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Research Paper

Influence of phosphorus and zinc fertilization on growth and yield of fenugreek (*Trigonella foenum-graecum*) in the semi-arid region of Rajasthan

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ABSTRACT

An experiment was conducted during the winter (*rabi*) seasons of 2015–16 and 2016–17 at Rajasthan Agricultural Research Institute, Sri Karan Narendra Agriculture University, Durgapura, Rajasthan, to study the effect of phosphorus and zinc fertilization on the growth and productivity of fenugreek (*Trigonella foenum-graecum* L.). Four levels of phosphorus (0, 20, 40 and 60 kg P_2O_5/ha) and 6 levels of zinc and zinc solubilizer [0, 2.5 and 5.0 kg Zn/ha, zinc solubilizer (*Bacillus endophyticus*), 2.5 kg Zn/ha + zinc solubilizer and 5 kg Zn/ha + zinc solubilizer were tested in split-plot design with 3 replications. Application of 40 kg P_2O_5/ha and 5 kg Zn/ha + zinc solubilizer resulted in significant increase in plant height, dry-matter accumulation, effective root nodules, leaf-area index, different yield attributes and yield of fenugreek. Application of 60 kg P_2O_5/ha increased the seed yield of fenugreek by 33% during 2015–16 and 40% during 2016–17 over the control. Zinc fertilization @ 5 kg Zn/ha + zinc solubilizer increased seed yield of fenugreek by 24% during 2015–16, while the increase was 27% during 2016–17 over the control.

Key words: Growth, Fenugreek, Phosphorus, Yield, Zinc, Zinc solubilizer

Fenugreek (*Trigonella foenum-graecum* L.), occupies an area of around 0.21 million ha, with the production of 0.26 million tonnes having the productivity of 1,000 kg/ha (GoI, 2016–17). Rajasthan represents major share of India's production, accounting for over 80% of the nation's total fenugreek production. However, farmers are not able to achieve its potential yield due to various factors. Besides aberrant weather conditions, the soils of Rajasthan are poor in macro and micronutrients, especially nitrogen (N), phosphorus (P), and zinc (Zn) (Ram *et al.,* 2021). Phosphorus deficiency is usually the most important single factor responsible for poor yield of legume crops. It is the main constituent of energy-rich phosphate compounds like ATP and ADP which is subsequently used for vegetative and reproductive growth through phosphorylation and also an important structural component of nucleic acid, phytin, phospholipids, and enzymes. Application of P enhanced the yield, protein, and phosphorus use-efficiency of rice in Indo-Gangetic Plains of India (Jinger *et al.,* 2021). Omission of P resulted in 8.9 and 11.4% reduction in maize and wheat grain yield, respectively (Joshi *et al.*, 2021). This proves that P application plays an instrumental role in enhancing the yield of crop.

Moreover, Zn is an important plant nutrient with specific role in symbiotic root-nodule metabolism, plant and root growth, synthesis of chlorophyll and enzymatic processes (Jatav *et al.,* 2020). Zinc is one of the imperative micronutrients required relatively in small concentrations (5–20 mg/kg) in plant tissues and its concentration in fenugreek seeds is highest among all the seed spices (Sammauria and Yadav, 2010). Nutrient deficiency in soil and plant is the key factor for poor productivity of pulses. The major reason for widespread occurrence of Zn deficiency in crop plants is attributed to low solubility of Zn in soils rather than its low total amount. Further, zinc-solubilizing bacteria play crucial role in dissolution or insoluble source of Zn and converts it into soluble form and make it available to plants through secretion of organic acids and other metabolites (Goteti *et al.,* 2013). It has been reported that application of Zn improved the yield, nutrient uptake of black gram in Bhubaneswar district of Odisha (Debata *et al.,* 2022). Singson *et al.* (2021) reported that application

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of Zn enhanced the dry matter accumulation, root dry weight, grain yield of rice in Umiam, Meghalaya. Many studies have been reported positive responses of P and Zn when applied separately. However, very few experiments have conducted so far on the effect of P and Zn applied concomitantly in fenugreek. In this regard, the current study was postulated that the fertilization of P and Zn is critical for improving the growth and yield of fenugreek. The objective of the study was to evaluate the effect of P and Zn on Fenugreek crop.

