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Influence of Phosphorus Levels and Zinc Application on Growth and Yield of Mothbean [*Vigna aconitifolia* (Jacq.) Marechal] in Loamy Sand Soil of Arid Region

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A field experiment was conducted during *kharif* season of 2010 at Agronomy farm, S.K.N. College of Agriculture, Jobner, Jaipur to study the influence of phosphorus levels and zinc application on growth and yield of mothbean [*Vigna aconitifolia* (Jacq.) Marechal]. The experiment was laid out in factorial randomized block design with three replications. The treatments consisting of four levels of phosphorus (0, 20, 40 and 60 kg P_2O_5 ha^{-1}) and four treatments of zinc (control, soil application @ 5 kg Zn ha^{-1}, soil application + one foliar spray @ 0.5% Zn at 25 DAS and soil application + two foliar spray @ 0.5% Zn at 25 and 40 DAS) making 16 treatment combinations. The results revealed that application of phosphorus upto 40 kg P_2O_5 ha^{-1} significantly increased plant height, branches plant^{-1}, dry matter accumulation plant^{-1} at 40 DAS and at harvest, total and effective root nodules plant^{-1}, fresh and dry weight of root nodules plant^{-1}, number of pods plant^{-1}, grains pod^{-1}, grain yield and stalk yield of mothbean over the preceding levels. Further application of 60 kg P_2O_5 ha^{-1} could not bring significant improvement over 40 kg P_2O_5 ha^{-1}. Increase in test weight was observed upto 20 kg P_2O_5 ha^{-1} only.

Key words : Loamy sand soil, phosphorus, soil application of zinc, foliar spray of zinc, growth, yield, mothbean.

Mothbean, also known as moth, dewbean and kidney bean is an indispensable component of dry land farming systems in arid and semi-arid regions because it is the most drought tolerant crop among *kharif* pulses largely grown in the dry Western and Central India with least agronomic practices. Mothbean has deep and extensive root system with profused vegetative growth and dense foliage and acts as a protective cover against soil erosion, smothering weeds and conserving soil moisture for longer period of time. The duration of the crop is very short, hence, it is most suitable for low rainfall areas of Western Rajasthan (Yadav, 2004). Being a legume crop, it forms symbiosis with *Rhizobia* and together they fix atmospheric nitrogen and thus provide sufficient nitrogen to meet the plants need. Mothbean contains about 20.5 per cent easily digestible protein being relatively rich in lysine and tryptophan, the essential amino acids in which cereals are deficient. The crop is also used as fodder and green manure. Its fodder is mixed with millets to make nutritious and palatable fodder for cattle. Phosphorus is a universally deficient plant nutrient in most of the soils of Rajasthan, particular in light textured soils where most of the mothbean is grown. Amongst the various factors limiting the plant growth, phosphorus deficiency is a recognized as a major bottleneck in realizing the full yield potential of mothbean (Patel *et al.,* 2004). It is responsible for the growth and development of roots and favourably influences the nodulation. It also plays an important role in energy storage and transfer. Zinc deficiency is prevalent worldwide and more than 50 per cent of world soils are deficient in zinc. Zinc is an essential micronutrient for plant and its deficiency limits crop growth and yield. Being an integral component of almost 300 enzymes, it affects carbohydrate metabolism, water absorption and reproduction of plants. Zinc plays an important role in the auxin metabolism like the tryptophan synthetase, tryptamine metabolism and hence, it affects the growth of plants. Further, zinc plays a key role in flowering and grain setting in crops (Zaidi *et al*., 1997). Its deficiency also leads to delayed maturity, lower yield quality. Therefore, in recent years zinc is considered as one of the constraints in the optimum production of crops. Keeping these points in view, the present investigation was under taken to assess the influence of phosphorus and zinc on growth and productivity of mothbean.

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Materials and Methods

The field experiment was conducted during *kharif* season of 2010 at Agronomy farm, S.K.N. College of Agriculture, Swami Keshwanand Rajasthan Agricultural University to study the influence of phosphorus levels and zinc application on growth and yield of mothbean. The soil of the experimental field was loamy sand in texture and alkaline in reaction (pH 8.2), low in organic carbon (0.14%) and nitrogen (132.7 kg ha^{-1}), medium in available phosphorus (16.3 kg ha^{-1}), potassium (150 kg ha^{-1}) and zinc (0.40 ppm). The experiment was laid out in factorial randomized block design with sixteen treatment combinations comprised of four phosphorus levels (0, 20, 40 and 60 kg P_2O_5 ha^{-1}) and four zinc treatments (control, soil application, soil application + one foliar spray and soil application + two foliar spray of zinc). A uniform dose of nitrogen (25 kg ha^{-1}) through urea, phosphorus through single super phosphate and soil application of zinc through sulphate, as per treatments were drilled in soil at the time of sowing of crop. Treatments involving soil application received 5 kg Zn ha^{-1} as zinc sulphate. Foliar spray was done @ 0.5 % Zn as $ZnSO_4$ at 25 DAS (one foliar spray) and 25 and 45 DAS (two foliar spray). Mothbean variety RMO-40 was sown with 15 kg seed ha^{-1}. The data obtained was statistically analysed by using the F-test as per procedure given by Gomez and Gomez (1984). For observations of growth parameters, five plants were randomly selected, tagged and numbered for recording observation whereas, in case of yield attributes such as pods per plant, seeds per pod and test weight were recorded at the time of harvest. Plants from the net plot area were harvested, tagged, bundled and dried under sun and weighed for bundle weight. Seed and stover yield were recorded after manual threshing and expressed as kg ha^{-1}.The straw yield was computed by subtracting seed yield from bundle weight.

