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Qualitative and Quantitative Response of Pea (*Pisum sativum* L.) Cultivars to Judicious Applications of Irrigation with Phosphorus and Potassium

Muhammad Irfan Ashraf*, Muhammad Aslam Pervez, Muhammad Amjad, Rashid Ahmad[1] and Muhammad Ayub
Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan
[1]Department of Crop Physiology, University of Agriculture, Faisalabad, Pakistan

Abstract

The goal of this study was to observe the impact of agro-management practices like, irrigation and nutrition on two pea (*Pisum sativum*) cultivars named Climax and Meteor at Horticultural Research Area, U.A.F. Growth parameters like Main stem Length (cm), number of leaves per plant, leaf Area (cm^2), number of pods per plant, length of pod (cm) number of seeds per pod and reproductive attributes like 1000 seed weight, seed yield/hectare were studied. Different combinations of irrigation, potassium and phosphorus fertilizers were used as treatments in earlier experiments to study their performance and the best one selected for pea crop. The combinations used were T_0 (Irrigation up to seed filling), T_1 (Irrigation up to seed filling + P120 kg ha^{-1}), T_2 (Irrigation up to seed filling + K100 kg ha^{-1}), T_3 (Irrigation up to seed filling + P120 kg ha^{-1}+ K100 kg ha^{-1}).Climax gave better seed yield 2.24 tons as compared to Meteor with 2.33 tons ha^{-1}seed yield. Irrigation up to seed filling + P120 kg ha^{-1}+ K100 kg ha^{-1} (T_3) showed better performance for vegetative and reproductive parameters similarly highest seed yield 2.63 tons ha^{-1} were found in T_3 for both cultivars of pea as compared to other combinations.

Keywords: Pea, Irrigation, Nitrogen, Phosphorus, Potassium, Seed vigour, Quality and yield

Introduction

Pea (*Pisum sativum* L.) a grain legume and a member of the leguminoseae family is a native of central or Southeast Asia (Warren et al., 1956). The pea is full of nutrition because its grain is rich in protein (27.8%), complex carbohydrates (42.65%), vitamins, minerals, dietary fibers and antioxidant compounds (Urbano et al., 2003). Good management practices are essential if optimum fertilizer responses are to be realized. These practices include use of recommended pea varieties, good seed bed preparation, proper seeding methods, effective plant insect control. Soil test results, field experience and knowledge of specific crop requirements help to determine the nutrients needed and the rate of application (Hadavizadeh, 1989). Seed quality can be increased by careful management of seed crops during production in the field, harvest, post harvest, processing and storage. Nutrition to the seed crop may improve seed quality (George et al., 1980). Chickpea and field pea have a relatively short growing season and use less water than many other broadleaf crops such as sunflower or safflower (Johnson et al., 2002). Most research on irrigation management for pea production has dealt with sensitivity to moisture stressed specific growth stages (Hukheri and Sharma, 1980; Pumphrey and Sehwanke, 1974; Salter and Williams, 1967). Pea yields often are increased by irrigation during vegetative and reproductive growth, when soil moisture is otherwise limiting (Guatam and Lenka, 1968; Hukheri and Sharma, 1980; Zain et al., 1983). However, few studies have examined the effects of irrigation on spring pea seed yield (Stoker, 1977; White et al., 1982; Zain et al., 1983) and quality (Biddle and King, 1978; Nichols et al., 1978). Baigorri et al., (1999) stated that pea seed yield was strongly dependent on water availability, especially at flowering and pod filling. Similarly, Martin and Jamieson, (1996) reported that water stress during the last half of the growing season (pollination, pod and seed formation periods) was a major factor in reducing seed yields in temperate dry areas. Water stress during seed filling decreased seed yield and quality. Changing irrigation strategies for pea seed production by irrigating during seed filling improved, physiological quality of the seed lots without decreasing seed yield. Nichols et al, (1978) working with potted pea plants observed no effect of drought stress on seed conductivity or germination. Dubey et al., (1999) conducted field experiment during summer seasons of 1993 and 1994 at Kukumseri, Himachal Pradesh, India. Pea cv. Arkel was irrigated at 4, 8 and 12 days intervals and given 0, 40, 80 and 120 kg P/ha. Yield increased with decreasing irrigation interval and generally increased with increasing P rate. Rathi et al., (1993) said that pea cv. JP-885 were grown in a sandy loam and given no

***Corresponding Author:** Muhammad Irfan Ashraf
Institute of Horticultural Sciences,
University of Agriculture, Faisalabad, Pakistan
Email: irfanflorist199@yahoo.com

irrigation. The phosphorus was given @ 0, 20, 40 and 60 kg/ha. Nitrogen and phosphorus contents in the seed was highest with irrigation and protein contents was highest with irrigation + 60 kg P_2O_5/ha. Deficient irrigation reduced seed yield more than excessive irrigation, whereas excessive irrigation caused the greatest reduction of seed quality. The main objective of the study was to observe different levels of irrigation, Phosphorus and Potassium for Pea seed crop.

