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Influence of plant hormones and level of phosphorus on growth and yield of field pea (*Pisum sativum* L.) under irrigated conditions of Punjab

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Abstract
The influence of plant hormones and level of phosphorus (i.e. 0, 40 and 60 kg P_2O_5 ha^{-1}) on growth and yield of field pea (*Pisum sativum* L.) was conducted at Campus for Research and Advanced Studies Dhablan of the G.S.S.D.G.S. Khalsa College, Patiala, Punjab during *Rabi*-2017-2018. The experiment laid out in factorial randomized block design with 3 replications, consisting of 12 treatment combination. The soil of experimental field was clay in texture with pH 7.3 and contained organic carbon 0.52, available nitrogen 262 kg ha^{-1}, available P_2O_5 22.6 kg ha^{-1}, available K_2O 129kg ha^{-1}. Application of 60 kg phosphorus ha^{-1} recorded significantly higher growth characters *viz*. plant height, number of leaves, number of branches, fresh weight and dry weight and yield (grain and straw yield) than lower levels of 40, 0 kg phosphorus ha^{-1}. Significantly higher growth and yield of field pea was recorded with GA_3 + IAA +IBA (50ppm + 50ppm + 50ppm) as compared to others. The maximum B: C ratio was recorded with application of 60 kg phosphorus ha^{-1} and GA_3 + IAA +IBA (50ppm + 50ppm + 50ppm). From the result, it was concluded that the maximum yield of the field pea could be achieved by application of P_2O_5 @ 60 kg ha^{-1} and GA_3 + IAA +IBA (50ppm + 50ppm + 50ppm).

Keywords: Phosphorus, GA_3 + IAA +IBA

Introduction
Field pea (*Pisum sativum* L.) is an annual herbaceous pulse crop in the world. It cool- season growing crop in many parts of the world. It is required in all over the world for consumption. Field pea (*Pisum sativum* L.) belongs to the family Fabaceae and genus Pisum. The field pea is native of the Mediterranean region of, southern Europe and to western Asia. India is apremier pulse growing country. Field pea is highly nutritious containing high percentage of digestible protein along with carbohydrates and vitamins. It is also very rich in minerals pea has proteins 22% in dry seed and 7.2% in green pod, fats 1.8g, mineral 3.2g, carbohydrates 62.22g, calcium 64mg, magnesium 34mg, phosphorus 139mg, copper 0.23mg, sulphur 95mg, iron 1.5mg, riboflavin 0.01mg, nicotinic acid 0.8mg and vitamin C 9.0mg per 100g of addible portion. This crop and it's by product is used as fodder.

India is one of the largest producers of the field pea in the world and stands at the 5th place in the list of major field pea producers next to France. In India, field pea is grown for its dry pods in Rabi season in the plain Northern India. Main pea cultivation states in India are Rajasthan, Uttar Pradesh, Orissa, Haryana, Bihar, Maharashtra, Madhya Pradesh and Punjab. Field pea is one of important pulse crop of the world cultivated over an area 5.9 million hectare with production of about 11.7 million tonnes. In India is grown over an area of 0.7 million hectares with production of about 0.6 million tonnes. In Punjab field pea is grown on 3.2 thousand hectares and a production of 4.1 thousand tonnes. It mainly grown in Hoshiarpur district under rain fed conditions.

The plant growth regulators are natural compounds, other 3 than supplements which in little focus impact the physiological procedures of plants. They have been utilized for different helpful impacts, for example, advancing root development, expanding number of flowers,

Natural product size and prompting early and uniform organic product maturing. The utilization of plant growth regulators either as plant shower or as seed treatment has acquired prodigious outcomes both yield and nature of numerous vegetable harvests. The impacts of plant growth regulators were affected by light, temperature, dampness, supplements and other natural variables. The efficiency of plant growth regulators changes under various fixations, techniques for application and time of use. Increasing the production of pea green pod and dry seed with high quality by using the foliar application of plant hormones. Plant hormones are the chemicals which regulates the growth of plants. Use of plant hormones enhance the growth and yield attributing characters of plants and increasing the quality and quantity of yield per unit area and it reduces the cost of production of crop.

