Discussion

Pea is one of the important grain legumes in India and used as a source of protein. The productivity of pea, however, continues to be below desired levels. There has been only marginal increase in average productivity of pea in last three decades. Better crop variety, crop management and balanced fertilization have very high impact in improving productivity of pea.

Phosphorus application was felt more useful in legumes as it is not only help in proliferation of root and bacterial colonies but also improves water use efficiency. Pea as a pulse has ability to fix atmospheric nitrogen and application of phosphorus to this crop is of vital significance in affecting pulse production.

5.1 Effect of phosphorus

5.1.1 Effect of phosphorus on growth attributes

Initial plant population due to varying levels of phosphorus did reach to the level of significance during both the years of study. This was mainly due to the fact that properly applied phosphetic fertilizers did affect the germination of seed which resulted in uniform plant population. Similar result was found by Vellayuttram and Shanmugam (1972) and also reported that phosphorus is important in root development and nodulation and it gives a rapid and vigorous start to plants by stimulating early and abundant root development.

There was increase in plant height with increase in the dose of phosphorus and the maximum height was attained with 80 kg P$_2$O$_5$/ha as compared with the remaining levels of phosphorus during both the years. It might be due to the fact that phosphorus plays an important role in the synthesis of tryptophane, a precursor of plant growth hormones. This is in close conformity with the findings of Srivastava and Verma (1985), who found that increasing P$_2$O$_5$ rate up to 60 kg ha' markedly increased the growth of peas. Significant increase in growth has also been observed with phosphorus application in pea (Kanauija et al., 1997; Parsad et al., 1989).

The levels of phosphorus exhibited highly significant differences in number of branches
per plant during both the years. It is also evident that increasing levels of phosphorus increased the number of branches per plant in 2007-08 and 2008-09. Application of 80 kg phosphorus per hectare produced higher number of branches per plant during both the years. It might have increased the number of primary and secondary branches per plant. Results are in the conformity with the results obtained by Patel et al. (1998) and reported that application of 50% nitrogen, increased plant height, number of branches, leaves per plant, number of pos per plant, grain per pod yield significantly compared with recommended level of nutrients (20kg N + 80 kg Phosphorus + 20 kg K) applied through chemical fertilizers.

There was increase in plant dry weight with increase in the dose of phosphorus and the maximum plant dry weight was attained with 80 kg P$_2$O$_5$/ha as compared to the remaining levels of phosphorus during both the years. It might be due to the fact that phosphorus plays an important role in the synthesis of tryptophane, a precursor of plant growth hormones. This is in close conformity with the findings of Gubbels (1992), Padmalatha and Rao(1993), Sarvaiya et al. (1993), Yadav and Chauhan (1997) and Verma et al. (1998) and observed that plant height, number of branches, shoot dry weight, number of pod, seed yield and biomass yield were increased application of phosphorus up to 60 kg P$_2$O$_5$ ha$^{-1}$ and then decreased at 90 kg P$_2$O$_5$ ha$^{-1}$.

In the present investigation, the levels of phosphorus showed highly significant differences in days to fifty per cent flowering during both the years. A perusal of the data indicates that maximum days to fifty percentage flowering were observed in control plots, but minimum days to fifty percent flowering were recorded in application of 80 kg phosphorus per hectare during both the years of study. It may be mainly due to the more availability of phosphorus.

The levels of phosphorus showed highly significant difference in days to maturity during both the years. The trend of the data revealed that increasing levels of phosphorus decreased the days of maturity in both the years. Application of 80 kg phosphorus per hectare lower days to maturity as compared to other phosphorus levels in both the years.

5.1.2 Effect of phosphorus on yield and yield attributes

Number of pods per plant increased significantly over control at all the levels of
phosphorus application during 2007-08 and 2008-09. Application of 80 kg phosphorus per hectare recorded more number of pods per plant as compared to other phosphorus levels in both the years. It may be due to more absorption of phosphorus by plants. This is in complete agreement with the findings of Srivastava and Ahlawat (1995) who reported that the highest rate of phosphorus produced maximum number of pods per plant of pea and similar in French bean (Ahlawat, 1996; Kanauija et al., 1999; Parmar et al., 1999; Singh, 2000).

There was significant increase in weight of pod per plant with increasing the dose of phosphorus at all the growth stages in both the years. Application of 80 kg phosphorus per hectare increased the weight of pods per plant as compared to other phosphorus levels in both the years. It may be due to more absorption of phosphorus by plants and formation of seed. This is in complete agreement with the findings of Srivastava and Ahlawat,(1995). Chandra et al. (1989) reported that increased seed yield with application of phosphorus in pea, pigeon pea (Tomar and Sharma, 1991) and french bean (Parmar et al. 1999).