Materials and Methods

This experiment was planned to assess interaction amongst promising levels of phosphorus and potassium. Irrigation levels were used which have been proved better in earlier experiments. Field experiment was laid out according to RCBD (Randomized Complete Design) with factorial arrangements. Different combination of phosphorus and potassium were used along with proved irrigation level in earlier experiment. Phosphorus and potassium were applied along with constant dose of Nitrogen @ 80 kg /ha Phosphorus and potash was applied at the time of seed bed preparation whereas, half dose of nitrogen was applied at the time of seed bed preparation and remaining was applied when flowering started. Immediately, after sowing water was applied. Irrigation was applied according to the schedule of the crop. Data collected on different crop parameters like growth, yield and seed quality were computed by using STATISTICA computer program. The least significant difference at 5% level of probability was used to test the differences among mean values (Steel et al*.,* 1997).Crop was looked after properly. The following treatments were studied. Irrigation up to seed filling: 10 irrigations (T_0), Irrigation up to seed filling; 10 irrigations + P120 kg ha^{-1} (T_1), Irrigation up to seed filling: 10 irrigations applied + K100 kg ha^{-1} (T_2), Irrigation up to seed filling (10 irrigations) + P120 kg ha^{-1}+ K100 kg ha^{-1} (T_3). Parameters, Main stem length (cm), Number of leaves per plant, Leaf area (cm^2), Number of pods per plant, Length of pod (cm), Number of seeds per pod, Seed fresh weight per plant (g), Seed dry weight per plant (g), 1000 seed weight (g) and Seed yield per hectare (tons) were studied. Seed vigour tests were performed like, Germination test, Electrical conductivity test, Emergence test and Accelerated ageing test. Chemical composition of the different parts (leaves, stems, pods) of pea plant and seeds were air dried, grinded and saved in small bottles for chemical analysis. Nitrogen, Phosphorus, Potassium and Protein were determined by according to the method described by Chapman and Parker (1961). Ash contents were determined by following method given in AACC (2000).

Results and Discussion

Growth parameters, Main stem length (cm), Number of leaves $plant^{-1}$ and Leaf Area (cm^2), showed Meteor ousted Climax, whereas treatment means indicated significant difference among them. Irrigation up to seed filling+ P120 Kg ha^{-1}+ K100 Kg ha^{-1} (T_3) was at the top while T_0 (control) remained at the bottom. Although vegetative growth requires Nitrogen yet for legumes comparatively more Phosphorus is needed for growth and Nitrogen fixation which might have contributed on the aspect to get more number of leaves. The treatment means showed that combined treatments performed better as compared separately. Similar results were reported by Patel et al., (1998) who stated that peas cv. "Arbel" significantly increased in plant height, number of branches, leaves per plant, number of pods per plant, grains per pod and pod yield when applied @ 20 kg N/ha + 80 kg P_2O_5/ha + 40 kg K_2O/ha. Shaukat (1994) reported that with the application of P increased root weight while negligible effects on number of nodules were observed. Vimala and Natarajan (1999) observed that plant height with increasing the rate of N and P was increased as well as the number of branches per plant were found enhanced.

Growth parameters, Number of pods per plant, Length of pod (cm), Number of seeds per pod, 1000 seed weight (g), and Seed yield ha^{-1} (tons) showed that Climax indicated better results as compared Meteor. While, Irrigation up to seed filling + P120 kg ha^{-1}+ K100 kg ha^{-1} (T_3) was also at the top with and control (T_0) was at bottom. Patel et al., (1998) they reported that significantly increased plant height, number of branches, leaves per plant, number of pods per plant, grains per pod and pod yield were observed when applied 20 kg N/ha + 80 kg P_2O_5/ha + 40 kg K_2O/ha was applied. Amjad et al., (2004) who observed that seed yield, 1000 seed weight and percentage of large sized seeds were increased significantly with the increasing level of P_2O_5.