MATERIALS AND METHODS

An experiment was conducted at research farm of the Rajasthan Agricultural Research Institute, Sri Karan Narendra Agriculture University, Durgapura, Jaipur (75°47'E, 26°51'N) Rajasthan, India during the winter (*rabi*) seasons of 2015–16 and 2016–17. This region falls under Agro-climatic zone IIIa (Semi-arid eastern plain zone) of Rajasthan, with average annual rainfall 543.5 mm. The weather condition at the experimental site during the 2 growing seasons is shown in Fig. 1. Soil at the site is classified as loamy sand. Prior to planting, soil samples were taken from 0 to 30 cm depth and analyzed for selected physical and chemical properties. The experiment was laid out in a split-plot design with 3 replications. During 2015–16 and 2016–17, fenugreek was planted after harvesting of cowpea and Indian mustard. Treatments comprised 24

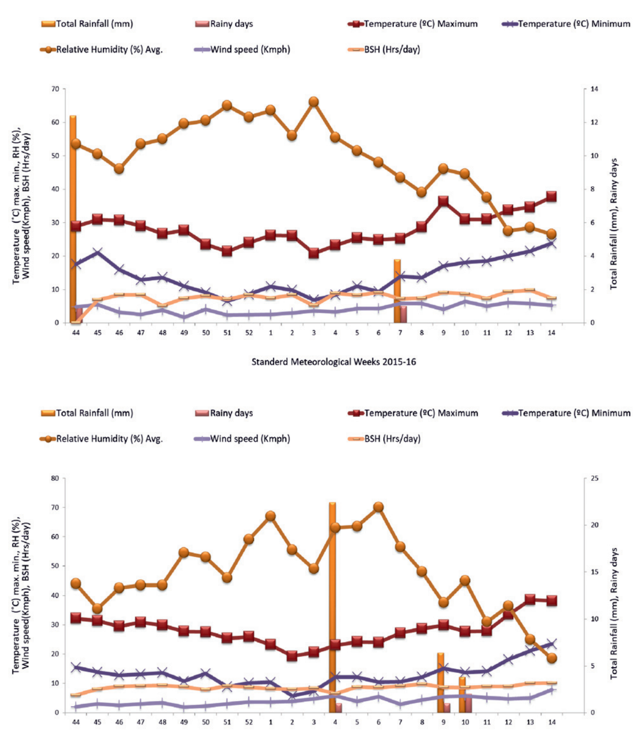

Fig. 1. Mean weekly weather parameters recorded during crop growing seasons of 2015–16 (top) and 2016–17 (bottom)