Major plant hormones are auxin, gibberellins, cytokinins, abscisic acid, and ethylene. Each type of hormones has a specific role in growth and development of plant. Auxins are produce in the apical meristems. Gibberellins effect stem elongation, fruit growth, and seed germination. GA3 produce more vegetative growth than need for its maximum pod production and yield when the climatic conditions favour vegetative growth (Tavelu Vadeo, 2018) [7]. Phosphorus has a crucial part in the energy metabolism of all plant cells and particularly for nitrogen fixation in legumes crop. Field pea has a relatively large requirement for phosphorus, yield and seed quality can be enhanced by phosphorus fertilizer in soils testing low in phosphorus. Phosphorus is needed for the development of the roots and healthy seedling. Phosphorus plays a most important role in the nitrogen fixation. Murat Erman *et al*. 2006-2007 reported that phosphorus application has significantly effect on the height of the plant, number of branches, roots and shoot dry weight of the plant, number of nodules, seed and biomass yields, numbers of pods, crude protein rate. Akhtar *et al*. 2003 [1] reported that potassium applied and in combination with phosphorus also has significant effect on green pod yield per hectare. Phosphorus not only increase root growth, it also promotes early plant maturity. Phosphorus is important component of protein and phospholipids.

Materials and Methods

The influence of plant hormones and level of phosphorus (i.e. 0, 40 and 60 kg P2O5 ha-1) on field pea (*Pisum sativum* L.) growth, yield and quality was studied at Campus for Research and Advanced Studies Dhablan of the G.S.S.D.G.S. Khalsa College, Patiala, Punjab during Rabi-2017-2018. The soil of experimental field was clay in texture with pH 7.3 and contained organic carbon 0.52, available nitrogen 262 kg ha-1, available P2O5 22.6 kg ha-1, available K2O 129kg ha-1. The experiment was laid out in factorial randomized block design (FRBD) with 12 treatments each treatment was replicated three times. It comprises of 3 plant hormones PH1: GA3 (50ppm), PH2: IAA (50ppm), PH3: IBA (50ppm) and GA3 + IAA +IBA 50ppm + 50ppm + 50ppm with same concentration and three different level of phosphorus (P0: 0, P1: 40 and P2: 60 kg P2O5 ha-1). All the plots were sown manually. The sowing of experimental crop was done on 12 October, 2017. The crop was kept free of weeds by hand hoeing at 10 and 20 days after emergence. The data were collected by following the standard procedure on, plant height (cm), number of leaves per plant, number of branches per plant, fresh weight (g), dry weight, number of flowers per plant, number of pods per plant, number of seed per pod per plant, 1000-seed weight, biological yield and seed yield.

Result and Discussion

Results (Table I) indicate that phosphorus and plant hormones had significant on all growth characters like plant height, number of leaves per plant, number of branches per plant, fresh weight (g), dry weight. The maximum plant height 72.49 cm was exhibited by P2 (60 kg P2O5 ha-1). Favorable effect of phosphorus applied up to 60 kg ha-1 has also been reported by Kumar (2014) and Athokpam *et al*. (2018). Plant hormones also affected plant height significantly at all stages of crop growth. Maximum plant height 96.40 cm was recorded with PH4 (GA3 + IAA +IBA). Similar effect of auxins and gibberellins in increasing plant height was reported by Vadeo (2018) [7]. The increasing in plant height due to the cell elongation or cell enlargement.

The phosphorus level 60 kg ha-1 resulted in significantly higher number of leaves per plant over control. It was also reported by Kandil (2014) [4]. The number of leaves significantly increases with the application of PH4 (GA3 + IAA +IBA) as compared to other plant hormones. Reduced number of leaves per plant at harvest compared with 90 DAS was due to senescence of leaves. The interaction effect of phosphorus and plant hormones gave non significant on the number of leaves.

The number of branches increased significantly with increasing the level of phosphorus. The maximum numbers of branches were produced with 60 kg P2O5 ha-1 as compared to control. A favorable effect of phosphorus application number of branches has also been reported by Mandal *et al*. (1997) [6] and Kandil (2014) [4]. Plant hormones also affected number of branches significantly at all stages of observations. Foliar application of plant hormones increases the numbers of branches. There were significantly increases the number of branches with the application of PH4.

