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Effect of phosphorus levels and Rhizobium culture on growth, yield and quality of early varieties of Garden pea (*Pisum sativum* L.)

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Abstract
The present investigation entitled "Effect of phosphorus levels and Rhizobium culture on growth, yield and quality of early varieties of Garden pea (*Pisum sativum* L.)" was carried out at the Horticulture Research Farm, A.K.S University, Satna (M.P). The field experiment was conducted during the rabi season of 2017-2018. The experiment was conducted in randomized block design with (factorial) 3 replications. The maximum pod yield 46.08 q/ha was obtained by the effective use of phosphorus @ 60kgP_2O_5/ha. Outstanding pod yield ie 47.50q/ha was obtained when Jawahar matar-3 was evaluated. Interactive use of $V_2Rh_1P_2$ (Jawahar matar-3 + with Rhizobium inoculation) produced a large quantity of pod yield ie 48.50 q/ha which was significantly outstanding among rest of the combinations. Shelling percent and protein content was found to be significantly more and it was 43.68% and 7.15% due to individual use of phosphorus @ 60kgP_2O_5/ha respectively.

Keywords: Garden pea, phosphorus, rhizobium culture, protein content and yield

Introduction
Garden pea is an important vegetable crop grown throughout the world. It is grown mainly as a winter vegetable in the plains of northern India and as a summer vegetable in the hills. Garden peas are utilized mainly as a vegetable. Beside, it is also consumed as a pulse. Sometimes, the Garden pea is grown for forage and green manure and a pods are sometimes fed to farm animals. The whole pod of Garden pea can be eaten as a pod and its wall contains less fibre. Garden peas are highly nutritive and are rich source of digestible proteins (7%), along with carbohydrates and vitamins. It is used as a fresh vegetable or in soup, canned, processed or dehydrated Phom *et al.*, 2014). Garden pea haulms form a nutritive fodder. Garden pea occupies an area of 7,42,000ha with a production of 4,346,000 tonnes in the world. While in India, it occupies an area of 79,789ha with a production of 4,88,252 tonnes. The average yield in India is 6.12 tonnes/ha which is at par with the world average of 6.1 tonnes/ha. Garden peas are sown in Rabi season from beginning of October to the end of November in northern plains (Shabeer *et al.*, 2010) [8]. The optimum temperature for seed germination is about 22 ºC, however, it can germinate up to 5 °C but at slow rate. Garden peas grow best at mean temperature of 13-18 ºC. It is tolerant to frost at early stage of growth (Vimla and Natrajan, 2000) [9]. But at later stage, the flowers and pods are affected. Garden pea is cultivated on a large scale in the states like Uttar Pradesh, Madhya Pradesh and Jharkhand. It is also grown in Himachal Pradesh, Punjab, West Bengal, Haryana, Bihar, Uttarakhand, Jammu and Kashmir, Odisha, parts of Rajasthan and Maharashtra. In south, it is grown in Karnataka and in the hilly regions like Ooty and Kodaikanalin Tamil Nadu. Uttar Pradesh is the leading state in the area (171.2 thousand ha) and production (17.82 lakh tonnes) followed by Madhya Pradesh (56.1 thousand ha; and 4.74 lakh tonnes).

Materials and Methods
The present investigation entitled " Effect of phosphorus levels and Rhizobium culture on growth, yield and quality of early varieties of Garden pea (*Pisum sativum* L.)'' was carried out at the Horticulture Research Farm, AKS University, Satna, M.P during Rabi season of 2017-18. Experiment was conducted with a view to work out the effect of phosphorus levels, Rhizobium inoculation, varieties and their interaction on growth, yield and quality of Garden pea. The experiment was conducted in randomized block design with (factorial) having 12 treatments in 3 replications. The allocation of the different treatments of the individual newly growth green pea plots of field using random number in each replication.

