	0.17	9.27	9.63	1.13	1.02	5.82
S_2	24.17	22.90	6.20	6.46	0.14	0.16	9.35	9.70	1.14	1.09	6.00
S_3	26.73	23.80	5.86	6.33	0.13	0.14	9.73	9.72	1.21	1.13	6.34
$CD_{0.05}$	1.11	1.89	0.17	0.14	0.02	0.01	0.18	0.57	0.06	0.03	0.01
Fertilizer Levels											
F_1	21.97	20.69	6.28	6.57	0.14	0.16	9.16	9.30	1.02	1.01	5.60
F_2	22.57	21.91	6.21	6.47	0.16	0.18	9.36	9.57	1.11	1.16	6.52
F_3	23.47	21.90	6.08	6.39	0.16	0.16	9.48	9.79	1.12	1.05	6.00
F_4	23.73	21.69	6.07	6.51	0.15	0.18	10.00	9.83	1.22	1.08	6.11
F_5	25.10	22.71	5.92	6.22	0.09	0.14	9.40	9.87	1.26	1.13	6.24
F_6	24.73	22.20	6.27	6.49	0.14	0.12	9.29	9.80	1.22	1.07	5.86
$CD_{0.05}$	1.09	1.05	NS	0.23	0.03	0.01	0.22	0.63	0.05	0.05	0.20
Interaction between irrigation systems and fertilizer levels											
$CD_{0.05}$ S x F	2.25	3.84	0.34	0.27	0.04	0.02	0.37	0.91	0.12	0.06	0.20

Table.1 indicates that treatment F_5 (2x FYM) had the maximum organic carbon in the sub-surface soil with a value of 1.26% where as the F_2 (FYM + 50% recommended dose of NPK) and F_6 (FYM + bio-fertilizer) were at par with respect to the organic carbon in the surface and sub-surface soil with values of 1.16 and 1.13 respectively. Soils under the S_3 (drip fertigation) maintained the higher organic carbon in both the soil depths having the corresponding values of 1.21 and 1.13 percent respectively. Amongst the interactions, S_3F_5 (drip fertigation + 2 x FYM) was found to have the organic carbon of 1.35% in the 0-15cm depth, S_3F_2 (drip fertigation with 50% NPK) was equally effective in maintaining higher organic carbon in the subsurface soil. Interaction S_2F_5 (drip irrigation +FYM) recorded a value of 1.30% organic carbon which was marginally higher than the organic carbon value reported in the S_3F_2 (fertigation with 100% NPK + FYM). (Akbarinia *et al*, 2004) also reported that organic amendments significantly increased organic carbon content of the soil. It may be ascribed to the better moisture conditions as well as better biomass under such treatments which ultimately resulted in higher organic carbon status.
Highest pod yield with a value of 112.50 qha^{-1} was found in the S_3 (drip fertigation). Among the fertilizer treatments F2 (FYM + 100% NPK) recorded the maximum pod yield and among the interactions S_3F_2 (fertigation with 100% NPK + FYM) proved to be the best interaction in its effect on the pod yield (120.54 qha^{-1}). The results obtained are in agreement with those found by (Marghany,1998), (Mahawarapa et al, 1998), (Prakash and Bhadoria , 2004) and (Sheveleva, 1974). The combined effect of the organics,

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recommended dose of chemical fertilizers, drip irrigation and fertigation can be clearly seen from the above results.

Table 2: Effect of different fertilizer and irrigation management systems on available N, P, K, exchangeable Ca, exchangeable magnesium and sulphate-sulphur