Fresh and dry weight of per plant increased with increasing level of phosphorus up to 60 kg ha-1 and with foliar application of plant hormones PH4 (GA3 + IAA +IBA). Significantly 60 kg P2O5 ha-1 were produce maximum fresh weight of the plant were 29.05 g. More number of leaves might have accompanied with more photosynthesis and accumulation of food material resulting in higher fresh weight. Plant hormones also influence the fresh weight of plant thus the maximum fresh weight of the plant 38.27 g. maximum dry weight of the plant were also recorded with the P2 (60 kg P2O5 ha-1) and PH4 (GA3 + IAA +IBA).

Table II shows that application of 60 kg P2O5 ha-1 and PH4 (GA3 + IAA +IBA) significantly increased the yield of the field pea thus the biological yield and seed yield were increased. Table II shows that phosphorus had significant effect on test weight and the effect of phosphorus application on seed weight was also found to be significant. Significantly, maximum test weight attained by treatment P2 (60 kg P2O5 ha-1).

Table 1: Influence of plant hormones and level of phosphorus on growth of field pea

	Plant height (cm)	No. of leaves	No. of branches	Fresh wt. (g)	Dry wt. (g)
Phosphorus level					
P_0	66.71	84.30	15.70	24.04	12.94
P_1	69.79	97.10	17.32	27.17	14.25
P_2	72.49	102.14	18.60	29.05	15.05
SE(M)±	1.574	1.527	0.607	0.739	0.468
CD(P= 0.05)	3.265	3.166	1.259	1.532	0.917
Plant hormones					
PH_1	76.14	85.93	15.76	21.92	13.89
PH_2	53.62	87.28	16.48	24.62	14.15
PH_3	52.48	84.77	14.93	20.89	11.36
PH_4	96.40	120.08	22.28	38.27	16.92
SE(M)±	1.818	1.763	0.701	0.853	0.541
CD(P= 0.05)	3.770	3.656	1.454	1.769	1.122

Phosphorus application significantly increases the grain yield of field pea with application of 60 kg phosphorus ha^{-1}produced higher grain yield (20.19q ha^{-1}) as compared to control. Plant hormone PH_4 recorded (21.32 q ha^{-1}) higher grain yield than the others. The maximum straw yield and biological yield were attained by the treatment P_2 (60 kg P_2O_5 ha^{-1}) which has been shown in table II. Significantly, the minimum straw yield and biological yield was observed in treatment P_0 (control). Minimum biological yield in treatments where no phosphorus and plant hormones were applied.

Table 2: Influence of plant hormones and level of phosphorus on yield and quality of field pea.

	Grain yield(q ha^{-1})	Straw yield (q ha^{-1})	Biological yield(q ha^{-1})
Phosphorus level			
P_0	15.93	18.09	34.02
P_1	18.53	20.44	38.98
P_2	20.19	21.69	41.89
SE(M)±	0.515	0.509	0.906
CD(P= 0.05)	1.067	1.055	1.880
Plant hormones			
PH_1	17.34	19.18	36.53
PH_2	18.68	20.32	38.98
PH_3	15.54	17.53	33.09
PH_4	21.32	23.27	44.59
SE(M)±	0.594	0.587	1.047
CD(P= 0.05)	1.233	1.218	2.170