The soil of the experimental field was clay loam in nature with pH 7.30, organic carbon 0.40 percent, available nitrogen 150.50 kg/ha, phosphorus 11.75kg/ha, and potassium 200 kg/ha. Three levels of phosphorus (0kg, 30 kg, and 60kg), Rhizobium inoculation and without Rhizobium and two cultivars ie Arkel and Jawahar matar-3) were evaluated in Randomized block design with three replications. Observations gathered were viz height of the plants, number of leaves/plant, number of branches/plant, and Phenological trait ie days taken to 50% flowering. Among yield and its attributes were length of pod (cm), width of pod (cm), number of seeds/pod, shelling percentage, fresh weight of pod, dry weight of pod/plant, total number of pods/plants, pod yield q/ha. Besides, protein content in % were determined. The experimental plot was kept free of weeds by repeated hand weeding. In order to control pests and diseases infestation, necessary organic plant protection measures like collection and destruction of removal of infected plants and spraying of Chlorpyriphos @ 2ml litre^{-1} of water for the control of mites was done. Garden pea variety was sown on 28th September 2018. The sowing was done by hand – drilling in the same furrows after application of fertilizer according to the treatments. A light irrigation was done just after 10 days of sowing and next irrigation was given before 5% flowering were over. As per treatments four picking of pods were done when these pods were in edible form. And total weight per plot of each picking were noted for observation.

Results and Discussion

Garden pea is an important Rabi Season vegetable as well as pulse crop which is a very important for human diet. The productivity of the crop is average mainly because of its cultivation on marginal land under poor phosphorous and bio fertilizer management. Although application of phosphorous and Rhizobium inoculation assured greater significance over the past decades, work on garden pea as whole is scantly because due to poor management of chemical fertilizer and poor availability of suitable soil often compel to use of phosphorous application from inorganic sources, therefore, Judicious use of phosphorous application and Rhizobium culture enhancing inorganic and organic sources has potential to improve soil fertility on sustainable basis. Since application of phosphorous and use of Rhizobium inoculation improve physico- chemical property of soil along with incourageous result by the use of biofertilizer towards soil fertility and sustainable productivity, therefore, the present experiment was conducted with the use of inorganic sources of phosphorus and use of biofertilize as Rhizobium culture.

Growth parameters of Green Pea

The height of plant, number of leaves per plant, number of branches/ plant were increased steadily and multifold, in general in almost all the treatments. However, use of phosphorus levels and Rhizobium culture, did not increase height of the plant and number of leaves at 15 days interval of growth. It was further noticed that varieties caused significant difference in height and number of leaves/plant and Jawahar matar-3 could able to show maximum height and number of leaves/plant. Plant height at 35 days after sowing caused impressive response when joint evaluation of phosphorus levels, Rhizobium inoculation and varieties were done and maximum height ie 54.81 cm was recorded when joint use of $V_2Rh_1P_2$ was used. Similarly at 35 days after sowing critical analysis of data brought progressive increase in number of leaves/plant by the individual use of phosphorus levels, Rhizobium inoculation and varieties and maximum number of leaves ie 18.74, 18.36 and 18.43 were obtained respectively. Large number leaves ie 19.55 were recorded when interactive uses of V2Rh1P2 were used. Number of branches/plants were not increased at 15 days of sowing when joint use of phosphorus levels, Rhizobium inoculation and varieties was done, however, individual use of phosphorus could able to show the effective response on number of branches/plant and more number of branches ie 4.39 were observed where individual use of phosphorus @ 60kgP_2O_5/ha, was used. Numbers of branches were significantly increased at 25 and 35 days after sowing and outstanding increase ie 13.56 were obtained by the interactive use of $V_2Rh_1P_2$. Similar findings were reported by (Gulpadiya and Chhonkar, 2014) [1] in chickpea and (Marko *et al.*, 2013) [6] black gram.

Phenological traits of Green Pea

Days taken to 50% flowering were another important observation which was affected by individual use of phosphorus levels, Rhizobium culture and varieties. Phosphorus @ 60kgP_2O_5/ha took 38.49 days in 50% flowering, however, Rhizobium inoculation and varieties could involved 39.90 days in 50% flowering and the best interaction ie $V_1Rh_1P_1$ was noticed which could utilize less number of days in 50% flowering. Similar findings were reported by (Jitender Kumar, 2011) [2] in Garden pea and (Kanaujia *et al.*, 2000) [3] in Pea.