combinations, consisting of 4 P levels (0, 20, 40 and 60 kg P_2O_5/ha) as main-plot treatments and 6 Zn levels [0, 2.5, 5.0 kg Zn/ha, Zn solubilizer (*Bacillus endophyticus*), 2.5 kg Zn/ha + Zn solubilizer and 5 kg Zn/ha + Zn solubilizer] as subplot treatments. A uniform dose of 20 kg N/ha along with P and Zn as per treatments were applied through diammonium phosphate and zinc sulphate (21%) respectively. To compensate the sulphur obtained from different levels of Zn-compensatory dose of sulphur was applied through elemental sulphur 21 days before sowing. Chemical fertilizers were uniformly broadcasted on soil surface of the plots and incorporated into the soil manually. A 50-ml-bottle of Zn solubilizer (*Bacillus endophyticus*) was diluted with 10 litres water and was then mixed with well-decomposed fine FYM (1 kg per plot) and applied as per the treatment. The fenugreek variety 'RMT 305' was sown on 3 November 2015 and 15 November 2016. To ensure successful establishment of crop, 6 irrigations were given during 2015–16 and 5 during 2016–17 through sprinkler method. No major insect/disease was observed during the life-cycle of fenugreek in the experiment. However, weeds were manually controlled twice at 30 and 58 days after sowing (DAS). The leaf-area measured by leaf-area meter (Model 203 Area meter, USA) and the leaf-area index (LAI) were estimated as per Watson (1958). The plant height (cm) was measured in the same plant regularly at 30 days intervals during the entire ontogeny. For harvest of fenugreek the entire plant was either pulled out of cut from the base with sickle when 70% of the pods turn yellow, and made into small bundles for drying them in sun. Grains were separated manually. Different plant growth, root parameters and yield attributes were measured using standard procedures. The seeds were dried up to 7–8% moisture, and cleaned through winnowing fan. Data were analyzed in SAS version 9.3 for analysis of variance (ANOVA). Treatments were compared by computing the 'F-test'. The significant differences between treatments were compared by critical difference at 5% level of probability. The correlation and regression coefficients were computed among economic yield and growth and yield attributes as per Gomez and Gomez, (1984).

RESULTS AND DISCUSSION

Growth attributes

All growth attributes, viz. plant height, leaf–area index, symbiotic root nodules/plant and their dry weight, dry-matter accumulation, were increased significantly with the application of 40 kg P_2O_5/ha during both the years, and that response was at par with 60 kg P_2O_5/ha for all the characters (Table 1 and 2). Dry-matter accumulation/plant was positively correlated with plant height and leaf area during both the years (Table 4).

Table 1. Effect of phosphorus and zinc fertilization on plant height and leaf area of fenugreek

Treatment	Plant height (cm)								Leaf area (m^2/plant)					
	30 DAS		60 DAS		90 DAS		At harvesting		30 DAS		60 DAS		90 DAS	
	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17
Phosphorus (P_2O_5 kg/ha)														
0	3.51	4.47	13.9	13.5	34.9	35.7	42.3	42.4	0.51	0.53	0.84	0.83	1.86	1.87
20	4.01	5.62	15.3	14.9	38.1	39.0	45.9	46.9	0.62	0.64	0.97	1.00	2.24	2.25
40	4.29	6.21	16.4	16.0	40.6	41.6	49.7	50.5	0.71	0.72	1.07	1.09	2.44	2.46
60	4.40	6.42	16.5	16.0	41.0	41.7	50.7	50.6	0.73	0.73	1.09	1.13	2.55	2.54
SEm±	0.06	0.13	0.26	0.27	0.67	0.50	0.90	0.95	0.01	0.01	0.02	0.01	0.04	0.04
CD (P=0.05)	0.22	0.46	0.91	0.94	2.32	1.72	3.13	3.30	0.06	0.05	0.07	0.05	0.16	0.15
Zinc (kg/ha)														
0	3.60	4.29	13.7	13.3	35.4	35.5	42.6	42.8	0.55	0.56	0.87	0.89	1.93	1.94
2.5	3.93	5.45	15.0	14.6	37.5	38.2	45.6	46.1	0.61	0.63	0.96	0.98	2.19	2.19
5.0	4.21	6.15	16.2	15.8	39.9	40.9	48.8	49.3	0.68	0.69	1.04	1.06	2.39	2.41
Zinc solubilizer	3.81	5.16	14.7	14.4	37.3	37.8	45.5	46.0	0.60	0.61	0.93	0.95	2.09	2.10
2.5 + zinc solubilizer	4.24	6.15	16.2	15.7	39.8	40.8	48.7	49.2	0.67	0.69	1.04	1.06	2.43	2.43
5.0 + zinc solubilizer	4.52	6.88	17.3	16.8	42.0	43.5	51.7	52.1	0.75	0.76	1.11	1.14	2.60	2.60
SEm±	0.06	0.12	0.30	0.30	0.67	0.69	0.88	0.92	0.01	0.01	0.01	0.01	0.04	0.04
CD (P=0.05)	0.17	0.34	0.84	0.84	1.92	1.97	2.50	2.63	0.03	0.04	0.05	0.05	0.12	0.12

