Asian Journal of Plant Sciences

ISSN 1682-3974

Asian Journal of Plant Sciences 3 (1): 108-113, 2004
ISSN 1682-3974

Influence of Phosphorus and Potassium Supply to the Mother Plant on Seed Yield, Quality and Vigour in Pea (*Pisum sativum* L.)

Muhammad Amjad, [1]Muhammad Akbar Anjum and Nadeem Akhtar
Institute of Horticultural Sciences, University of Agriculture, Faisalabad 38040, Pakistan
[1]University College of Agriculture, Bahauddin Zakariya University, Multan 60800, Pakistan

Abstract: Phosphorus (0, 23, 46 or 69 kg P_2O_5 ha^{-1}) and potassium (0, 50, 100 or 150 kg K_2O ha^{-1}) were applied in various combinations to pea crop at the time of seed bed preparation. Nitrogen dose (46 kg N ha^{-1}) was kept constant and applied in two split doses, i.e. half at the time of sowing while the other half was applied before flowering. Seed yield, 1000 seed weight and percentage of large sized seeds (<6.25 mm in dia.) increased significantly with increasing level of P_2O_5. However, time taken to complete 50% germination and electrical conductivity of seed leachates decreased significantly. Application of K_2O to the crop had significant positive influence on seed yield, 1000 seed weight and percentage of large sized seeds up to the dose of 100 kg ha^{-1}. Time taken to complete 50% germination and electrical conductivity of seed leachates were also affected significantly being minimum at the dose of 100 kg K_2O ha^{-1}. Application of P_2O_5 and K_2O to the crop had no significant effect on seed germination percentage.

Key words: *Pisum sativum*, electrical conductivity, pea, plant nutrition, seed production

INTRODUCTION

The production of good quality seed is an important prerequisite to successful vegetable production. Unfortunately, vegetable seed production in Pakistan is not so much encouraging, as a result a huge quantity of seed have to be imported every year at a great expense of foreign exchequer. Pea is a highly self-pollinated crop and production of true to type seed does not have any problem. Therefore, there is need that a serious approach should be made to cope with the situation by increasing seed yield. Again there is need not only to increase the yield but also to improve the quality of seed. Pea seed yield and quality can be enhanced by adopting improved agronomic practices, particularly by applying balanced nutrition to the crop. A lot of work has been conducted on production technology of peas but a little work has been carried out on pea seed production. As a grain legume, peas are capable of fixing most of the nitrogen required from air. The nutrients available to plant particularly nitrogen and phosphorus are important constituents of protein and phospholipids. Phosphorus is essential for seed production. It not only enhances root growth but also promotes early plant maturity[1]. It may affect cell membrane integrity and hence seed vigour[2]. The influence of potassium on quality can be indirect as a result of its positive interaction with other nutrients (especially with nitrogen) and production practices[3]. It promotes the synthesis of photosynthates and also transport to fruits, grains, tubers and storage organs and to enhance their conversion into starch, protein, vitamins, oil etc.[4].

Application of nitrogen and phosphorus to pea crop usually results in increased green pod[5,6] and seed yields. In pea, increasing phosphorus levels, generally increases plant height, number of pods per plant[7] pod length, number of seeds per pod, pod weight[8] green pod yield[9] seed yield[7,10,11] and 1000 seed weight. Increased seed yield has also been obtained in other leguminous crops i.e. French bean[12,15] cowpea[16,17] and pigeon pea [18] with increasing rate of phosphorus application. Phosphorus applied to the mother plant had no effect on seed germination but it increased seed vigour in pea[2,19]. Joint applications of phosphorus and potassium at all proportions had positive effects on growth and yield of peas[20]. The work regarding the effect of potassium especially on yield, quality and vigour of pea seed is quite meagre and no such work has been conducted under local conditions. The present research was, therefore, envisaged to study the effect of various levels of phosphorus and potassium alone and in different combinations on the seed yield and vigour in pea cv. Samrina Zard.

