Effect of Phosphate Fertilization and Manganese Application on Growth and Yield of Broadbean

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ABSTRACT

A field experiment was conducted in the Faculty of Agriculture Experimental Farm in Tripoli to test the effect of superphosphate fertilization, at the rates 500 and 750 kg/ha, and manganese application, as a seed soaking solution or as a foliar spray on the growth and yield of broadbean.

Phosphate fertilization at the rates tested gave highly significant increases in the fresh and dry weights of the plants, seed yield and size of seeds. Nodulation of the plants was not affected by the phosphate fertilization. However, the nitrogen content of leaves was significantly increased by superphosphate fertilization at the rate of 750 kg/ha.

Manganese application, either as seed soaking solution or as foliar spray had no significant effect on fresh and dry weights of plants. Manganese foliar spray significantly reduced the yield of seeds. There was no interaction between the phosphate fertilization and the manganese application.

INTRODUCTION

The data on the effect of phosphate fertilization on the growth and yield of legumes are rather voluminous. The response obtained is being dependent on the fertility level of the soil under experimentation, its phosphorus fixing power, and the level of available phosphorus in the soil. In intensively cultivated and heavily fertilized areas, large quantities of phosphorus accumulate in the soil which is reflected in low or nil response to phosphate fertilization in many field experiments (1,4,14,19). On the contrary, in Libya the soil has either been recently reclaimed and cultivated, or has not been intensively cultivated, usually with a low level of available phosphorus. Under such conditions crop response to phosphate application is expected to be high.

In pot experiments with broadbean (*Vicia faba* L.) and field peas (*Pisum arvense* L.) Eppendorfer *et al.* (5, 6) reported highly significant increases in dry matter yield and the nitrogen concentrations in seeds. Also, the beneficial effect of phosphate application on nodulation of legumes and activity of the nodules produced in fixing nitrogen was reported by several investigators (2,7,13,17).

The essentiality of manganese in the metabolism of higher plants is well established.

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Under alkaline soil conditions the availability of this trace element is usually low (12,15,20), and this may result in restricted plant growth and low yield although deficiency symptoms may not be apparent. With severe manganese deficiency plant tops show chlorosis. The decrease in availability of manganese at pH values higher than 6 has been attributed to the valence changes of manganese from the manganous (Mn^{2+}) available form to higher valences (Mn^{3+} and M^{4+}) which are less available (12).

According to Cox (3) manganese fertilization has been recommended in U.S.A. whenever the acid-extractable manganese was less than 0.07 meq/100 g of soil (19 ppm) and the soil pH was greater than 6.2. Nevertheless, the diverse soil conditions and the species or even the variety of the plant grown greatly affect these levels. Bean Crops, especially soybean are among the crops sensitive to manganese deficiency (3,12).

The experiment reported here was designed to test the effect of phosphate fertilization and manganese application on the growth and yield of broadbean.

MATERIALS AND METHODS

This experiment was carried out in the Farm of the Faculty of Agriculture, University of Tripoli during the season of 1973. The soil of the experiment was not cultivated with field crops before; it had a sandy loam texture, pH of 8.1 and contained 0.3% organic matter and less than 1 ppm of available phosphorus. The amount of acid-extractable manganese, determined colorimetrically by the periodate method (12) was found to be 11 ppm.

Three levels of superphosphate (20% P_2O_5): 0, 500 and 750 kg/ha, and three manganese treatments: seed soaking treatment, foliar spray treatment, as well as untreated control were tested on broadbean (*Vicia faba*), in a 3 × 3 factorial experiment. Treatments of the experiment were made in plots 4 × 4 m in size, and were laid out in the field in a randomized complete block design with 4 replicates. The superphosphate was added to the soil and incorporated with the upper 15 cm one day before planting. For the manganese application treatments, a diluted solution of manganese sulphate, reagent grade, containing 5 ppm Mn was used for soaking the seeds for 16 hrs before planting; or as a foliar spray for the plants at a rate of 2.6 kg Mn/ha added in one application at the age of 4 weeks.

Broadbean seeds (local cultivar) were planted in rows 25 cm apart and the seeds were hand drilled in holes (one seed per hole) spaced at 25 cm in the row. The plants were not given any nitrogen fertilizer based on the reported depressive effect of combined nitrogen on nodulation and nitrogen fixation by leguminous plants (2,7). Weeding was made before spraying the plants with the manganese solution, and sprinkler irrigation was applied when necessary. The plants were sprayed with 0.2% malathion for the control of aphids whenever aphid attack occurred.