DAS, Days after sowing

Table 2. Effect of phosphorus and zinc fertilization on dry matter accumulation, symbiotic root nodules and their dry weight in fenugreek

Treatment	Dry matter accumulation (g/plant)								Symbiotic root nodules (No.)				Dry weight of symbiotic root nodules (mg/plant)			
	30 DAS		60 DAS		90 DAS		At harvesting		45 DAS		90 DAS		45 DAS		90 DAS	
	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17
Phosphorus (P_2O_5 kg/ha)																
0	0.35	0.36	1.45	1.93	7.33	7.66	8.80	9.30	4.67	4.42	7.61	9.18	1.69	2.75	13.0	13.1
20	0.44	0.45	2.53	3.08	8.43	9.21	10.8	11.2	5.00	5.87	8.86	10.2	2.33	3.40	14.2	14.2
40	0.48	0.52	2.96	3.74	9.05	10.02	12.1	12.1	5.25	6.48	9.71	10.9	2.77	3.78	15.0	15.2
60	0.50	0.53	3.11	3.92	9.25	10.19	12.9	12.4	5.29	6.62	10.1	11.2	2.79	3.87	15.3	15.4
SEm±	0.008	0.013	0.08	0.07	0.12	0.13	0.30	0.23	0.06	0.07	0.15	0.15	0.07	0.06	0.20	0.27
CD (P=0.05)	0.027	0.045	0.28	0.23	0.42	0.46	1.03	0.80	0.20	0.26	0.50	0.51	0.23	0.22	0.68	0.94
Zinc (kg/ha)																
0	0.37	0.39	2.14	2.74	7.29	8.01	9.95	9.46	4.61	4.59	7.54	9.29	1.84	2.80	12.8	12.8
2.5	0.42	0.45	2.43	3.09	8.21	8.94	10.8	10.7	4.95	5.51	8.84	10.1	2.23	3.29	13.9	14.1
5.0	0.46	0.49	2.66	3.31	8.95	9.77	11.5	11.9	5.25	6.35	9.91	10.8	2.61	3.71	14.9	15.0
Zinc solubilizer	0.41	0.43	2.27	2.89	7.97	8.67	10.6	10.4	4.80	5.22	8.08	9.78	2.19	3.10	13.6	13.7
2.5 + zinc solubilizer	0.48	0.50	2.70	3.40	8.98	9.72	11.7	12.0	5.22	6.35	9.53	10.8	2.55	3.70	15.1	15.2
5.0 + zinc solubilizer	0.52	0.53	2.86	3.59	9.70	10.50	12.4	13.0	5.49	7.08	10.5	11.4	2.95	4.09	15.9	16.0
SEm±	0.010	0.013	0.06	0.08	0.11	0.14	0.17	0.18	0.05	0.09	0.16	0.17	0.06	0.07	0.21	0.17
CD (P=0.05)	0.029	0.037	0.18	0.23	0.33	0.40	0.50	0.52	0.14	0.26	0.46	0.47	0.17	0.19	0.59	0.48

DAS, Days after sowing

Since P helps in cell-division, its adequate availability owing to increasing level resulted in increased inter-nodal length leading to increased plant height and leaf area. Increased leaf area during periodic stages as evident from significantly higher LAI (Fig. 2), probably resulted in more interception of solar radiation. In addition, P is noted especially for its role in capturing and converting the Sun's energy into useful plant compounds leading to formation of greater amount of photosynthates and consequently accumulating more dry matter (Table 2). Tang *et al.* (2001) reported that, by 35 days after transplanting (DAT), the number of nodules tended to increase with increasing P supply and the nitrogenase activity per unit nodule mass doubled when the external P concentration was increased. Jinger *et al.* (2022) also reported that the plant height and LAI of wheat was increased due to residual P fertilization accomplished in preceding rice crop which reduced the immobilization of P and increased its availability to wheat. Similarly P fertilization with bio-inoculants increased the growth, yield, and yield attributes of pigeon-pea under Indo-Gangetic Plains of India (Gupta *et al.,* 2018).