Corresponding Author: Dr. Muhammad Akbar Anjum, University College of Agriculture, Bahauddin Zakariya University, Multan 60800, Pakistan E-mail: anjumbzu@yahoo.com

MATERIALS AND METHODS

The seeds of pea (*Pisum sativum* L.) cv. Samrina Zard were obtained from Vegetable Section, Ayub Agricultural Research Institute, Faisalabad. The fertilizers namely urea, triple super phosphate and sulphate of potash were used as nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) sources, respectively. Keeping the nitrogen dose constant (46 kg N ha^{-1}), four levels of each phosphorus (0, 23, 46 and 69 kg P_2O_5 ha^{-1}) and potassium (0, 50, 100 and 150 kg K_2O ha^{-1}) were applied in various combinations to the crop. The detailed account of the treatments is given below.

P_0K_0 = 0 kg P_2O_5+0 kg K_2O ha^{-1}
P_0K_1 = 0 kg P_2O_5+50 kg K_2O ha^{-1}
P_0K_2 = 0 kg P_2O_5+100 kg K_2O ha^{-1}
P_0K_3 = 0 kg P_2O_5+150 kg K_2O ha^{-1}
P_1K_0 = 23 kg P_2O_5+0 kg K_2O ha^{-1}
P_1K_1 = 23 kg P_2O_5+50 kg K_2O ha^{-1}
P_1K_2 = 23 kg P_2O_5+100 kg K_2O ha^{-1}
P_1K_3 = 23 kg P_2O_5+150 kg K_2O ha^{-1}
P_2K_0 = 46 kg P_2O_5+0 kg K_2O ha^{-1}
P_2K_1 = 46 kg P_2O_5+50 kg K_2O ha^{-1}
P_2K_2 = 46 kg P_2O_5+100 kg K_2O ha^{-1}
P_2K_3 = 46 kg P_2O_5+150 kg K_2O ha^{-1}
P_3K_0 = 69 kg P_2O_5+0 kg K_2O ha^{-1}
P_3K_1 = 69 kg P_2O_5+50 kg K_2O ha^{-1}
P_3K_2 = 69 kg P_2O_5+100 kg K_2O ha^{-1}
P_3K_3 = 69 kg P_2O_5+150 kg K_2O ha^{-1}

The experiment was laid out as factorial with randomised complete block design in three replications. Total area under the experiment was 432 m^2, with net subplot size 3x3 m^2. Seeds were sown on both sides of the raised beds prepared at a distance of 75 cm. Plant to plant distance was maintained as 7 cm. Phosphorus and potassium were applied to all the treatments at the time of seed bed preparation. Half of the nitrogen was applied at the time of sowing while the other half was applied before flowering. Data were recorded on the following parameters during the course of time: seed yield per plant (g) and per hectare (tonnes), 1000 seed weight (g), large sized seeds (%), seed germination (%), time to complete 50% germination (days) and electrical conductivity (µS cm^{-1} g^{-1}) of seed leachates.

Seed yield: Ten plants were randomly selected in each treatment in each replication and all the pods were threshed separately. Seed yield per plant was recorded in grams with the help of a digital balance and then average yield per plant was worked out. Seed yield h^{-1} was estimated by multiply number of plant in one h^{-1} and seed yield per plant.

1000 seed weight: One thousand seeds were counted from each treatment in each replication and then weighed using a digital balance.

Grading for seed size: One kg seeds were taken from each treatment, counted and then passed through a sieve having the holes of 6.25 mm diameter. Number of seeds remained in the sieve were counted and the percentage of large sized seeds (more than 6.25 mm in diameter) were recorded. Local seed multiplication companies usually follow this practice.

Standard germination test: Seed germination was tested at 20°C for 8 days[26] with four replicates of 100 seeds for each treatment. The seeds were evenly distributed in 15 cm Petri dishes on 15 cm filter papers (Whatman # 1), moistened with 7 ml of water daily. Each Petri dish was covered with its lid and placed in an incubator for germination. Number of seeds germinated was recorded in each treatment and percentage was calculated.