Chemical composition (Nitrogen, Ash and Protein) of pea Leaves were indicated significant results for cultivars, different nutrient levels and their interactions. Ash %, Nitrogen % and Protein % were better in Climax as compared to Meteor. Treatment means showed that T_3 was at the top while, T_0 (control) was found at bottom, while the other treatments gave close results like, T_3 and control (T_0).Treatment (T_3) performed better for both the cultivars. All other combination of treatments was in between by showing similar results. These results in agreement with the findings of Kanaujia et al., (1997) who reported that effects of P, K and rhizobium on growth yield and quality of pea and found significant growth and nodulation increase with the increasing of P and K levels and confirmed that the level of 60 kg P and K ha^{-1} was the best. Chemical composition

Table 1: Qualitative and Quantitative Response of Pea (*Pisum sativum* l.) to Judicious Applications of Irrigation with Phosphorus and Potash on Growth Parameters of Two Pea Cultivars

Growth Parameters	Main Stem Length (cm)			Number of Leaves Per Plant			Leaf Area (cm^2)		
Treatments	**Climax**	**Meteor**	**Mean**	**Climax**	**Meteor**	**Mean**	**Climax**	**Meteor**	**Mean**
T_0	42.750	53.750	48.250d	63.750	64.000	63.875d	252.25	250.25	251.25d
T_1	43.250	55.000	49.125bc	66.500	65.500	66.000c	253.00	252.25	252.62c
T_2	45.250	60.000	49.625b	67.000	67.000	67.000b	254.00	253.00	253.50b
T_3	57.250	62.750	60.000a	70.250	68.000	69.125a	255.00	254.00	254.50a
Cultivars Mean	47.125b	57.875a	-	66.875a	66.125b	-	253.56a	252.37b	-

Means followed by the same letter in a column do not differ significantly at $p \leq 0.05$.

Table 2: Qualitative and Quantitative Response of Pea (*Pisum sativum* l.) to Judicious Applications of Irrigation with Phosphorus and Potash on Growth Parameters of Two Pea Cultivars

Growth Parameters	Number of Pods per plant			Length of pod (cm)			Number of Seeds per pods		
Treatments	**Climax**	**Meteor**	**Mean**	**Climax**	**Meteor**	**Mean**	**Climax**	**Meteor**	**Mean**
T_0	22.250	22.000	22.125d	5.2050	5.1500	5.1775d	5.1500	6.0125	5.5812d
T_1	23.000	23.500	23.250c	5.6050	5.1750	5.3900c	5.5250	6.2750	5.9000bc
T_2	24.750	24.250	24.500b	5.6200	5.6000	5.6100b	5.6500	6.3375	5.9937bc
T_3	28.000	27.000	27.500a	6.1475	7.0750	6.6112a	6.1750	8.3025	7.2300a
Cultivars Mean	24.500a	24.187b	-	5.6443b	5.7500a	-	5.6250b	6.7318a	-

Means followed by the same letter in a column do not differ significantly at $p \leq 0.05$.

Table 3: Qualitative and Quantitative Response of Pea (*Pisum sativum* l.) to Judicious Applications of Irrigation with Phosphorus and Potash on Yield Parameters of Two Pea Cultivars

Yield Parameters	1000 Seed weight (g)			Seed yield per hectare		
Treatments	**Climax**	**Meteor**	**Mean**	**Climax**	**Meteor**	**Mean**
T_0	242.25	250.50	246.37d	2.0050	2.0525	2.0287d
T_1	243.00	253.25	248.12c	2.2075	2.1200	2.1637c
T_2	244.25	254.75	249.50b	2.3757	2.2825	2.3291b
T_3	245.75	256.75	251.25a	2.7450	2.5300	2.6375a
Cultivars Mean	243.81b	253.81a	-	2.3333a	2.2462b	-

Means followed by the same letter in a column do not differ significantly at $p \leq 0.05$.

Table 4: Qualitative and Quantitative Response of Pea (P*isum sativum* l.) to Judicious Applications of Irrigation with Phosphorus and Potash on Chemical Composition of Leaves of Two Pea Cultivars

Chemical Composition	Nitrogen %			Protein %			Ash %		
Treatments	**Climax**	**Meteor**	**Mean**	**Climax**	**Meteor**	**Mean**	**Climax**	**Meteor**	**Mean**
T_0	1.7850	1.7775	1.7812d	11.225	11.525	11.375d	13.703	13.810	13.756c
T_1	1.8100	1.8275	1.8300c	11.357	11.540	11.448c	13.450	13.710	13.580d
T_2	1.8350	1.8500	1.8425b	11.520	11.578	11.549b	13.850	13.852	13.851b
T_3	1.8600	1.8625	1.8612a	11.640	11.623	11.631a	14.710	14.640	14.675a
Cultivars Mean	1.8225ab	1.8293a	-	11.435b	11.566a	-	13.928b	14.003a	-

Means followed by the same letter in a column do not differ significantly at $p \leq 0.05$.