Yield and quality parameters of Green Pea

Critical evaluation of phosphorus indicated that maximum length ie 8.22 cm was obtained by the use of 60kgP_2O_5/ha. Use of Rhizobium inoculation could affect length of pod and significantly more length of pod ie 8.02 cm was obtained. Varieties also brought beautiful response and significantly superior length (7.89 cm) was noticed in cv Jawahar matar-3. Interactive use of $V_2Rh_1P_2$ was proved to be more effective and significantly super length of pod ie 8.95 cm was recorded with the interactive use as mentioned above. Width of pod was also improved and maximum width ie 3.18 cm was noticed by the use of phosphorus @ 60kgP_2O_5/ha. Rhizobium inoculation was the next treatment who could cause impressive response in increasing width of pod and 3.40 cm was recorded. Jawahar matar-3 could able to secure maximum width of pod and it was 3.43 cm which was superior over next one. Combine use of $V_2Rh_1P_2$ proved to be effective and 3.8 cm width of pod was recorded. Number of grains per pods were also affected by the individual use of phosphorus levels, Rhizobium inoculation and varieties and their interaction. Significantly superior number of grain per pod ie 7.39, 6.82, 7.83, 6.65 were obtained by the individual use of 60kgP_2O_5/ha, Rhizobium inoculation, Jawahar matar-3 and $V_2Rh_1P_2$ respectively. Highest shelling percentage ie 43.68, 42.30 41.92 and 44.90 were obtained by the individual use of 60kgP_2O_5/ha, Rhizobium inoculation, Jawahar matar-3 and $V_2Rh_1P_2$ respectively. Fresh weight of pod was also influenced by the use of treatments and maximum fresh weight ie 46.48 (g), 46.10 (g), 46.03 (g) and 47.40 (g) were obtained by the incorporation of 60kgP_2O_5/ha, Rhizobium inoculation, Jawahar matar-3 and combine use of $V_2Rh_1P_2$respectively. Dry weight of pod in (g) also showed the increasing trend and maximum dry weight ie 39.64 (g), 38.96 (g) 39.36 (g) and 37.57 (g) were recorded by the individual use of 60kgP_2O_5/ha, Rhizobium inoculation, varieties and combine use of $V_2Rh_1P_2$ respectively. Number of pods per plant were also found in increasing trend and

large number of pods 13.97, 13.22 13.00 and 14.60 were obtained due to use of 60kgP_2O_5/ha, Rhizobium inoculation, Jawahar matar-3, and $V_2Rh_1P_2$ respectively. Pod yield q/ha was affected significantly by the individual use of phosphorus levels, Rhizobium inoculation varieties and interactive use of all the three factors. Maximum pod yield 46.08 q/ha, 42.85 q/ha, 47.50 q/ha and 48.50 q/ha were obtained by the use of 60kgP_2O_5/ha Rhizobium inoculation, Jawahar matar-3 and interactive use of $V_2Rh_1P_2$respectively. protein content in pods of Garden pea was differed significantly due to use of phosphorus levels, Rhizobium inoculation, varieties and their interaction. Abundant quantity in percent of protein ie 7.15%, 7.14% and 7.20% were noted by the use of 60kgP_2O_5/ha, Rhizobium inoculation, Jawahar matar-3 and interactive use of $V_2Rh_1P_2$ respectively. Similar findings were reported by (Khichi *et al.*, 2016) [5] in Garden pea and (Khan *et al.*, 2013) [4] in Pea and also (Kumanwat and Kumawat, 2009) in mungbean.

Table 1: Growth Yield and quality parameters of Garden pea as influenced by phosphorus levels and Rhizobium culture and interaction.