Time taken to complete 50% germination: Time to reach 50% of final germination (T_{50}) was calculated from the formula of Coolbear *et al.*[21]:

$$T_{50} = t_i + \left[\frac{(N+1)/2 - n_i}{n_j - n_i}\right] \text{x} \ (t_j - t_i)$$

Where, n_i < (N+1)/2 < n_j, N is the number of seeds germinated and n_i and n_j are total number of seeds germinated by adjacent counts at times t_i and t_j, respectively.

Electrical conductivity test: Electrical conductivity of seed leachates was measured by using the recommended method of soaking[22]. Four replicates of 25 seeds of known weight were placed in 75 ml of distilled water in 100 ml glass beakers at 20±1°C for 24 h and then the conductivity of soaked water was determined using a conductivity meter (JENWAY 4070) as described earlier[23].

Statistical analysis: Data collected were subjected to statistical analysis using Fisher's analysis of variance technique. Treatment means were compared using Duncan's multiple range test at 5% probability level[24].

RESULTS AND DISCUSSION

Seed yield: Data regarding seed yield per plant and per hectare are presented in Table 1 and Table 2, respectively. Observations appertaining to seed yield per plant revealed significant differences among the phosphorus and potassium levels applied and among their interaction means as well. As the rate of phosphorus application increased, seed yield increased significantly. The highest rate of phosphorus application (69 kg P_2O_5 ha^{-1}) resulted in maximum seed yield per plant. This was followed by the phosphorus dose of 46 kg P_2O_5 ha^{-1}, however both the levels of phosphorus differed significantly. Phosphorus application greatly improves the yield attributes (pods per plant and seeds per pod) and seed yield in French bean[25] and in pea[11]. Increased seed yield with application of phosphorus has also been reported by various workers in pea[7,10] pigeon pea[18] and French bean[15]. Means of potassium levels revealed that maximum seed yield per plant was obtained from the plants received higher doses of potassium. However, potassium doses of K_2O @ 150 and 100 kg ha^{-1} behaved alike and stood at par. It can be visualized from the data that the effect of potassium was less pronounced than that of phosphorus. Concerning the interaction mean, the maximum seed yield per plant was produced with the combinations of 69 kg P_2O_5+100 kg K_2O ha^{-1} and 69 kg P_2O_5+150 kg K_2O ha^{-1}, closely followed by 46 kg P_2O_5+150 kg K_2O ha^{-1} and 46 kg P_2O_5+100 kg K_2O ha^{-1}. All these treatments behaved statistically alike and stood at par with each other. The minimum seed yield was recorded from control plants, which did not receive any fertilizer (Table 1). These results are in close conformity with the results of Vorob[20] who recorded positive effect of joint application of phosphorus and potassium at all proportions on growth and yield of pea. As the data for seed yield per hectare has been derived from the data of seed yield per plant, therefore, the results presented the same picture by following the similar trend (Table 2).

1000 seed weight: Data concerning the factor of study indicated that the phosphorus and potassium treatments have significant effect on seed weight while results in relation to their interaction were found non-significant (Table 3). The maximum weight of 1000 seeds was recorded from the plants received 69 kg P_2O_5 ha^{-1} and minimum from those received no phosphorus. These results are in accordance with the findings of Chandra *et al.*[10] who reported that application of phosphorus to pea cvs. Pea-116 and T-163 resulted in increased 1000 seed weight. In case of potassium treatments, maximum 1000 seed weight was obtained from the plants received 150 kg K_2O ha^{-1}, closely followed by those harvested from the plants received 100 kg K_2O ha^{-1}. However, both these treatments were statistically alike. The minimum 1000 seed weight was obtained from those did not receive any potassium. These results demonstrate that not only phosphorus, potassium application also improves seed weight in pea.

