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Effect of moisture stress and phosphorus, sulphur and zinc fertilizers on growth and development of pea (*Pisum sativum*)

S. KASTURIKRISHNA[1] AND I.P.S. AHLAWAT

Division of Agronomy, Indian Agricultural Research Institute, New Delhi 110 012

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ABSTRACT

Response of pea (*Pisum sativum* L.) cv. 'Swastik' ('DMR 11') to moisture stress and application of phosphorus, sulphur and zinc fertilizers was studied during the winter season of 1992–93 and 1993–94 at the Indian Agricultural Research institute, New Delhi. Higher values of root dry weight, number and dry weight of root nodules/plant, nitrogenase activity, and growth parameters (leaf-area index, net assimilation rate, crop-growth rate, nitrate reductase activity) were observed with no moisture stress treatment, i.e. irrigation at all the 3 stages, viz. vegetative, flowering and pod filling. Application of 26.2 kg P/ha recorded higher values for root and growth parameters when compared to 13.1 kg P/ha and no P. Application of 40 kg S+5 kg Zn/ha also improved root and growth parameters, and yield of pea.

***Key words*:** Moisture stress, Phosphorus, Sulphur, Zinc, Growth, Development, Pea

Field pea is an important winter pulse crop grown on mid to higher elevations throughout the world, and it ranks second in food legume production in the world (FAO, 1986). In India, it occupies 0.49 million ha and contributes 0.42 million tonnes of pulse production with an average productivity of only 628 kg/ha. The important factors responsible for poor yields are lack of high-yielding varieties suited to different agro-climatic conditions, growing of the crop on marginal and sub-marginal lands and poor management technology. Fertilizer and irrigation are the 2 key factors of production technology, which need to be judiciously utilized for efficient and economic crop production. The development of high-yielding and input-responsive varieties in the last decade necessitated to study their response to these 2 inputs, and hence this investigation was carried out

Present address. [1]Central Tobacco Research Institute, Rajahmundry, Andhra Pradesh - 533 105

MATERIALS AND METHODS

The field experiment was conducted at the Indian Agricultural Research Institute, New Delhi, during the winter seasons of 1992–93 and 1993–94. The soil was sandy loam with pH 7.3; 0.046 and 0.044% total N; 8.96 and 9.20 kg/ha available P; 161.0 and 159.5 kg/ha available K; 10.00 and 10.62 ppm available S; and 0.51 and 0.52 ppm of DTPA-extractable Zn in 0–30 cm soil depth in the respective growing seasons. The experiment was laid out in a split-plot design replicated thrice with combination of 4 moisture-stress treatments (moisture stress either at vegetative or flowering or pod-filling stage, and no moisture stress) and 3 phosphorus levels (0, 13.1 and 26.2 kg P/ha) as main plot treatments and 3 sulphur and zinc combinations (no S and no Zn, 40 kg S/ha and 40 kg S+5 kg Zn/ha) as sub-plot treatments. The pea cultivar 'Swastik' ('DMR 11') was sown in rows 30 cm apart on 9 November in 1992 and 11 November in 1993, and was harvested on 20 March in 1993 and 17 March in 1994.

RESULTS AND DISCUSSION

Moisture stress

Moisture stress at vegetative stage recorded significantly higher dry weight of root as compared to stress either at flowering or pod filling and no moisture-stress treatments. At 90 days stage, irrigation at all the stages and moisture

Table 1. Effect of moisture stress, and phosphorus, sulphur and zinc fertilizers on root growth and nodulation of pea

Treatment	Root dry weight (90 DAS)		Number of root nodules/plant (90 DAS)		Dry weight of root nodules (mg/plant) (90 DAS)		Nitrogenase activity (µM C_2H_4/ plant/hr) (flowering stage)	
	1992–93	1993–94	1992–93	1993–94	1992–93	1993–94	1992–93	1993–94
Moisture stress								
At vegetative stage	0.71	0.84	21.97	33.99	40.02	63.46	3.75	4.18
At flowering stage	0.50	0.64	25.40	38.07	46.94	72.23	4.40	4.75
At pod-filling stage	0.52	0.64	27.44	39.87	51.68	76.85	4.85	5.06
No stress	0.52	0.64	27.43	40.40	53.18	80.38	4.99	5.29
CD (P = 0.05)	0.03	0.03	1.98	1.75	3.58	3.95	0.33	0.27
Phosphorus (P kg/ha)								
0	0.44	0.48	20.99	34.27	36.76	61.79	3.45	4.06
13.1	0.58	0.74	26.17	38.57	49.36	74.96	4.63	4.93
26.2	0.67	0.81	29.52	41.40	57.75	82.94	5.41	5.46
CD (P = 0.05)	0.03	0.02	1.71	1.58	3.10	3.42	0.29	0.24
Sulphur and zinc (kg/ha)								
No S and no zn	0.52	0.61	23.14	36.00	42.24	67.48	3.96	4.44
40 S	0.57	0.68	26.24	38.00	49.34	73.14	4.63	4.81
40 S+5 Zn	0.60	0.74	27.30	40.25	52.28	79.07	4.90	5.20
CD (P=0.05)	0.03	0.02	0.39	0.54	0.82	2.41	0.09	0.18