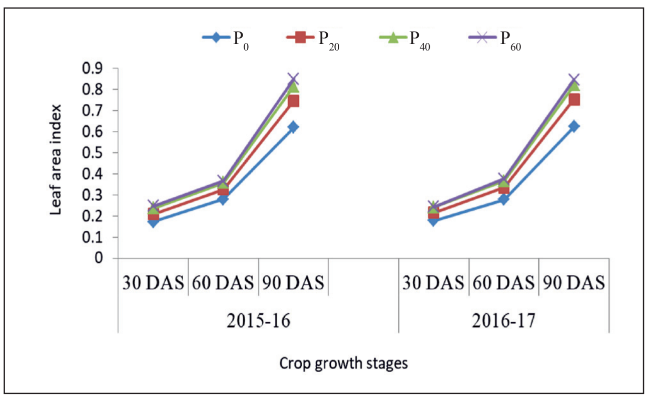

Fig. 2. Effect of phosphorus fertilization on leaf area index of fenugreek

Irrespective of the P application, fenugreek also responded positively to all the Zn treatments at different periodical stages. However, it showed negative response to Zn solubilizer for dry-matter accumulation/plant at 30 days after sowing (during 2016–17) and 60 days after sowing (in both the years) (Table 2). The plant height, dry-matter accumulation and LAI at all growth stages was recorded highest with 5.0 kg Zn/ha + zinc solubilizer and found superior to rest of the treatments, followed by 2.5 kg Zn/ha + Zn solubilizer and 5.0 kg Zn/ha during both the years (Table 1 & Fig. 3). The response noted with later 2 treatments was significantly better than the control, Zn solubilizer and 2.5 kg Zn/ha but non-significantly differed with each other. However, effect of Zn solubilizer was at par with 2.5 kg Zn/ha, though both were significantly better than the control during both the years. Root nodules recorded 90 days after sowing (DAS) during 2015–16 and 45 DAS during 2016–17, showed that, all the treatments exhibited significant variations to each other except treatment of 5.0 kg Zn/ha that was found statistically at par with 2.5 kg Zn/ha + Zn solubilizer. However, at 45 DAS during 2015–16 and at 90 DAS during 2016–17, effect of Zn solubilizer was statistically at par with that of 2.5 kg Zn/ha. During 2015–16, application of 2.5 kg Zn/ha + Zn solubilizer was found at par with 5 kg Zn/ha and 5 kg Zn/ha + Zn solubilizer for dry-matter at 60 DAS; however, during 2016–17 treatments of 5 kg Zn/ha + Zn solubilizer and 2.5 kg Zn/ha + Zn solubilizer were at par with 5 kg Zn/ha and the first 2 treatments were also at par with each other. Zinc is known to play an activator of several enzymes in plants and is directly involved in the biosynthesis of growth substances such as auxin which is important for nodulation in legumes and produces more plant cells and more dry matter. Customary application of inorganic Zn partially caters to the plant need, as 96–99% of applied Zn is converted into different insoluble forms (Goteti *et al.,* 2013) and become unavailable to plant, hence it is plausible that exploitation of native Zn by way of mineralizing and solubilizing through bacteria may aid in overcoming Zn deficiency and increasing availability of Zn by solubilizing the complex Zn in soil and nitrogen through the strong production of ammonia to crops. Ramesh *et al.* (2014) observed in their study that, the *Bacillus aryabhattai* strains MDSR7 and MDSR14 produced substantially higher amount of soluble Zn content. Similar findings were also reported by Awomy *et al.* (2012).