Percentage of large sized seeds: Information procured on seed grading indicated that phosphorus and potassium levels applied and their interaction had significant effect on seed size. Phosphorus application improved the seed size and percentage of large sized seeds increased with the increasing levels of phosphorus. Highest rate of phosphorus application (69 kg P_2O_5 ha^{-1}) resulted in highest percentage of large sized seeds as compare to other treatments, while minimum percentage of large sized seeds was recorded in plants received no phosphorus. Similar trend was observed for potassium levels, indicating that potassium also affects the seed size. However, potassium doses of K_2O @ 150 and 100 kg ha^{-1} behaved statistically alike and stood at par. The interaction between the phosphorus and potassium levels indicated that the increasing rate of phosphorus and potassium in different combinations resulted in increased percentage of large sized seeds. The highest percentage of large sized seeds was obtained when crop was fertilized with higher levels of both phosphorus and potassium (Table 4). These results indicate that both phosphorus and potassium play important role in seed development and hence to increase seed size.

Seed germination: Seed germination percentage was not affected by the levels of phosphorus and potassium and their combinations used (Table 5). This indicates that the fertilizers applied to seed crop have no influence on germination capacity of the seed. Shukla *et al.*[19] have already reported that increasing Phosphorus application has no effect on seed germination when pea cultivars were applied P_2O_5 @ 45, 60 or 75 kg ha^{-1}. Similar results have been reported by Padrit *et al.*[2]. Therefore, the results of present study are in conformity with previous findings.

Time taken to complete 50% germination: The number of days required to reach 50% seed germination can be used as an index of seed vigour. Phosphorus and potassium treatments and their interaction indicated highly significant results for the parameter under study. Means for phosphorus levels depicted that the minimum number of days were taken to complete 50% germination by the seed harvested from plants received 69 kg P_2O_5 ha^{-1}, while maximum days were taken by the

Table 1: Seed yield per plant (g) as affected by different levels of P_2O_5 and K_2O

	Levels of K_2O				
Levels of P_2O_5	K_0 (0 kg ha^{-1})	K_1 (50 kg ha^{-1})	K_2 (100 kg ha^{-1})	K_3 (150 kg ha^{-1})	Mean
P_0 (0 kg ha^{-1})	8.15h*	9.54g	10.35g	10.65g	9.67d
P_1 (23 kg ha^{-1})	11.89f	13.11de	14.28c	14.13cd	13.35c
P_2 (46 kg ha^{-1})	12.65ef	14.76c	16.69ab	16.71ab	15.20b
P_3 (69 kg ha^{-1})	13.03de	15.92b	17.57a	17.42a	15.99a
Mean	11.43c	13.33b	14.72a	14.73a	

Table 2: Seed yield per hectare (tonnes) as affected by different levels of P_2O_5 and K_2O

	Levels of K_2O				
Levels of P_2O_5	K_0 (0 kg ha^{-1})	K_1 (50 kg ha^{-1})	K_2 (100 kg ha^{-1})	K_3 (150 kg ha^{-1})	Mean
P_0 (0 kg ha^{-1})	2.61h*	3.05g	3.31g	3.41g	3.10d
P_1 (23 kg ha^{-1})	3.81f	4.20de	4.57c	4.52cd	4.27c
P_2 (46 kg ha^{-1})	4.05ef	4.72c	5.34ab	5.35ab	4.87b
P_3 (69 kg ha^{-1})	4.17de	5.09b	5.62a	5.57a	5.12a
Mean	3.66c	4.27b	4.71a	4.71a	

Table 3: 1000 seed weight (g) as affected by different levels of P_2O_5 and K_2O

	Levels of K_2O				
Levels of P_2O_5	K_0 (0 kg ha^{-1})	K_1 (50 kg ha^{-1})	K_2 (100 kg ha^{-1})	K_3 (150 kg ha^{-1})	Mean
P_0 (0 kg ha^{-1})	136.69a*	139.32a	141.23a	141.62a	139.72d
P_1 (23 kg ha^{-1})	141.36a	144.60a	145.18a	145.25a	144.10c
P_2 (46 kg ha^{-1})	143.57a	146.17a	148.05a	149.51a	146.82b
P_3 (69 kg ha^{-1})	144.71a	147.24a	149.52a	150.63a	148.02a
Mean	141.58c	144.33b	145.99a	146.75a	