The levels of phosphorus showed highly significant differences in number of grains per pod during both the years. The trend of the data revealed that increasing levels of phosphorus decreased the number of grains per pod in both the years. Application of 80 kg phosphorus per hectare recorded higher number of grains per pod as compared to other phosphorus levels in both the years. It may be stated that adequate supply of phosphorus played an important role. Similar results were also reported by Sharma and Mandeo (1996) who observed that nodulation per plant, seeds per pod, 100 seed weight and seed yield were greatest with 75 kg P/ha and rhizobium + FYM + PSB in soybean and pea as well as.

Test weight (1000 seeds) increased significantly over control at all the levels of phosphorus application during both the years. Application of 80 kg phosphorus per hectare higher test weight 1000 seeds as compared to other phosphorus levels in both the years. It may be due to the more absorption of phosphorus by plants. Similar results were also reported by Amjad et al., (2004) and stated that seed yield and 1000 seed weight were significantly increased with increased level of P₂O₅ and K₂O applications up to the dose of 69+100 kg ha⁻¹, respectively.
The levels of phosphorus showed highly significant differences in grain yield during both the years. The trend of the data revealed that increasing levels of phosphorus increased the grain yield in both the years. Application of 80 kg phosphorus per hectare higher grain yield as compared to other phosphorus levels in both the years. The increase in seed yield was associated with increase in development characters like pods per plant, number of grain per pod and test weight 1000 seeds. Similar results have been reported by Kumrawat (1997) and reported that seed yield and test weight of pea increase significantly due to the application of Rhizobium, phosphate solubilizing microorganism and N-P-K fertilizers.

Straw yield increased significantly over control at all the levels of phosphorus application during both the years. Application of 80 kg phosphorus per hectare higher straw yield as compared to other phosphorus levels in both the years. This increase in straw yield might be due to higher availability of phosphorus. Similar results were also reported by Eira et al. (1974) reported that highest yield of pea with 79 kg P2O5/ha, but the most economical rate was 55 kg /ha in alluvial soil.

In the present trial, phosphorus levels caused highly significant differences in harvest index during both the years. In general, greater harvest index was recorded with higher application of phosphorus during both the years. Application of 80 kg phosphorus per hectare enhanced the higher harvest index as compared to other phosphorus levels in both the years. It may be due to increasing seed yield.

5.1.3 Effect of phosphorus on quality characters

A perusal of the data indicates that increasing levels of phosphorus showed the minor increasing in protein percentage in grain during 2007-08 and 2008-09. The maximum protein percentage was noticed with 80 kg phosphorus per hectare. Phosphorus uptake by grain increased with increasing levels of phosphorus which might be involved in raising the protein percentage of pea seed. Similar results were also observed by Tosum and sever (1992) reported that P fertilizer did not significantly affect seed yield or protein content.

There was increase in nitrogen percentage in straw with increase in the dose of phosphorus and the maximum nitrogen percentage in straw was attained with 80 kg P2O5 /ha as
compared to the remaining levels of phosphorus during both the years. It might be due to more absorption of phosphorus by plants. This is in close conformity with the findings of Jakobsen (1985) who reported that the nutrient content of a given organ depends on its sink strength for that particular nutrient.

Phosphorus percentage in straw and grain increased significantly over control at all the levels of phosphorus application during both the years. Application of 80 kg phosphorus per hectare increased the higher phosphorus percentage in straw and grain as compared to other phosphorus levels in both the years. This increase in phosphorus percentage in straw and grain might be due to higher availability of phosphorus. Similar results were also reported by Rao and Reddy (1997) and Singh et al. (1981) observed that increases in root dry weight, number of nodule, crude protein rate and phosphorus content of seed by the application of phosphorus up to 90 kg P$_2$O$_5$ ha$^{-1}$.

5.2 Response of varieties

5.2.1 Response of varieties on growth attributes

Initial plant population due to different varieties of pea reached to the level of significance during both the years of study. This was mainly due to the varieties of pea affected the germination of seed which resulted in uniform plant population.

There was increase in plant height with varying varieties and the maximum height was attained by Sapania (KPMR-144-2) variety as compared to the other varieties of pea during both the years. It might be due to the varietal differences due to genetic characters. Jadhav et al. (1995) found that pea genotype KPMR-144-2 was found to be superior in terms of plant height and test weight over Aparna pea genotype.

The varieties of pea exhibited highly significant differences in number of branches per plant during both the years. Sapania (KPMR-144-2) variety produced higher number of branches per plant during both the years. It may be due to the genetic characters of this variety.

Higher plant dry weight was recorded in Sapania (KPMR-144-2) variety than other varieties. It may be due to the more plant height and number of leaves per plant of this variety as
In the present investigation, the different varieties of pea showed highly significant differences in days to fifty percent flowering during both the years. A perusal of the data indicates that maximum days to fifty percentage flowering were observed in Malviya-2 variety, but minimum days to fifty percent flowering were recorded in Sapana (KPMR-144-2) variety during both the years of study. It may be mainly due to the genetic characters. Ramaiah et al. (1994) at Bangalore observed that number of days to 50 per cent flowering and to physiological maturity was lowest in KPMR-144-2 and similar in the other 2 cultivars.