Yield attributes and yield

Pods/plant, pod length, seeds/pod, test weight, seed and straw yield/ha improved significantly up to application of 40 kg P_2O_5/ha in both the years (Table 3). Activation of metabolic processes through P application and its role in building phospholipids and nucleic acid is known. Thus, the favourable stimulatory effect of P under sufficient P supply that on nodulation, production of assimilates and their efficient partitioning into different sinks significantly improved the yield attributes viz. pods/plant, seeds/pod, test weight, and ultimately the seed and straw yields. Our results confirm the findings of Kumawat *et al.* (2021). Sharma *et al.* (2014) reported positive impacts of P fertilizers on fenugreek yield.

All the Zn treatments significantly improved the yield attributes and yields over the control. Application of 5.0 kg Zn/ha + Zn solubilizer resulted in the highest yield attributes and yield, followed by 2.5 kg Zn/ha + Zn solubilizer, 5.0 kg Zn/ha and 2.5 kg Zn/ha during both the years (Table 3). Fertilization with Zn had strong positive impact, and integration of Zn solubilizer with basal doses

Table 3. Effect of phosphorus and zinc fertilization on yield attributes of fenugreek

Treatment	Pods/plant		Pod length (cm)		Seeds/pod		Test weight (g)		Seed yield (kg/ha)		Straw yield (kg/ha)	
	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17
Phosphorus (P_2O_5 kg/ha)												
0	19.2	19.8	8.69	8.91	9.49	9.87	10.1	10.6	988	1014	1900	2018
20	22.2	23.0	10.1	10.9	11.4	11.9	11.0	11.6	1141	1193	2215	2453
40	24.3	25.1	11.1	11.9	12.8	13.1	11.8	12.4	1280	1351	2455	2668
60	25.3	26.1	11.8	12.3	13.3	13.5	11.8	12.5	1318	1415	2563	2737
SEm±	0.52	0.53	0.26	0.27	0.23	0.24	0.21	0.11	27	24	49	36
CD (P=0.05)	1.78	1.84	0.89	0.92	0.79	0.84	0.72	0.38	92	82	170	123
Zinc (kg/ha)												
0	20.4	21.15	9.04	9.30	10.3	10.5	10.2	10.8	1047	1087	2020	2099
2.5	22.4	23.1	10.2	10.7	11.4	11.6	10.9	11.6	1160	1192	2219	2441
5.0	23.6	24.4	11.1	11.8	12.2	12.4	11.5	12.2	1222	1286	2352	2635
Zinc solubilizer	21.5	22.2	9.56	9.88	10.9	11.1	10.7	11.3	1101	1176	2136	2228
2.5 + zinc solubilizer	23.8	24.6	11.0	11.6	12.5	13.0	11.5	12.2	1261	1338	2447	2633
5.0 + zinc solubilizer	24.8	25.6	11.8	12.6	13.1	13.8	12.1	12.8	1298	1382	2525	2778
SEm±	0.37	0.38	0.17	0.19	0.15	0.18	0.14	0.15	16	16	39	41
CD (P=0.05)	1.04	1.08	0.50	0.56	0.44	0.52	0.41	0.43	45	46	111	116

Table 4. Correlation between plant height, leaf area, dry-matter/plant, pods/plant, seeds/pod and seed yield of fenugreek.