Table 4: Percentage of large sized seeds as affected by different levels of P_2O_5 and K_2O

	Levels of K_2O				
Levels of P_2O_5	K_0 (0 kg ha^{-1})	K_1 (50 kg ha^{-1})	K_2 (100 kg ha^{-1})	K_3 (150 kg ha^{-1})	Mean
P_0 (0 kg ha^{-1})	68.48h*	69.72gh	70.80g	72.29ef	70.32d
P_1 (23 kg ha^{-1})	71.14fg	77.59c	79.80b	79.47b	77.00c
P_2 (46 kg ha^{-1})	73.41e	79.32b	83.57a	83.65a	79.99b
P_3 (69 kg ha^{-1})	75.76d	80.55b	83.97a	83.95a	81.06a
Mean	72.20c	76.80b	79.53a	79.84a	

Table 5: Seed germination (%) as affected by different levels of P_2O_5 and K_2O applied to the seed crop

	Levels of K_2O				
Levels of P_2O_5	K_0 (0 kg ha^{-1})	K_1 (50 kg ha^{-1})	K_2 (100 kg ha^{-1})	K_3 (150 kg ha^{-1})	Mean
P_0 (0 kg ha^{-1})	95.00a*	97.50a	96.75a	95.25a	96.13a
P_1 (23 kg ha^{-1})	96.75a	96.00a	97.00a	96.75a	96.63a
P_2 (46 kg ha^{-1})	96.25a	94.75a	95.00a	94.75a	95.19a
P_3 (69 kg ha^{-1})	95.00a	95.50a	94.50	97.50a	95.63a
Mean	95.75a	95.94a	95.81a	96.06a	

Table 6: Time taken to complete 50% germination (days) as affected by different levels of P_2O_5 and K_2O applied to the seed crop

	Levels of K_2O				
Levels of P_2O_5	K_0 (0 kg ha^{-1})	K_1 (50 kg ha^{-1})	K_2 (100 kg ha^{-1})	K_3 (150 kg ha^{-1})	Mean
P_0 (0 kg ha^{-1})	4.69a*	4.62abc	4.56c	4.60bc	4.62a
P_1 (23 kg ha^{-1})	4.67ab	4.45d	4.43d	4.45d	4.50b
P_2 (46 kg ha^{-1})	4.44d	4.34e	4.32e	4.33e	4.36c
P_3 (69 kg ha^{-1})	4.43d	4.17f	4.23f	4.43d	4.31d
Mean	4.56a	4.40c	4.39c	4.45b	

Table 7: Electrical conductivity (µS cm^{-1} g^{-1}) of seed soaked waters as affected by different levels of P_2O_5 and K_2O applied to the seed crop

	Levels of K_2O				
Levels of P_2O_5	K_0 (0 kg ha^{-1})	K_1 (50 kg ha^{-1})	K_2 (100 kg ha^{-1})	K_3 (150 kg ha^{-1})	Mean
P_0 (0 kg ha^{-1})	43.42c*	42.34cd	41.21de	47.87a	43.71a
P_1 (23 kg ha^{-1})	43.36c	37.32g	36.99g	46.34b	41.00b
P_2 (46 kg ha^{-1})	39.43f	34.67hi	35.38h	46.03b	38.88c
P_3 (69 kg ha^{-1})	40.12ef	33.36I	37.05g	46.04b	39.14c
Mean	41.58b	36.92c	37.66c	46.57a	

* Means sharing similar letters are statistically non-significant at P=0.05 (DMR test)

seeds procured from plants received no phosphorus. Mean values for potassium levels revealed that minimum number of days to complete 50% germination was required by the seed taken from plants received 100 kg K_2O ha^{-1}, closely followed by those harvested from the plants received 50 kg K_2O ha^{-1}. Both these treatments were statistically at par. Interaction means depicted that minimum days were taken to complete 50% germination by the seed harvested from plants applied with 69 kg P_2O_5+50 kg K_2O ha^{-1}. The seed procured from plants, which received no fertilizer took maximum number of days (Table 6). It is evident from the results that both phosphorus and potassium are necessary for pea seed production. However, potassium dose higher than 100 kg K_2O ha^{-1} might has adverse effects on seed vigour.