(Nitrogen %, Ash %and Protein %) of pea Stems were depicted significant results for cultivars, irrigation, phosphorus, potassium and their interactions. Chemical composition was better in Climax as compared to Meteor. T_3 gave better results but control (T_0) was found at bottom while other treatments showed results in between T_3 and control (T_0). These results are in agreement with the findings of Kanaujia et al., (1997) who evaluated the effect of Phosphorus, Potash and rhizobium on growth, yield and quality of pea and reported that the growth and nodulation were significantly increased with l increasing of levels of Phosphorus and Potash alone and found the best of P and K was 60 Kg ha^{-1}. Seeds from plants supplied with nitrogen might be more vigorous than contro seeds. Application of nitrogen

Table 5: Qualitative and Quantitative Response of Pea (*Pisum sativum* l.) to Judicious Applications of Irrigation with Phosphorus and Potash on Chemical Composition of Stems of Two Pea Cultivars

Chemical Composition	Nitrogen %			Protein %			Ash %		
Treatments	**Climax**	**Meteor**	**Mean**	**Climax**	**Meteor**	**Mean**	**Climax**	**Meteor**	**Mean**
T_0	1.2850	1.3400	1.3125d	8.1225	8.2650	8.1937d	11.408	11.780	11.594d
T_1	1.3375	1.3400	1.3387c	8.3600	8.3425	8.3512c	11.390	11.830	11.610c
T_2	1.3475	1.3550	1.3512ab	8.4125	8.4125	8.4125b	11.848	12.063	11.955b
T_3	1.3550	1.3550	1.3550a	8.4700	8.4650	8.4675a	12.245	12.238	12.241a
Cultivars Mean	1.3312b	1.3475a	-	8.3412b	8.3712a	-	11.722b	11.977a	-

Means followed by the same letter in a column do not differ significantly at $p \leq 0.05$.

Table 6: Qualitative and Quantitative Response of Pea (*Pisum sativum* l.) to Judicious Applications of Irrigation with Phosphorus and Potash on Chemical Composition of Pod + Seeds of Two Pea Cultivars

Chemical Composition	Nitrogen %			Protein %			Ash %		
Treatments	**Climax**	**Meteor**	**Mean**	**Climax**	**Meteor**	**Mean**	**Climax**	**Meteor**	**Mean**
T_0	3.3350	3.4150	3.3750d	20.910	20.985	20.947d	4.4250	4.4300	4.4275d
T_1	3.3550	3.4350	3.3950bc	20.980	21.255	21.111c	4.5225	4.4850	4.5037c
T_2	3.3475	3.4400	3.3937bc	21.593	21.463	21.528b	4.6375	4.6100	4.6237b
T_3	3.4550	3.4625	3.4587a	21.663	21.602	21.632a	4.7050	4.7150	4.7100a
Cultivars Mean	3.3731b	3.4381a	-	2.1286b	21.326a	-	4.5725a	4.5600b	-

Means followed by the same letter in a column do not differ significantly at $p \leq 0.05$.

Table 7: Qualitative and Quantitative Response of Pea (*Pisum sativum* l.) to Judicious Applications of Irrigation with Phosphorus and Potash on Seed Nutrient Concentration of Two Pea Cultivars

Nutrient Concentration	Nitrogen %			Protein %			Potash %		
Treatments	**Climax**	**Meteor**	**Mean**	**Climax**	**Meteor**	**Mean**	**Climax**	**Meteor**	**Mean**
T_0	3.4175	3.7875	1.8937d	0.3825	0.3850	0.3837a	0.8900	1.0200	0.9550a
T_1	3.2275	3.1125	3.1700c	0.2400	0.2625	0.2512d	0.5625	0.5800	0.5712d
T_2	3.6325	3.3950	3.5137a	0.3300	0.3550	0.3425c	0.6850	0.9800	0.8325c
T_3	3.3125	3.3325	3.3225b	0.3550	0.3625	0.3587b	0.8100	0.9925	0.9012b
Cultivars Mean	3.3975b	3.4068a	-	0.3268b	0.3412a	-	0.7368b	0.8931a	-

Means followed by the same letter in a column do not differ significantly at $p \leq 0.05$.

