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Effect of phosphorus and sulphur on chlorophyll, yield components and yield of field pea (*Pisum sativum* L.) genotypes

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ABSTRACT

A field experiment was conducted during winter seasons of 2015-16 and 2016-17 to study the effect of P and S levels on chlorophyll content, yield components and yield of field pea (Pisum sativum L.) genotypes at Rewa (M.P.). The experiment was laid out in split plot design with five genotypes and five levels of P and S and three replications. The results revealed that the increasing P and S levels from P_0S_0 to $P_{60}S_{45}$ increased the chlorophyll content almost significantly. Similarly, Pant Matar-4 encouraged this parameter upto maximum extent over rest of the genotypes at every stage of growth. This was followed by Azad Matar-3, Azad Matar-1 and Pant Matar-3. Arkel genotype recorded the lowest chlorophyll content in each case. The yield and yield components were found maximum from Pant Matar-4 and Azad Matar-3 as compared to Azad Matar-1 and Pant Matar-3, the grain yields being 18.95, 16.15, 15.02 and 112.54 qha^{-1},respectively. Yield attributes also improved significantly over control with P and S levels and maximum values of pods/plant (8.97), grains/pod (8.04) and test weight (197.1g) were recorded under P_{60} S_{45} level. The best P and S level was $P_{60}S_{45}$ producing18.09 qha^{-1}. Pant Matar-4 applied with $P_{60}S_{45}$ recorded the highest yield (23.21 q ha^{-1}). The second best combination was Azad Matar-3 with $P_{60}S_{40}$ (20.34 q ha^{-1}).

Keywords: Chlorophyll content, fertility levels, field pea, genotypes.

INTRODUCTION

Field pea (*Pisum sativum* L.) commonly known as *Matar* is one of the important pulse crop of India. Pulses are rich in protein and are the main source of energy ranging from 17 to 28 % almost double than in the cereals. The heavy withdrawal of nutrients by the newly developed high-yielding crop varieties under intensive cropping systems have aggravated the multinutrient deficiencies in the soil. Legumes usually require almost equal amount of phosphorus and sulphur. Phosphorus is another major plant nutrient, next to nitrogen, which plays an important role in the balanced nutrition of plants. Legume crop requires large amounts of P to perform their physiological and biochemical functions in the plant. The requirement for P which is essential for root growth and root-nodulation, on the other hand, has to be fulfilled largely through inorganic fertilizers. Sulphur is now recognized as a fourth major plant nutrient after N, P and K. On an average, crops absorb sulphur as much as they absorb P, and field scale deficiencies of S in the soils and plants are becoming increasingly important. The increasing reports of S deficiency and the fact that crops require S and P in the comparable amounts suggest that S deserves greater attention that it has received so far. Use of S-free fertilizers and acute problem of P-fixation in soil is posing a great threat towards sustainable productivity of field pea. Leaves and the chlorophyll content are the important parameters for photosynthesis of any crop, which ultimately affect the crop productivity. In fact, leaf is the factory for conversion of solar energy into the chemical energy by the process of photosynthesis. The water and CO_2 in the presence of sunlight give rise to the chlorophyll formation. This physiological process is likely to be influenced by the varieties grown and nutrients applied. Proper nutrition of P and S to field pea varieties would produce relatively more number of functional leaves and photosynthesizing area thereby increased photosynthates. Chlorophyll has got the major part to play. Due to fertility variations in different soil types the response of a certain field pea genotype to direct fertilizer application is highly inconsistent, location and even site specific (Sharma *et al.*, 2006, Singh and Singh 2017). Under the existing agro-climatic condition, it was essential to find out the amount of chlorophyll synthesized in certain newly developed field pea varieties with different P and S levels. Therefore the present research was taken up.