At the beginning of the flowering stage, when the plants were 8 weeks old, a sample of 4 plants with their roots, was taken at random from each plot for examining nodulation and determining the fresh and dry weight of the plants. The total nitrogen content in the leaves of the dried plants was determined by the Kjeldahl procedure (8).

After harvesting, the seeds were threshed out and the weight of seed yield from the whole plot was determined. The average weight of 100 seeds randomly picked from seeds of the whole plot was determined for seed size estimation. All data obtained were subjected to the analysis of variance and the means of the different treatments were compared using the least significant difference method (18).

RESULTS

The F values for the data obtained on the effect of phosphate fertilization and manganese application on the growth and yield of broadbean plants are shown in Table 1. The phosphate fertilization significantly affected all growth measurements and yield, whereas the manganese application affected only the yield of seeds. There was no interaction between the two factors.

Table 1 F-values for growth measurements of plants, yield of seeds, and size of seeds obtained

Source of variation	df	F-value				
		Fresh wt of plant	Dry wt of plant	N-content in leaves	Yield of seeds	wt of 100 seeds
Blocks	3	1.63	2.31	0.93	7.9[b]	2.29
Phosphate fertilization	2	13.87[b]	15.52[b]	3.57[a]	156.0[b]	32.24[b]
Manganese application	2	0.61[b]	0.29	0.73	9.2[b]	0.71
Interaction	4	1.22	1.23	0.49	2.12	1.71

[a] Significant at the 5% level.
[b] Significant at the 1% level.

Fresh and dry weights of the plants

The plants fertilized with superphosphate at the rate of 500 and 750 kg/ha showed highly significant increases in fresh and dry weights over those of the unfertilized control plants (Table 2). The mean increases in fresh weight and dry weight of the plants due to phosphate application at the rate of 500 kg/ha amounted to 57% and 43% respectively. The difference in fresh weight of the plants grown under the two phosphate levels was not significant, but there was a significant difference in dry weight of plants fertilized with the two phosphate levels, showing higher values in the treatment fertilized with 750 kg/ha.

Manganese application either as seed soaking solution or as foliar spray had no significant effect on the fresh or dry weights of the plants.

Nodulation and nitrogen content of leaves

Comparison of the numbers of the large effective nodules carried by the roots of plants from the different treatments showed that neither phosphate fertilization nor manganese application did affect the nodulation of the plants. Plant roots from the unfertilized control treatment were found to carry as many large effective nodules as those on the plants from the other treatments. However, phosphate fertilization at the rate of 750 kg/ha significantly increased the nitrogen content of the leaves (Table 2). This increase amounted to 22% of the nitrogen content of the leaves of the unfertilized plants. Phosphate fertilization at the low level did not give a significant increase in the nitrogen content of leaves (11.9%). Also, neither of the manganese treatments significantly affected the nitrogen content of leaves (Tables 1, 2).

Yield and size of seeds

Seed yield and size of seeds obtained, as estimated by the weight of 100 seeds, showed highly significant increases due to phosphate fertilization at the two levels tested

Table 2 Effect of phosphate fertilization and manganese application on fresh and dry weights of plants and nitrogen content in leaves of broadbean

	Fresh wt/plant (g)				Dry wt/plant (g)				Nitrogen content in leaves mg/g dry wt			
Superphosphate added kg/ha	0	500	750	Mean	0	500	750	Mean	0	500	750	Mean
Manganese treatment												
No manganese (control)	30.93	42.94	40.71	38.19	3.21	4.78	4.82	4.27	32.55	34.12	37.28	34.65
Seed soaking solution	20.27	36.81	49.01	35.36	2.89	4.26	5.86	4.33	26.60	34.65	30.33	31.86
Foliar spray	20.77	33.26	46.92	33.65	3.03	4.01	5.39	4.14	29.40	30.35	36.58	32.11
Mean	23.99	37.67	45.54		3.04	4.35	5.36		29.52	33.04	36.06	
L.S.D. at 5%		8.54 g				0.79 g				5.24 mg		
L.S.D. at 1%		11.58 g				1.08 g				7.10 mg		

(Table 3). The mean increases in seed yield and size by the phosphate fertilization at the rate of 500 kg/ha amounted to 270% and 17%, respectively. The high phosphate level (750 kg/ha), however, did not significantly increase seed yield or size above the low phosphate level (500 kg/ha).

Manganese application as foliar spray had no effect on the size of seeds but caused a highly significant reduction in the yield of seeds. The decrease in seed yield due to the manganese foliar spray treatment amounted to 24.5%. The preplanting manganese treatment as seed soaking solution did not significantly decrease the yield.