Table 8: Qualitative and Quantitative Response of Pea (*Pisum sativum* l.) to Judicious Applications of Irrigation with Phosphorus and Potash on Quality Parameters of Two Pea Cultivars

Quality Parameters	Electrical conductivity (µs/g)			Emergence %			Germination %		
Treatments	**Climax**	**Meteor**	**Mean**	**Climax**	**Meteor**	**Mean**	**Climax**	**Meteor**	**Mean**
T_0	17.250	23.000	20.125d	80.250	86.250	83.250d	5.2050	5.1500	5.1775d
T_1	19.000	24.000	21.500c	81.750	87.250	84.500c	5.6050	5.1750	5.3900c
T_2	20.000	24.250	22.125b	84.500	90.250	87.375b	5.6200	5.6000	5.6100b
T_3	22.000	24.500	23.250a	96.500	98.250	97.375a	6.1475	7.0750	6.6112a
Cultivars Mean	19.562b	23.937a	-	85.750b	90.500a	-	5.6443b	5.7500a	-

Means followed by the same letter in a column do not differ significantly at $p \leq 0.05$.

fertilizer increased the quality of proteins to a greater degree than all other amino acids. Similar findings have been reported by (Ries and Everson, 1973; Ene and Bean, 1975).

Chemical composition (Nitrogen %, Ash % and Protein %) of pea Pod + Seeds showed significant results for cultivars, treatments and their interactions. Ash % was better in Meteor with 4.57% as compared to Climax with 4.56%, Ash % was high in T_3 4.57% but T_0 was present at bottom with 4.55%. Nitrogen % and Protein % were better in Climax as compared to Meteor. Nitrogen and Protein % level was also high

in T_3 but T_0 was at the bottom These results are supported by Kanaujia et al., (1997) who evaluated the effect of P, K and rhizobium on growth, yield and quality of pea cv. Lincolin reported that the growth and nodulation were significantly increased with the increasing levels of P and K (0, 30, 60, 90 Kg ha^{-1}) alone and found P and K with 60 Kg ha^{-1}, was the best.

Seed nutrient concentration (Potash %, Nitrogen % and Phosphorus %) showed significant results for cultivars and treatments. Potash (%), Nitrogen (%) and Phosphorus (%) were better in Climax as compared to Meteor with treatment T_3 but T_0 was at the bottom while other treatments showed results inferior. These results are in line with the findings of Kanaujia et al., (1997) who reported the effect of P, K and rhizobium on growth, yield and quality of pea and reported that the growth and nodulation were significantly increased with the increasing levels of P and K (0, 30, 60, 90 Kg ha^{-1}) alone which also increased the seed yield and quality.

Seed vigour tests, electrical conductivity and emergence % tests showed Climax performed better than Meteor. Treatment means showed that Irrigation up to seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1} (T_3) was at the first position, followed by T_2, whereas, T_0 and T_1 occupied the last two positions. These results are in line with the findings of Bhopal (1991) who observe the response of garden pea to N and P application and reported in vigorous vegetative with increasing rate of N up to 40 kg N/ha and then declined at 60 kg N/ha. Germination % test showed that Meteor performed comparatively better than Climax under the aspect of germination percentage with 94.50 and 93.81 respectively. As far as germination %age is concerned, T_3 also stood at the 1st position, followed by T_2, where as, T_0 (control) occupied at last position by showing less germination %. Moreover treatment mean values followed the sequence of T_3 (96.25), T_2 (94.25), T_1 (93.50), and T_0 (92.62).These results are in line with the findings of, Cutcliffe and Munro (1980) studied the effects of NPK on pea crop and reported that maximum germination was found 85-95% by increasing the rate of N and P.

Conclusion

Climax gave better seed yield 2.24 tons as compared to Meteor with 2.33 tons ha^{-1}seed yield. Treatment, Irrigation up to seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1} (T_3) was found at the top with 2.63 tons ha^{-1}seed yield, followed by T_2 with 2.33 tons ha^{-1} while control (T_0) was found at the bottom with 2.02 tons ha^{-1} respectively. As far as seed vigour tests showed that Irrigation up to seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1} (T_3) was better for both cultivars. Different chemical composition tests of leaves, stems and pods were observed it was found that Climax cultivar was better as compared to Meteor. It is concluded that seed vigour of Climax cultivar with Irrigation up to seed filling + P120 Kg ha^{-1}+ K100 Kg ha^{-1} gave better results as compared to other levels of phosphorus, potash and Irrigation.

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