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MATERIALS AND METHODS

A field experiment was conducted during winter seasons of 2015 -16 and 2016-17 at the Private Agriculture – cum- Research Farm, Beenda Semariya Road, Rewa (M.P.) The soil of the experimental field was clay-loam having pH 7.4-7.5, electric conductivity 0.33-0.35 dS m^{-1}, organic carbon 8.8 to 9.0 g kg^{-1}, available N 219-221 kg ha^{-1}, available P_2O_5 14.0 – 14.8 kg ha^{-1}, available K_2O 362-377 kg ha^{-1} and available S 19.8-20.6 kg ha^{-1}. The rainfall received during the cropping period was 760 and 794 mm in both the years. The treatments comprised five field pea genotypes (Arkel, Pant Matar-3 and 4, Azad Matar 1 and 3) in the main-plots and five P and S levels in the sub-plots (Table -1). The experiment was laid out in split-plot design with three replications. The field pea genotypes, inoculated with *Rhizobium* and PSB were sown between 13 and 17 October in both the years using 100 kg seed ha^{-1} at 30 cm row spacing. A common dose of 23 kg N ha^{-1} and the P and S levels were applied through diammonium phosphate, urea and single superphosphate, respectively. A uniform dose of 20 kg K_2O ha^{-1} was applied as basal through muriate of potash in all the treatments. The crop was grown as per recommended package of practices. The crop was harvested between 20 and 26 March in both the years. The chlorophyll content of leaves and pod-wall was estimated at 45, 60 and 75 days after sowing by acetone extraction method (Witham *et al.*, 1971). The yield and yield components were recorded at harvest and subjected to statistical computation.

RESULTS AND DISCUSSION

Chlorophyll content in leaves and pod-wall

The general trend with respect to periodical changes in chlorophyll content in leaves was that the total chlorophyll content was increased from 45 days to 60 days period, thereafter declined with the advancement of plant growth. The same trend was also noticed in case of chlorophyll content in pod-wall of pea (Table 1). The decline in the chlorophyll content after 60 DAS could be due to the flowering and pod development stages, respectively, where there is diversion of photosynthates towards the development of active sinks. Sharma *et al.* (2006) made similar observations in mungbean. Therefore, it is important to consider the stage of plant into account of growth to find out the peak activity of these parameters. As regards with the treatments effect, the increasing fertility level from P_0S_0 up $P_{60}S_{45}$ increased the chlorophyll content almost significantly. Similar results have been reported by Shukla *et al.* (2013). Similarly, Pant Matar- 4 encouraged this parameter upto maximum extent over rest of the genotypes at every stage of observations. This was, however, followed by Azad Matar- 3 and then equally followed by Azad Matar-1 and Pant Matar- 3. Arkel genotype recorded the lowest chlorophyll content in each case. The great variability in chlorophyll formation among the genotypes from different parental origin was eventual. The present findings are in consonance with those of Sharma *et al.* (2006), Singh *et al.* (2013) and Raj *et al.* (2014).

Table 1: Chlorophyll content (mg/g) at different growth stages as influenced by genotypes and P and S levels (Pooled for two seasons)

Treatments	Total chlorophyll in leaves			Total chlorophyll in pod wall	
	45	60	75 DAS	60	75 DAS
Genotypes					
Arkel	2.76	3.03	2.57	2.35	2.00
Pant Matar-3	2.85	3.12	2.69	2.45	2.12
Pant Matar-4	3.08	3.30	2.90	2.69	2.37
Azad Matar-1	2.95	3.10	2.70	2.54	2.17
Azad Matar-3	3.02	3.20	2.80	2.62	2.28
C D. (P=0.05)	0.02	0.03	0.20	0.17	0.113
P and S (kg ha^{-1})					
P_0S_0	2.46	2.66	2.23	1.96	1.67
$P_{30}S_0$	2.71	2.87	2.50	2.29	1.96
$P_{60}S_0$	2.97	3.20	2.77	2.63	2.25
$P_{60}S_{22.5}$	3.14	3.40	2.97	2.82	2.43
$P_{60}S_{45}$	3.36	3.63	3.18	2.97	2.65
C.D. (P=0.05)	0.01	0.01	0.055	0.055	0.10

Yield components

The factors which are directly responsible for ultimate grain production viz. number of pods/plant, number of grains/pod and 1000 - grain weight were augmented almost significantly due to increased supply of phosphorus and sulphur up to $P_{60}S_{45}$. At this fertility level, the yield components were maximum (8.97 pods/plant, 8.04 grains/pod, 197 g test weight and 9.08 g grain weight/plant). The probable reason may be ascribed as it resulted in greater chlorophyll synthesis, accumulation of carbohydrates, protein and their translocation to the reproductive organs which in turn, increased the higher number of pods as well as other yield components. These results are in close agreement with those of Patel *et al.* (2012), Singh *et al.* (2013), Raj *et al.* (2014), Saket *et al.* (2014) and Singh *et al.* (2017).