Treatment	N (kgha^{-1})		P (kgha^{-1})		K (kgha^{-1})		Ca (kgha^{-1})		Mg (kgha^{-1})		S (kgha^{-1})	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Irrigation Systems												
S_1	315.20	305.10	95.40	78.95	156.80	116.08	525.10	522.80	164.10	168.50	56.36	54.55
S_2	319.40	311.00	116.00	98.70	210.00	134.5	535.30	514.80	173.50	167.70	56.69	57.92
S_3	330.40	318.10	128.80	108.60	267.70	154.5	538.00	554.00	177.20	190.40	60.42	57.54
$CD_{0.05}$	14.47	10.73	4.72	3.19	15.53	7.34	11.38	NS	5.59	5.74	0.86	1.16
Fertilizer Levels												
F_1	310.50	296.80	117.80	94.00	199.70	178.50	519.60	510.00	171.10	172.40	57.93	53.00
F_1	323.00	326.10	144.10	119.10	242.00	199.20	521.20	525.70	173.10	177.80	57.92	55.52
F_1	314.60	299.00	84.57	71.75	186.00	97.06	518.60	550.30	175.30	164.40	57.36	57.00
F_1	329.30	315.50	167.00	154.20	279.30	218.20	521.60	517.30	190.90	181.20	59.26	56.71
F_1	315.90	298.90	81.89	63.47	200.70	99.03	548.80	515.80	155.60	186.40	55.83	55.52
F_1	336.30	332.40	85.20	7.07	162.00	99.86	566.90	564.20	163.80	174.80	58.65	59.41
$CD_{0.05}$	15.49	22.11	7.53	7.25	14.89	13.29	16.20	NS	9.38	12.42	1.70	1.09
Interaction between irrigation systems and fertilizer levels												
$CD_{0.05}$ SxF	29.39	21.80	9.60	6.48	31.53	14.90	23.11	101.59	11.30	11.66	1.75	2.35

Available nitrogen, phosphorus and potassium

The effect of the S_3 (drip fertigation) on the available nitrogen was most pronounced and it recorded the highest available nitrogen for both the soil depths i.e. 330.40 kg ha^{-1} and 318.10 kgha^{-1} for 0-15 cm and 15-30 cm, respectively. Similar effect amongst the fertilizer treatments was shown by F_6 (FYM + biofertilizer) , with 336.30 kgha^{-1} for 0-15 cm soil depth and 332.40 kgha^{-1} for 15-30 cm soil depth. Out of the interactions maximum available nitrogen was observed in S_3F_4 (drip fertigation with 150% NPK) combination for the surface soil and in S_3F_6 (drip irrigation + FYM & biofertilizer) for sub surface soil. Out of the different fertilizer levels the most remarkable effect on the phosphorous availability was observed in F_4 (FYM + 150 % NPK) for both the soil depths with values of 167.00 kgha^{-1} for 0-15cm and 154.20 kgha^{-1} for 15-30cm soil depth. Amongst the irrigation systems S_3 (drip fertigation) proved to be the best, which resulted in 128.80 kgha^{-1} available phosphorous in the surface soil and 108.60 kgha^{-1} in sub-surface soil. The interaction S_2F_4 (drip irrigation + soil application of 150% NPK) enhanced the phosphorous availability to the extent of 171.30 and 167.30 kgha^{-1} in surface and sub-surface soils.S_3 (drip fertigation) indicated a maximum level of available potassium in both the soil depths. F_4 (FYM +150% NPK) had the same effect on the potassium availability as on the phosphorous availability and recorded the highest value of available potassium in both the depths. However S_3F_4 (drip fertigation with 150% NPK + FYM) and S_2F_2 (drip irrigation + FYM & 50% NPK) combinations proved to be superior in their effect on the available potassium in surface and sub-surface soils respectively. Findings of the (Fiuczek, 1976), (Bhalarao *et al*, 2001) and (Treder *et al.*, 1997)) support the results obtained. Higher doses of NPK and better soil moisture conditions under the drip irrigation/ fertigation systems maintained higher levels of available nutrients in the soil.

Exchangeable calcium, magnesium and sulphate- sulphur

Effect of different irrigation systems and fertilizer levels on the soil content of exchangeable calcium, magnesium and sulphate- sulphur was found to be in line with that on N. P and K availability, with maximum values of each recorded in the drip fertigation (S_3). However the effect of the different fertilizer treatments and interactions was found to be different for the aforementioned nutrient elements. Maximum exchangeable calcium was recorded in F_4 and S_3F_6 (drip irrigation + FYM & biofertilizer) for both the depths, The highest value of exchangeable magnesium was found in the F_6 (FYM + biofertilizer) and S_3F_1 (drip fertigation with 100% NPK) for the surface soil and in F_5 (2x FYM) and S_3F_5 (drip irrigation + 2x FYM) for the sub-surface soil. While maximum sulphate-sulphur was recorded in the F_4 (FYM + 150% NPK) and S_3F_2 (drip fertigation with 100 % NPK + FYM) for the surface soil and in F_6 (FYM + biofertilizer) and S_2F_5 (drip irrigation + 2x FYM) for the sub-surface soils. (Petterson *et al*, 1983) also reported an increased content of these nutrients under fertigation and is mainly ascribed to the positive interactions of the nutrients and moisture and also their greater availability due to increased organic inputs.

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