Variable	Plant height		Leaf area		Dry-matter/plant		Pods/plant		Seeds/pod		Seed yield	
	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17	2015–16	2016–17
Plant height	1	1										
Leaf–area	0.967**	0.966**	1	1								
Dry-matter/plant	0.958**	0.993**	0.952**	0.972**	1	1						
Pods/plant	0.958**	0.956**	0.942**	0.943**	0.977**	0.955**	1	1				
Seeds/pod	0.955**	0.961**	0.934**	0.930**	0.953**	0.967**	0.961**	0.954**	1	1		
Seed yield	0.948**	0.962**	0.922**	0.926**	0.927**	0.957**	0.942**	0.966**	0.990**	0.985**	1	1

***P<0.01; **P<0.05–0.1; *P=0.1; So, highly significant correlation at P<0.05–0.1

of Zn proved more effective. This was followed by 2.5 kg Zn/ha + Zn solubilizer remaining at par with the 5.0 kg Zn/ha + Zn solubilizer and application of 5.0 kg Zn/ha for pods/plant (during both the years), seeds/pod and seed and straw yield/ha (during 2015–16). However, effect of 2.5 kg Zn/ha + Zn solubilizer was at par only with 5.0 kg Zn/ha for pod length, test weight during both the years; and for straw yield/ha during 2016–17. Application of Zn solubilizer and 2.5 kg Zn/ha when applied alone, were also effective over the control and were statistically at par with each other, during both the years, for pods/plant, pod length, test weight and straw yield/ha, and for seeds/pod and seed yield/ha during 2016–17 (Table 3). Seed yield was positively correlated with pods/plant and seeds/pod during both the years (Table 4). Significant response to P and Zn fertilization in rice and maize was also reported by Mondal *et al.* (2020) and Joshi *et al.* (2020), respectively.

Zinc translocation to seeds is higher during reproductive phases like fertilization and pollen grain formation which helps in increasing yield (Teja *et al.,* 2021). Zinc solubilizer solubilizes the unavailable fixed Zn; thus increased the availability of nutrients to plant and yield. The results pertaining to increased Zn availability owing its fertilization and solubilizing microbes, as observed in the present study, are in close conformity to those reported by and Vaid *et al.* (2014) and Noman *et al*. (2015).

Effect of weather

During the crop-growth period of 2016–17, the temperature conditions were more favourable than of 2015–16. The mean values for maximum temperature (Tmax.), during initial first few Standard Meteorological Weeks (SMWs) were relatively higher, whereas mean minimum temperature (Tmin.) values were declining sharply leading to greater diurnal variations during 2015–16. On contrary, these values were more favourable during 2016–17. Besides, the mean values for Tmax and Tmin were declining at constant rates during 2016–17 as compared to that during 2015–16, where greater fluctuations were noticed. In later part of crop duration, mean temperature values for both maximum and minimum increased from 4th SMW (22–28 January, at pod-filling stage of crop) during both the years, but there was a sharp increase during 2015–16 than during 2016–17. Tubiello *et al.* (2007) and Kang *et al.* (2009) also reported profound effect of weather conditions on productivity of crops.

Till the end of the 12th SMW during 2016–17, Tmax remained well below 34°C and the Tmin well below 19°C on the other hand during 2015–16; corresponding values were approaching 36°C and 20°C, respectively. Further, during 2015–16, the minimum mean value went down below 7°C for 2 meteorological weeks, while such observations were noticed only once during 2016–17. Approximately 32.6 mm rains were received during the crop season of 2016–17 as against only 16 mm rains during 2015–16. These 2 climatic variables along with better atmospheric humidity during later phase of crop, created favourable growing season for relatively longer period and increased the yield of fenugreek during 2016–17. The seed yield was positively correlated with Tmax and Tmin, rainfall, and rainy days during both the years (Table 5). Similar observations were made by Cheng-zhi *et al.* (2021) by existing inherent relationship between global mean temperature and world soybean yield. Padmalatha *et al*. (2006) observed significant variations in groundnut growth and yield due to planting dates. They have reported that pod yield was significantly and positively correlated with RH, but negatively correlated with Tmin and Tmax.