Treatments	Plant Height (cm)	Number of leaves per plant	Number Of branches	Pod Length (cm)	Width of pod (cm)	Number of Grains per pods	Fresh Weight of pod (g)	Dry weight of pod (g)	Pod Yield q/ha	Protein content
Phosphorus Level (P)										
P0 (0kgP_2O_5kg/ha)	47.46	17.36	12.42	7.14	3.16	5.75	45.02	36.32	30.52	7.10
P1 (30kgP_2O_5kg/ha)	50.94	18.44	12.68	7.93	3.42	6.57	45.87	37.20	40.08	7.11
P2 (60kgP_2O_5kg/ha)	53.82	18.74	13.03	8.22	3.48	7.39	46.48	39.64	46.08	7.15
SEm (±)	0.08	0.13	0.04	0.06	0.02	0.03	0.13	0.15	0.10	0.01
CD (p=0.05)	0.25	0.38	0.11	0.18	0.07	0.09	0.40	0.44	0.29	0.03
Rhizobium Culture (Rh)										
Rh0 (without)	49.77	18.00	12.61	7.50	3.31	6.32	45.48	36.48	39.50	7.11
Rh1 (with)	51.70	18.36	12.81	8.02	3.40	6.83	46.10	38.96	42.83	7.15
SEm (±)	0.07	0.10	0.03	0.05	0.02	0.03	0.11	0.12	0.08	0.01
CD (p=0.05)	0.20	0.31	0.09	0.15	0.06	0.08	0.33	0.36	0.23	0.02
Variety (V)										
V_1(Arkel)	50.52	18.43	12.62	7.63	3.27	6.49	45.55	36.08	40.52	7.09
V_2(Jawahar matar-3)	50.96	17.93	12.80	7.89	3.43	6.65	46.03	39.36	47.50	7.14
SEm (±)	0.07	0.10	0.03	0.05	0.02	0.03	0.11	0.12	0.08	0.01
CD (p=0.05)	0.20	0.31	0.09	0.15	0.06	0.08	0.33	0.36	0.23	0.02
Int. (P x Rh x V)										
$V_1Rh_0P_0$	46.66	16.91	12.00	6.88	3.00	5.62	44.08	34.24	31.52	7.03
$V_1Rh_0P_1$	47.81	16.99	12.48	7.18	3.18	5.63	45.22	35.37	41.00	7.11
$V_1Rh_0P_2$	47.87	18.28	12.66	7.22	3.21	5.83	45.33	35.75	42.85	7.12
$V_1Rh_1P_0$	47.22	17.26	12.53	7.26	3.25	5.93	45.44	36.19	42.95	7.12
$V_1Rh_1P_1$	48.49	17.74	12.76	7.29	3.29	6.03	45.55	36.41	43.50	7.14
$V_1Rh_1P_2$	48.60	19.26	12.88	7.32	3.37	6.13	45.65	36.54	43.85	7.18
$V_2Rh_0P_0$	53.20	17.84	12.49	8.00	3.11	7.03	46.03	36.00	44.00	7.03
$V_2Rh_0P_1$	53.31	18.92	12.60	8.15	3.28	7.10	46.11	36.34	45.00	7.08
$V_2Rh_0P_2$	53.50	19.00	12.72	8.24	3.74	7.20	46.17	36.47	46.00	7.15
$V_2Rh_1P_0$	53.20	18.11	12.83	8.27	3.29	7.23	46.26	37.35	46.55	7.12
$V_2Rh_1P_1$	53.81	18.31	13.00	8.35	3.62	7.30	46.30	37.48	47.55	7.14
$V_2Rh_1P_2$	54.98	19.55	13.56	8.95	3.88	7.83	47.40	37.52	48.50	7.20
SEm (±)	0.16	0.25	0.07	0.12	0.05	0.06	0.27	0.30	0.19	0.02
CD (p=0.05)	0.49	0.76	0.22	0.12	0.15	0.18	0.81	0.89	0.57	0.06

Conclusion

On the basis of the results obtained, It is concluded that the maximum pod yield 46.08 q/ha was obtained by the effective use of phosphorus @ 60kgP_2O_5/ha. Outstanding pod yield ie 47.50q/ha was obtained when Jawahar matar-3 was evaluated. Interactive use of $V_2Rh_1P_2$ (Jawahar matar-3 + with Rhizobium inoculation) produced a large quantity of pod yield ie 48.50 q/ha which was significantly outstanding among rest of the combinations. Shelling percent and protein content was found to be significantly more and it was 43.68% and 7.15% due to individual use of phosphorus @ 60kgP_2O_5/ha respectively.

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