Results and Discussion

Growth attributes

All growth attributing characters *viz*., plant height, branches $plant^{-1}$, dry matter accumulation $plant^{-1}$, total and effective number of root nodules and fresh and dry weight of root nodules $plant^{-1}$ of mothbean varied significantly with different phosphorus levels (Table 1). The successive increase in phosphorus level significantly increased the plant height, branches $plant^{-1}$, and dry matter accumulation $plant^{-1}$ at 40 DAS and at harvest. The influence of treatment receiving 60 kg P_2O_5 ha^{-1}, was however comparable with the application of phosphorus @ 40 kg P_2O_5 ha^{-1}. Similarly, the total and effective number of root nodules $plant^{-1}$ and fresh and dry weight of root nodules $plant^{-1}$ were also significantly increased with increasing levels of phosphorus upto 60 kg ha^{-1}. The increase in growth attributes might be obvious since phosphorus has been considered as an essential constituent of all living organisms which plays an important role in conservation and transfer of energy in metabolic reactions of living cells including biological energy transformations. Phosphorus not only plays an important role in root development and proliferation but also improves nodulation and nitrogen fixation by supplying assimilates to the roots. The energy obtained from photosynthesis and metabolism of carbohydrates stored in storage components (ATP and ADP) for subsequent use in growth resulted in vigours growth of plants. The above results are in conformity with the results of Patel *et al.* (2004) who reported that plant height, branches $plant^{-1}$ and dry matter accumulation $plant^{-1}$ of mothbean were significantly increased by the application of phosphorus. Sepat and Yadav (2008) also reported that phosphorus fertilization significantly improved growth attributes of mothbean including number and weight of root nodules.

Table 1. Influence of phosphorus levels and zinc application on growth attributes of mothbean

Treatment	Plant height (cm)		Branches $plant^{-1}$		Dry matter accumulation $plant^{-1}$ (g)		Nodules (No.)		Weight of nodules $plant^{-1}$ (mg)	
	40 DAS	At harvest	40 DAS	At harvest	40 DAS	At harvest	40 DAS	At harvest	40 DAS	At harvest
Phosphorus levels (kg P_2O_5/ha)										
0	13.28	22.43	3.66	4.15	3.63	7.88	12.05	8.89	120.95	52.40
20	14.55	24.34	4.54	4.91	4.51	8.55	13.58	9.62	128.33	56.77
40	15.53	25.99	5.25	5.34	5.15	9.14	14.61	10.30	134.59	61.23
60	15.61	26.24	5.47	5.49	5.40	9.38	14.89	10.45	138.94	62.50
SEm±	0.34	0.56	0.10	0.11	0.11	0.19	0.30	0.21	2.14	1.24
CD (P = 0.05)	0.96	1.59	0.28	0.31	0.32	0.55	0.86	0.62	6.17	3.59
Zinc application										
Control	13.20	22.44	3.82	4.39	3.80	7.91	12.22	8.93	122.84	50.63
Soil application (5 kg ha^{-1})	14.49	24.12	4.56	4.84	4.52	8.53	13.50	9.63	129.06	57.37
Soil application + one foliar spray (0.5% at 25 DAS)	15.48	25.71	5.16	5.19	5.05	9.09	14.37	10.25	135.26	61.78
Soil application + two foliar spray (0.5% at 25 & 40 DAS)	15.79	26.72	5.39	5.48	5.32	9.42	15.02	10.46	135.65	63.12
SEm±	0.34	0.56	0.10	0.11	0.11	0.19	0.30	0.21	2.14	1.24
CD (P = 0.05)	0.96	1.59	0.28	0.31	0.32	0.55	0.86	0.62	6.17	3.59