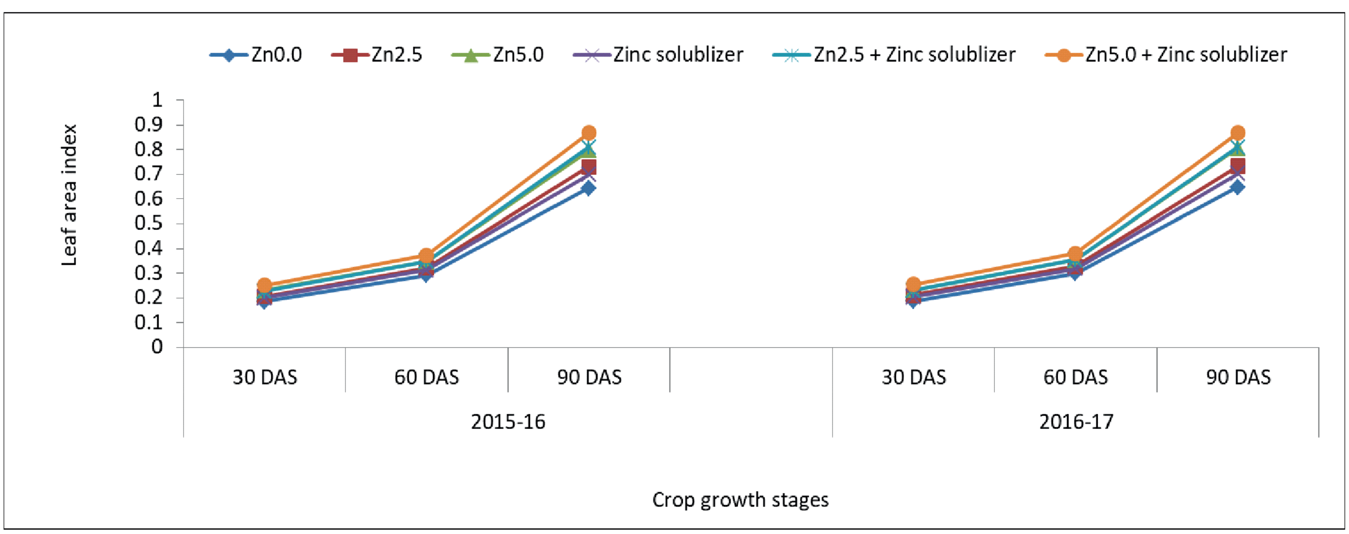

Fig. 3. Effect of zinc fertilization on leaf area index of fenugreek

Table 5. Correlation coefficients (r) and regression equations for the relationship between seed yield (Y) (kg/ha) and weather parameters during fenugreek (X) crop

Dependent variable (Y)	Independent variable (X)	2015–16		2016–17	
		Correlation coefficient (r)	Regression equation $Y = a + b_y x .X$	Correlation coefficient (r)	Regression equation $Y = a + b_y x .X$
Seed yield (kg/ha)	Temperature max.	0.418**	$Y = 783.44 + 14.25 X_1$	0.248*	$Y = 981.48 + 9.17 X_1$
	Temperature min.	0.284*	$Y = 1062.96 + 8.91 X_2$	0.400**	$Y = 1012.28 + 17.16 X_2$
	Rainfall (mm)	–0.355*	$Y = 1205.77 + –22.72 X_3$	–0.002*	$Y = 1283.59 + –0.10 X_3$
	No. of rainy days	–0.263*	$Y = –1203.42 + –155.81 X_4$	0.007*	$Y = 1238.29 + 30.96 X_5$

***P<0.01; **P<0.05–0.1; *P=0.1; So, highly significant correlation at P<0.05–0.1

On the basis of results obtained from two-years of study, it could be concluded that P and Zn application had significant effect on growth, yield, and yield attributes of fenugreek. Co-application of 40 kg P_2O_5/ha + 5 kg Zn/ha + zinc solubilizer to fenugreek could be a feasible as well as approachable practice for harnessing higher crop productivity especially under North-Western pockets of India. Further, numerous Zn solubilizer could be determined with different system of crop intensification, irrigation scheduling under different land capability classes.

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