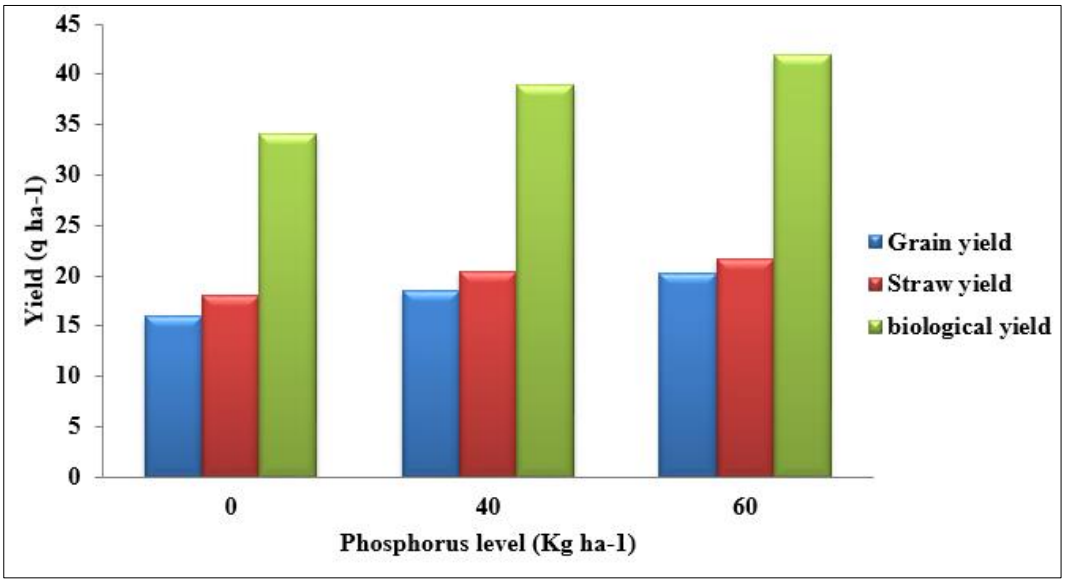

Fig 1: Influence of level of phosphorus on grain yield, straw yield and biological yield

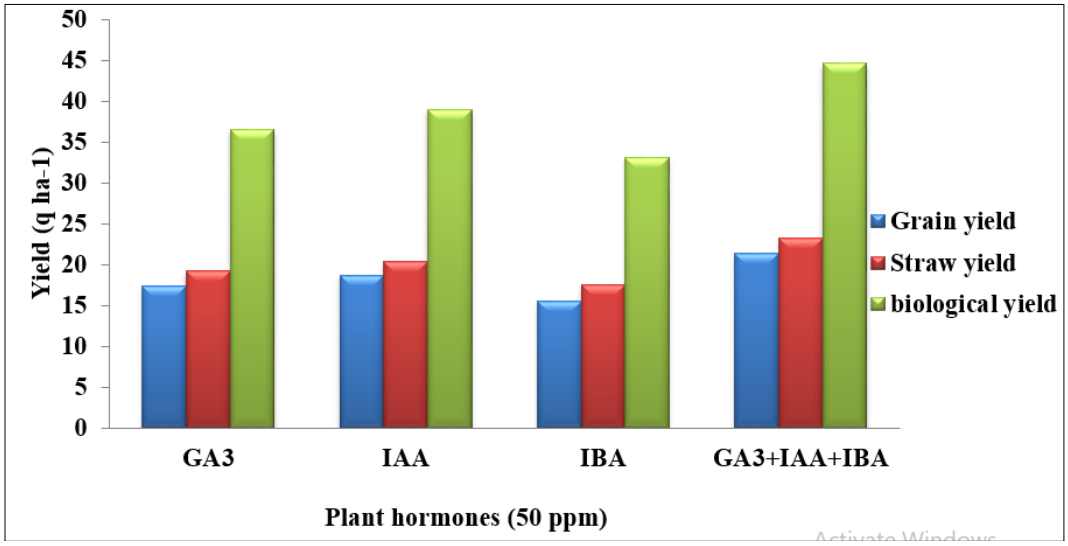

Fig 2: Influence of plant hormones on grain yield, straw yield and biological yield

Conclusion

On the basis of experimental finding it can be concluded that application of phosphorus @ 60 kg ha^{-1} was recorded highest growth and yield of field pea. In case of growth regulators, the highest growth and yield were reported with application of PH_4 (GA_3 + IAA+ IBA). Thus the results of the study concluded that application of phosphorus @ 60 kg/ha along with growth regulators PH_4 (GA_3+ IAA+ IBA) gave highest growth and yield However, the study requires more critical testing at various locations with staggered survey before final recommendations are made.

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