Application of zinc in soil @ 5 kg ha^{-1} + two foliar sprays @ 0.5% at 25 and 45 DAS gave significantly higher plant height, branches $plant^{-1}$, dry matter accumulation $plant^{-1}$ total and effective number of root nodules $plant^{-1}$ and fresh and dry weight of root nodules $plant^{-1}$ at 40 DAS and at harvest, than no zinc and soil application of zinc @ 5 kg ha^{-1} alone. However, it was at par with soil application + one foliar spray of zinc (Table 1). The improvement in these growth characters might due the fact that zinc is an essential component of several enzymes and plays an important role in nitrogen metabolism and higher uptake of nitrogen in plant, resulting into increased amino acids and protein synthesis in cells of plant, causing better growth. Zinc also helps in catalyzing various physiological processes and auxin synthesis in plants which ultimately increased the growth parameters of plant. The foliar applied zinc with soil application might be more effective as compared to soil applied zinc alone probably due to higher uptake efficiency of foliar applied zinc which resulted in increased photosynthetic efficiency by delaying the leaf senescence. Singh and Sharma (2005) had also reported similar results who found that application of soil and foliar applied zinc gave significantly higher plant height, dry matter accumulation, branches $plant^{-1}$ and number of root nodules $plant^{-1}$ in mothbean.

Yield attributes and yields

The phosphorus application had tremendous effect on yield attributes and yield of mothbean. Every increase in the level of phosphorus significantly increased the number of pods $plant^{-1}$, number of grains pod^{-1}, grain yield and straw yield upto 60 kg P_2O_5 ha^{-1}, which was however, comparable with the application of 40 kg P_2O_5 ha^{-1} (Table 2). However, test weight increased significantly upto 20 kg P_2O_5 ha^{-1} only. The increase in grain yield with 40 kg P_2O_5 was 22.19 and 7.06 % over control and 20 kg P_2O_5 ha^{-1}, respectively. The better development of yield attributes with phosphorus fertilization might be due to its key role in root development, energy transformation and metabolic process of plant through which increased translocation of photosynthetes towards the sink development might have occurred. The higher crop growth with more supply of phosphorus might also regulate starch / sucrose ratio in the source leaves and the reproductive organs (Giaquinta and Quebedeaux, 1980) have made available more photosynthates for formation of yield attributing parameters which consequently yielded more grains (Table 2). The concomitant increase in yield attributes and positive correlation between yield attributing characters and grain yield might have also provided an additional support for increased grain yield. The improvement in straw yield might be due to the fact that phosphorus tends to increase growth and development in terms of plant height, branches and dry matter by improving nutritional environment of rhizospere and plant system leading to higher plant metabolism and photosynthetic activity. These findings corroborate the results of Nadeem *et al.* (2004), Kumawat (2006) and Sepat and Yadav (2008).

Table 2. Response of phosphorus levels and zinc application on yield attributes and yield of mothbean

Treatment	Pods $plant^{-1}$	Grains pod^{-1}	Test weight (g)	Yield (kg ha^{-1}) Grain	Yield (kg ha^{-1}) Straw
Phosphorus levels (kg P_2O_5/ha)					
0	19.43	3.64	25.38	658	1669
20	23.35	4.59	26.75	751	1795
40	25.72	5.29	27.21	804	1908
60	26.95	5.40	27.42	833	1914
SEm±	0.48	0.10	0.44	18	39
CD (P = 0.05)	1.40	0.30	1.28	51	112
Zinc application					
Control	20.50	3.87	25.12	665	1659
Soil application (5 kg ha^{-1})	23.65	4.58	26.86	739	1787
Soil application + one foliar spray (0.5% at 25 DAS)	25.08	5.11	27.29	800	1905
Soil application + two foliar spray (0.5% at 25 & 40 DAS)	26.23	5.37	27.49	842	1934
SEm±	0.48	0.10	0.44	18	39
CD (P = 0.05)	1.40	0.30	1.28	51	112

Soil application of zinc @ 5 kg ha^{-1} + one foliar spray @ 0.5%, being at par with soil application + two foliar spray, bring significant increase in number of pods $plant^{-1}$, grain pod^{-1}, grain and straw yields over control and soil application of zinc alone. The test weight improved significantly with soil application of zinc @ 5 kg Zn ha^{-1} over control and remained at par with rest of the treatments of applied zinc (Table 2). The increase in yield attributes could be attributed to increased size of source and consequently the enhanced partitioning of photosynthates towards newly formed sink agrees with the results obtained by Singh and Sharma (2005). The increase in yields with application of zinc might be due to its important role in regulating the auxin concentration in plants. The substantial increase in grain and straw yields might be due to better growth and development of plant parts in terms of dry matter, plant height, branches per plant which might have increased the yield attributes and ultimately enhanced the grain yield significantly.

Foliar spray of zinc along with soil application might have resulted in effective absorption by plants and translocation of assimilates more efficiently for developing grains by proper filling as foliar application of zinc is a better way for supplying optimum nutrition for crop to complete its reproductive phases. Similar findings were also reported by Sharma and Abrol (2007). The interaction effect between phosphorus and zinc application was found non significant probably due to similar effect of both for increasing the growth and yield of mothbean.

Thus, the present study revealed that for higher growth and yield, mothbean should be fertilized with 40 kg P_2O_5 ha^{-1} and soil application of zinc @ 5 kg ha^{-1} + one foliar spray of zinc @ 0.5 % under loamy sand soils of arid region.

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