Electrical conductivity of seed soaked water: The electrical conductivity test is a measurement of electrolytes leaking from plant tissues. Vigour rating for the electrical conductivity tests is inversely related to seed vigour, i.e. high readings indicate low vigour and vice versa. Statistical analysis indicated significant results for phosphorus and potassium levels and also for their interaction. The mean values of phosphorus levels depicted that electrical conductivity of seed leachates decreased with the increasing rate of phosphorus applied to the mother plants from which seed was harvested. Seed harvested from plants, which received 69 kg P_2O_5 ha^{-1} resulted in lowest electrical conductivity of the leachates. Shukla *et al.*[19] and Padrit *et al.*[2] have reported that phosphorus application to pea crop improved seed vigour, however, it had no effect on conductivity of seed leachates[2] which is in contrast to the findings of the present study. Mean values for potassium levels revealed that the lowest electrical conductivity was recorded from the seed harvested from the plants received 50 kg K_2O ha^{-1}, closely followed by those harvested from the plants received 100 kg K_2O ha^{-1}. Maximum electrical conductivity was recorded in the leachates of the seed harvested from the plants received the highest dose of potassium (150 kg K_2O ha^{-1}). This indicates that the highest level of potassium applied to the mother plants also resulted in reduced vigour of seeds, suggesting that the nutrient regimes required for higher seed yield might differ from those to produce high quality seeds. With regard to interaction of the factors probed, it may be pointed out that lowest electrical conductivity was recorded from the leachates of the seed harvested from plants, which received 69 kg P_2O_5+50 kg K_2O ha^{-1}. Maximum electrical conductivity was recorded in the leachates of seed procured from the plants received 23 kg P_2O_5+150 kg K_2O ha^{-1} (Table 7), indicating that higher level of potassium might result in reduced seed vigour.

REFERENCES

1. Mullins, G.L., B.F. Hajek and C.W. Wood, 1996. Phosphorus in agriculture. Bull. No. 2. Dept. Agron. Soils, Auburn, USA., pp: 1-35.
2. Padrit, J., J.G. Hampton, M.J. Hill and B.R. Watkin, 1996. The effects of nitrogen and phosphorus supply to the mother plant on seed vigour in garden pea (*Pisum sativum* L.) cv. Pania. J. Appl. Seed Prod., 14: 41-45.
3. Usherwood, N.R., 1985. The role of potassium in crop quality. In: Munson, R.S. (Ed.). Potassium in Agriculture. ASA-CSSA-SSSA, Madison, WI, USA., pp: 489-513.
4. Mengel, K. and F.A. Kirkby, 1997. Principles of Plant Nutrition, 4th Ed. International Potash Institute, Bern, Switzerland, pp: 685.
6. Verma, M.L., A.R. Bhandari and J.N. Raina, 1997. Effect of nitrogen and phosphorus application on the yield and macronutrient concentrations of pea (*Pisum sativum* L.). Internat. J. Tropical Agric., 15: 195-198.
5. Saini, J.P. and S.R. Thakur, 1996. Effect of nitrogen and phosphorus on vegetable pea (*Pisum sativum* L.) in cold desert area. J. Agric. Sci., 66: 514-517.
7. Srivastava, T.K. and I.P.S. Ahlawat, 1995. Response of pea (*Pisum sativum* L.) to phosphorus, molybdenum and biofertilizer. Indian J. Agron., 40: 630-635.
8. Gupta, C.R., S.S. Sengar and J. Singh, 2000. Growth and yield of table pea (*Pisum sativum* L.) as influenced by levels of phosphorus and lime in acidic soil. Vegetable Sci., 27: 101-102.
9. Dubey, Y.P., B.P. Kaistha and R.C. Jaggi, 1999. Influence of irrigation and phosphorus on growth, green pod yield and nutrient uptake of pea (*Pisum sativum* L.) in Lahaul Valley of Hiamachal Pradesh. Indian J. Agron., 44: 137-140.
10. Chandra, R., R. Pollsetty and J.D.S. Panwar, 1989. Effect of chloromequat and phosphorus on growth and yield of pea. Ann. Plant Physiol., 31: 65-73.
11. Sinha, B.N., B.S. Mehta and J. Mandal, 2000. Quality and seed yield of garden pea (*Pisum sativum* L.) cultivars as influenced by date of planting and phosphorus levels. Indian J. Agric. Sci., 70: 248-249.