Table 3 Effect of phosphate fertilization and manganese application on seed yield and average weight of 100 seeds

Superphosphate added	Yield of seeds kg/plot				Average weight of 100 seed g			
kg/ha	0	500	750	Mean	0	500	750	Mean
Manganese treatment								
No manganese added (control)	2.04	4.47	5.10	3.87	95.93	103.0	110.27	103.06
Seed soaking solution	0.90	4.82	4.72	3.48	89.01	105.9	113.03	102.64
Foliar spray	0.62	3.94	4.20	2.92	85.12	107.8	107.52	100.14
Mean	1.19	4.41	4.68		90.02	105.56	110.27	
L.S.D. at 5%		0.454 kg				5.44 g		
L.S.D. at 1%		0.615 kg				7.38 g		

DISCUSSION

Under the conditions of the present investigation highly significant positive effects for phosphate fertilization on the growth and yield of broadbean plants were obtained. The response was more pronounced on the fresh and dry weights of the plants and yield of seeds than on the nitrogen content of leaves or seed size. These results are in agreement with the results reported by Eppendorfer *et al.* (5, 6) who found that the effect of phosphate fertilization was more pronounced on dry matter yield than on nitrogen concentration in the seeds.

The significant positive effect of phosphate fertilization on the nitrogen content of leaves without pronounced effect on nodulation would indicate that phosphate fertilization increased the efficiency of the nodules in fixing nitrogen. Although other investigators reported the importance of phosphorus fertilization for optimum nodulation of legumes (7,13), it was found that a higher level of applied phosphorus was required for maximum nodule activity (13). Excess phosphorus, however, decreased the weight of nodule tissues, the leghemoglobin concentration, and the amount of nitrogen fixed (9). The results on the influence of mineral nutrients on the Rhizobium-legume association have been difficult to interpret, yet it is believed that the legume host is the prime beneficiary of the fertilizer treatment and that the rhizobia benefit indirectly from the improved nourishment or environment which their host can provide (2).

Manganese application as seed soaking solution had no significant effect on the growth or yield of broadbean, whereas manganese applied as foliar spray significantly reduced the yield of seeds. This is probably attributed to difference in the amount of manganese absorbed by the plants in the two treatments. Differences in manganese ab-

sorbtion and translocation by different methods of manganese application were reported by other investigators (10). Cox (3) obtained a significant positive response in the yield of soybean to applied manganese in four out of nine field experiments carried in manganese-deficient soils (1.5 to 6 ppm acid-extracted Mn). In the other 5 experiments the manganese spray application increased the Mn content of the plants but had no significant effect on yield.

Under the conditions of the present investigation the negative response to the manganese spraying treatment may be attributed to the fact that the soil of the experiment was not severely deficient in manganese, and that broadbean is not as sensitive to Mn-deficiency as some other crops such as soybean, wheat and oats (3,7,11). Thus, spraying of manganese at the rate used supplied manganese in excess of the plants need, and could be responsible for the deleterious effect on yield. It is also known that the superphosphate fertilization increases the availability and uptake of soil manganese due to its effect on soil reaction (11,16). Therefore, it is reasonable, on the basis of the results obtained on manganese application, not to recommend any manganese treatment to broadbean plants in the Tripoli area.

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تأثير التسميد الفوسفاتي والمعاملة بالمنجنيز على نمو ومحصول نبات الفول

فريده حسن بدوي – عمران القائد

المستخلص

أجريت تجربة في مزرعة كلية الزراعة بطرابلس لدراسة تأثير التسميد الفوسفاتي بمعدل ٥٠٠ ، ٧٠٠ كجم سوبر فوسفات للهكتار والمعاملة بالمنجنيز في صورة محلول مخفف (٥ جزء في المليون) بنقع البذور قبل الزراعة أو برش النباتات عند عمر ٤ أسابيع على نمو ومحصول نبات الفول .

وقد أدى التسميد الفوسفاتى بالمعدلات المختبرة الى زيادة معنوية جدا في الوزن الأخضر والجاف للنباتات ، محصول البذور وحجم البذور الناتجة .

وبالرغم من أن التسميد الفوسفاتي لم يكن له تأثير على العقـــد الجذرية التى تحملها النباتات فأن المحتوي النيتروجينى لأوراق النباتات زاد زيادة معنوية بالتسميد بمعدل ٧٥٠ كجم سوبر فوسفات للهكتار .

لم يكن لاضافة المنجنيز سواء في صورة محلول بنقع البذور أو برش النباتات بمحلول مخفف تأثير معنوى على نمو النباتات ولكن أدت المعاملة بالرش إلى نقص معنوي في محصول البذور.