Varieties of pea showed highly significant differences in days to maturity during both the years. The trend of the data revealed that Sapana (KPMR-144-2) variety taken lesser days to maturity in both the years. Singh (1998) reported that KPMR-144-2, out yields other genotypes and it has several desirable characters like early maturity and also high yielding ability.

5.2.2 Response of varieties on yield and yield attributes

The varieties of pea exhibited highly significant differences in number of pods per plant during both the years. Sapana (KPMR-144-2) variety produced maximum number of pods per plant in both the years. It may be due to growth quality of variety. Similar results were also observed by Shivashankar et al. (1990) based on their experiments for five years at Bangalore concluded that KPMR-144-2 is the best among all varieties due to its yield contributing characters like number of pods per plant and 1000-seed weight.

Varieties of pea showed highly significant differences in weight of pods per plant during both the years. The trend of the data revealed that Sapana (KPMR-144-2) variety taken maximum weight of pods per plant in both the years. It may be due to bold seeds. Similar results were also observed by Purushotham et al. (2001) who reported that among different cultivars Aparna, Rachana, Sapana (KPMR-144-2), Arkel and Malviya-2, the highest weight of pods per plant was registered by Sapana (KPMR-144-2).

The different varieties of pea showed highly significant differences in number of grains per pod during both the years. The trend of the data revealed that Sapana (KPMR-144-2) variety
produced higher number of grains per pod as compared to other varieties of pea in both the years. It may be due to the genetic characters of variety. Kohli et al. (1992) observed that maximum number of grain per pod in KPMR-144-2 and similar in the Rachana and Arkel cultivars.

Test weight increased significantly due to varieties of pea during both the years. Sapana (KPMR-144-2) variety recorded higher test weight as compared to other varieties of pea in both the years. It may be due to the bolder seeds. Similar results were also observed by Birari et al. (1993) at Dapoli observed that among seven promising genotypes, the high yielding genotypes were KPMR-144-2 and Malviya. KPMR-144-2 showed a high degree of predictability for 1000-grain weight and harvest index and was rated as the most stable genotype.

The different pea varieties showed highly significant differences in grain yield during both the years. The trend of the data revealed that Sapana (KPMR-144-2) variety produced higher grain yield as compared to other varieties of pea in both the years. The increase in seed yield was associated with increase in development characters like pods per plant, number of grain per pod and test weight 1000 seeds. Similar results were also observed by Gracy-Mathew et al. (1998) in Kerala and reported that Sapana (KPMR-144-2) and Rachana were high yielding, short duration cultivars.

Varieties differed significantly in straw yield during both the years. Sapana (KPMR-144-2) variety produced higher straw yield as compared to other varieties of pea in both the years. This increase in straw yield might be due to the more plant height and number of leaves per plant.

In the present trial, varieties of pea showed highly significant differences in harvest index during both the years. In general, greater harvest index was recorded with Sapana (KPMR-144-2) variety during both the years. Sapana (KPMR-144-2) variety higher harvest index as compared to other varieties in both the years. It may be due to the higher grain yield.

### 5.2.3 Response of varieties on quality characters

A perusal of the data indicates that different varieties of pea showed the protein percentage in grain during both the years. The maximum protein percentage was noticed in Sapana (KPMR-144-2) variety. More uptake of phosphorus by which might be involved in
increasing the protein percentage of pea seed. Similar results were also reported by Nirmal et al. (2001) reported that in Varanasi, yield potential of Sapana and Malviya-2 genotype was highest among 20 tested cultivars. Higher protein content was recorded in Sapana and Malviya-2 cultivars of pea.

Maximum nitrogen percentage in straw was observed in Sapana (KPMR-144-2) variety as compared to the other varieties of pea during both the years. It might be due to the ability of this variety to absorb more nitrogen than other varieties.

Varieties brought about significant differences in phosphorus percentage in straw and grain in both the years. Sapana (KPMR-144-2) variety recorded higher phosphorus percentage in straw and grains than other varieties of pea in both the years. This increase in phosphorus percentage in straw and grain might be due to higher absorption of phosphorus by this variety.

5.3 Economics

The maximum expenditure (Rs. 48286.60) incurred under the treatment combination 80 kg P₂O₅/ha and Sapana (KPMR-144-2) during both the years. This was mainly due to increasing levels of phosphorus and suitable variety which raised the common cost under various treatments. However, low fertility under control, i.e. 0 kg P₂O₅/ha and Malviya-2 variety treatment combinations resulted in the lowest cost of cultivation. Gross as well as net income increased with application of 80 kg P₂O₅/ha to Sapana (KPMR-144-2). This was because of increased grain and straw yields.