The number of pods/plant, number of grains/pod and 1000-grain weight were found to vary significantly due to different genotypes. Pant Matar- 4 performed the best (10.13 pods/plant, 7.90 grains/pod, 219.5 g test weight and 9.63 g grains weight/plant). The second best genotype was Azad Matar-3. Azad Matar-1 and Pant Matar-3 recorded equally lower yield-attributes. The significantly lowest yield-attributes were recorded from the Arkel genotype. The significant variation in yield-attributes amongst the different genotypes might be attributed to the immense variability in their growth parameters which were responsible for the increased chlorophyll formation, production of photosynthates, and thereby increased translocation of photosynthates towards the reproductive organs. Moreover, Pant Matar-4 and Azad Matar-3 might have resulted in higher rate of photosynthesis and reduced respiration. Thus higher accumulation of photosynthates brought about increased growth and development of such plants.

Table 2: Yield attributes and yield field pea as influenced by genotypes and P and S levels (Pooled for two seasons)

Treatment	Pods/ plant	Grains/ pod	1000-grain weight (g)	Grain weight/ plant (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
Genotypes							
Arkel	6.31	5.37	157.4	6.19	10.79	12.66	44.98
Pant Matar-3	7.19	6.07	162.1	6.64	12.54	14.64	45.97
Pant Matar-4	10.13	7.90	219.5	9.63	18.95	15.95	53.91
Azad Matar-1	7.24	6.14	159.3	6.83	15.02	14.56	52.24
Azad Matar-3	9.07	7.80	214.2	9.07	16.15	14.30	52.65
C D. (P=0.05)	0.35	0.03	1.72	0.34	0.28	1.58	1.69
P and S (kg ha^{-1})							
P_0S_0	7.11	5.26	163.8	5.94	11.24	14.62	43.30
$P_{30}S_0$	7.61	6.00	168.5	6.76	13.06	14.65	47.99
$P_{60}S_0$	7.79	6.57	189.4	8.02	15.04	14.12	50.97
$P_{60}S_{22.5}$	8.46	7.41	193.6	8.56	16.00	14.36	52.17
$P_{60}S_{45}$	8.97	8.04	197.1	9.08	18.09	14.36	55.31
C.D. (P=0.05)	0.30	0.02	1.49	0.30	0.25	NS	1.48

Productivity of field pea

The grain yield and harvest index were enhanced almost significantly with the increasing fertility level up to $P_{60}S_{45}$, the values being 18.09 q ha^{-1} grain yields and 55.3% harvest index. The increases in these parameters were up to 6.85 q ha^{-1} and 12.0 %, respectively over P_0S_0 treatment (Table 2). The trend of increases in grain yield obtained due to these treatments was exactly in accordance with the similar increases in the yield components. These results are in the line with those of Singh *et al.* (2013), Shukla *et al.* (2013), Raj *et al.* (2014), Saket *et al.* (2014) and Singh (2017). Amongst the field genotypes, Pant Matar- 4 recorded significantly higher grain yield (18.95 q/ha) with maximum straw yield (15.95 q ha^{-1}). The second best genotypes was Azad Matar-3 and then Azad Matar-1, whereas Arkel produced the lowest grain (10.79 q ha^{-1}) and straw (12.66 q ha^{-1}). The harvest index was also found in the same order.

Table 3: Interaction effect of genotypes and P and S levels grain yield of pea (Pooled for two seasons)

Genotypes	P_0S_0	$P_{30}S_0$	$P_{60}S_0$	$P_{30}S_{22.5}$	$P_{60}S_{45}$
Arkel	8.83	9.53	10.67	11.37	13.54
Pant Matar-3	9.82	11.55	13.01	13.26	15.03
Pant Matar-4	13.73	17.01	19.68	21.09	23.21
Azad Matar-1	11.76	13.12	15.19	16.71	18.31
Azad Matar-3	12.08	14.09	16.66	17.55	20.34
C.D. (P=0.05)			0.55		

The yield obtained under different genotypes was exactly in accordance with their yield components, which were responsible for such increases in yield. The treatment interactions were found to be significant wherein synergistic influence was noted among the genotypes grown with different fertility levels (Table 3). The Pant Matar-4 grown with highest fertility level ($P_{60}S_{45}$) recorded maximum yield (23.21 q ha^{-1}), followed by the same genotype with $P_{30}S_{22.5}$ (21.09 q ha^{-1}) and the Azad Matar-3 with $P_{60}S_{45}$ (20.34 q ha^{-1}).The trend of differences in increasing grain and straw yields under the different genotypes was exactly in accordance with the similar increases in the yield components. The variable increases in yield components and consequently the grain yield of pulses as a result of different genotypes have been reported by Kumar and Singh (2011) and Phom *et al.* (2014).

From the results, it may be concluded that genotype Pant Matar-4 with application of 45 kg S + 60 kg P_2O_5 ha^{-1} was found optimum as it is resulted in the highest growth and higher productivity of field pea besides enhancing chlorophyll content.

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