stress at pod-filling stage being on a par recorded significantly more number and dry weight of root nodules/plant and nitrogenase activity than stress at vegetative and flowering stages (Table 1). Enhanced N supply through symbiotic N-fixation due to adequate moisture supply in no moisture-stress treatment might be a direct cause for positive response with no moisture-stress treatment. The improved symbiotic nitrogen fixation in this treatment was evident from greater number and dry weight of nodules and nitrogenase activity.

No moisture stress and moisture stress at pod-filling stage recorded higher values of leaf-area index and nitrate reductase activity. Whereas net assimilation rate and crop-growth rate registered higher values with no moisture stress and moisture stress at vegetative stage. Crop with no moisture stress maintained superiority to the crop experiencing moisture stress at any of the phenological stage with respect to growth and development consequently resulted in higher grain yield (Table 2). Barky *et al.* (1985) also reported that omitting 1 irrigation at any 1 stage (vegetative, flowering and pod formation) decreased vine length, leaf area and yield.

Table 2. Effect of moisture stress, and phosphorus, sulphur and zinc fertilizers on growth parameters and yield of pea

Treatment	Leaf-area index (90 DAS)		Crop growth rate (g/m²/d) (90 DAS-harvest)		Net assimilation rate (g/m²/d) (90 DAS-harvest)		Nitrate reductase activity (μM NO_2^-/g/hr) (flowering stage)		Grain yield (tonnes/ha)	
	1992–93	1993–94	1992–93	1993–94	1992–93	1993–94	1992-93	1993-94	1992-93	1993–94
Moisture stress										
At vegetative stage	0.96	1.01	5.89	7.85	7.06	9.16	1.58	2.22	1.58	2.07
At flowering stage	0.99	1.06	4.20	6.69	4.92	7.51	1.70	2.38	1.26	1.83
At pod-filling stage	1.01	1.10	4.90	6.92	5.65	7.62	1.95	2.61	1.47	1.97
No stress	1.05	1.14	6.65	8.82	7.25	9.19	2.00	2.73	1.84	2.38
CD (P=0.05)	0.05	0.05	0.77	1.07	0.92	0.83	0.15	0.18	0.05	0.07
Phosphorus (P kg/ha)										
0	0.96	1.03	4.45	6.42	5.49	7.54	1.39	2.09	1.24	1.69
13.1	1.02	1.08	5.67	7.79	6.40	8.55	1.86	2.54	1.60	2.14
26.2	1.03	1.13	6.11	8.50	6.77	9.02	2.17	2.82	1.78	2.36
CD (P = 0.05)	0.04	0.04	0.60	0.59	0.75	0.70	0.12	0.14	0.04	0.06
Sulphur and zinc (kg/ha)										
No S and no Zn	0.98	1.05	4.98	6.93	5.90	7.82	1.59	2.29	1.41	1.88
40 S	1.01	1.08	5.45	7.70	6.24	8.51	1.86	2.48	1.56	2.09
40 S + 5 Zn	1.02	1.10	5.80	8.08	6.52	8.78	1.97	2.68	1.65	2.21
CD (P=0.05)	0.02	0.03	0.40	0.43	0.30	0.30	0.06	0.09	0.05	0.06

Phosphorus

Application of 26.2 kg P/ha recorded significantly higher root dry weight/plant, number and dry weight of root nodules/plant, and nitrogenase activity over 13.1 kg P/ha and the control. Phosphorus enhances the activity of *Rhizobia,* which increases N-fixation in the root nodules. The greater availability of N to plant improves plant growth and development (Singh *et al.,* 1983).

The favourable effect of phosphorus on leaf-area index, NAR, CGR and nitrate reductase activity was noticed not only between 90 DAS and harvest (Table 2) but also at early stages of crop growth (data not reported here). It is interesting to note that the improvement in growth parameters as well as physiological parameters persisted till maturity, and resulted in substantial increase in total dry matter and yield.

Sulphur and zinc

The improvement in growth attributes was more pronounced with combined application of S and Zn. The improvement in plant growth by S and Zn fertilizers may be assigned to improved nodulation resulting in enhanced N fixation, which in turn might have improved leaf-area index and photosynthesis. These results are in conformity with those of Sharma and Kamath (1991) and Lakkineni and Abrol (1994). Zinc application also contributed in increase in grain yield probably owing to its influence on auxin synthesis, nodulation and N fixation, which promoted plant growth and development, thereby favourably influencing grain yield. Similar findings were also obtained by Islam *et al.* (1989).

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