12. Singh, K.N., K.D. Prasad and V.P.S. Tomar, 1983. Response of French bean to different levels of nitrogen and phosphorus in Nilgiri-Hills under rain fed conditions. Indian J. Agron., 26: 101-102.
13. Deshpande, S.B., A.S. Jadhav and A.B. Deokar, 1995. Effects of phosphorus and intra row spacing on the yield of French bean. J. Maharashtra Agric. Univ., 20: 423-425.
14. Baboo, R., N.S. Rana and P. Pantola, 1998. Response of French bean (*Phaseolus vulgaris* L.) to nitrogen and phosphorus. Ann. Agric. Res., 19: 81-82.
15. Parmar, D.K., T.R. Sharma, J.P. Saini and V. Sharma, 1999. Response of French bean (*Phaseolus vulgaris*) to nitrogen and phosphorus in cold desert area of Himachal Pradesh. Indian J. Agron., 44: 787-790.
16. Jain, P.C., R.R. Das and G.S. Chauhan, 1984. Yield response of cowpea to phosphorus, potash and row spacing under rain fed conditions. Legume Res., 7: 69-72.
17. Tenebe, V.A., Y. Yusuf, B.K. Kaigama and I.O.E. Asenime, 1995. The effects of source and levels of phosphorus on the growth and yield of cowpea (*Vigna unguiculata* L.) varieties. Tropical Sci., 35: 223-228.
18. Tomar, S.S. and R.K. Sharma, 1991. Effect of levels of nitrogen, phosphorus and its method of application on growth, yield and economics of pigeon pea under rain fed conditions. Gujrat Agric. Univ. Res. J., 17: 82-84.
19. Shukla, Y.R., U.K. Kholi and S.K. Sharma, 1993. Influence of phosphorus fertilization on yield and quality traits in early cultivars of garden pea. Hort. J., 6: 129-131.
20. Vorob'-ev-V.A., 2000. Effective inoculation of leguminous plants in relation to provision of phosphorus and potassium and dependence on rhizosphere temperature. Agrokhimiya, 2: 42-44.
21. Coolbear, P., A. Francis and D. Grierson, 1984. The effect of low temperature pre-sowing treatment on the germination performance and membrane integrity of artificially aged tomato seeds. J. Exp. Bot., 35: 1609-1617.
22. International Seed Testing Association (ISTA), 1987. Handbook of Vigour Test Methods. Internat. Seed Test. Assoc. Zurich, Switzerland, pp: 53-115.
23. Amjad, M. and M.A. Anjum, 2003. Effect of post-irradiation storage on the radiation-induced damage in onion seeds. Asian J. Plant Sci., 2: 702-707.
24. Petersen, R.G., 1994. Agricultural Field Experiments-Design and Analysis. Marcel Dekker, Inc., New York, pp: 78-89.
25. Ahlawat, I.P.S., 1996. Response of French bean (*Phaseolus vulgaris*) varieties to plant density and phosphorus level. J. Agric. Sci., 66: 338-342.
26. International Seed Testing Association (ISTA), 1985. International rules for seed testing. Seed Sci. Technol., 13: 299-355.