

## Effect of Phosphorus and Nitrogen Fertilization and Foliar Applied Manganese on Yield and Nutrient Concentration of Soybean, *Glycine max.* (L)

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**ABSTRACT.** A greenhouse experiment was conducted on clay loam soil of pH 7.8 to evaluate the effect of P and N fertilization and foliar applied Mn on yield and nutrient concentration in leaves and seeds of soybean. A significant yield increase was obtained for each added increment of P fertilizer up to 30 kg P<sub>2</sub>O<sub>5</sub>/acre. At application rates of 0, 15, 30 and 45 kg P<sub>2</sub>O<sub>5</sub>/acre, the seed yield was subsequently 27.8, 65.8, 84.8 and 83.6% of the maximum yield obtained at the maximum calculated P level. The yield increases were 14.2 and 10.2% due to N and Mn applications. In all cases, in which P was combined with N, the seed yield was relatively higher than with P or N applied alone.

Phosphorus, N and Mn concentration in leaves and seeds were positively correlated with the applied nutrient fertilizers. At any given level of applied P and Mn, the P concentrations were significantly higher in +N treatment than -N treatment. Phosphorus concentration in leaves and seeds decreased by Mn application. While P and Mn applications affected the Mn content of both leaves and seeds, they did not influence the N%.

Restricted growth and chlorotic leaf symptoms are observed on crops growing on alluvial and calcareous soils in the Northern part of Egypt. Manganese deficiency is one of the most conspicuous symptoms observed on soybean plants grown in this area. Under high soil pH and with low inherent soil Mn, the availability of Mn applied to the soil is too low (Cox 1978, Okhi *et al.* 1977 and Okhi *et al.* 1979). Therefore high application rates are required to correct Mn deficiency in soybeans by the soil application method.

Several reports have been published on the effect of P and N applications on growth, seed yield and protein content of soybeans, but conflicting results were widely reported. Despite the positive correlation that existed between P application rates and yield (Carter and Hartwig 1964, Cassman *et al.* 1980, deMooy and Pesek 1971, Jiménez and Villalobos 1980 and Wang *et al.* 1980), other

investigators (Miller *et al.* 1961 and Naples and Koegh 1969) failed to obtain a similar trend.

Nitrogen like phosphorus and all other micronutrients is necessary for soybean at all growth stages. There is no assurance, however, of a yield increase from N applications. Several investigators (Bhangoo and Albritten 1972, Boswell and Anderson 1976, Pal and Saxena 1976 and Wang *et al.* 1980) obtained a marked yield increase by N application. Additional data presented by Jiménez and Villalobos (1980), Valdés *et al.* (1978) and Welch *et al.* (1973) indicated an insignificant yield increase.

The present work was undertaken to study the influence of variable levels of P, N and Mn on seed yield and nutrient concentration in leaves and seeds of soybeans.

#### Material and Methods

A greenhouse experiment was conducted on clay loam soil of pH 7.8 in a cemented basin system of 150×75×50 cm. Each basin was supplied with an outlet tube for drainage purposes. Sixteen treatments, comprised of 4 rates of superphosphate fertilizer of 15.5% P<sub>2</sub>O<sub>5</sub> (0, 15, 30 and 45 kg P<sub>2</sub>O<sub>5</sub>/acre), 2 rates of ammonium sulfate fertilizer of 20.6% N (0 & 40 kg N/acre) and 2 rates of Mn foliar applications (0 & 3.6 kg MnSO<sub>4</sub>/acre) were used in factorial arrangement of randomized complete block design with three replications.

The P fertilizer treatments were broadcasted and mixed with the upper 25 cm soil layer prior to planting. Nitrogen was applied in solution from at 3 intervals, every 2 weeks after emergence. Callend cultivar of soybeans inoculated with rhizobia were seeded in 9 hills per row, each of 25 cm apart and 150 cm long (18 hills per plot). Manganese foliar application was applied to the upper plant surfaces at V-5 and R-2 stages. Manganese sulfate was dissolved in water and sprayed with a plastic hand sprayer at a rate of 100 liter per acre.

Random samples of the uppermost mature leaves of soybeans plant, grown in each basin, were separately collected at R-6 stage for chemical analysis. Leaf and seed samples were dried at 70 °C, ground to pass through a 0.5 mm mesh screen, wet ashed with 4:1 (v/v) HNO<sub>3</sub>/HClO<sub>4</sub> mixture and analyzed for Mn by atomic absorption spectrophotometer (Varian Techtron Model A-120). Phosphorus was determined by the vanadate method (Jackson 1958). Nitrogen content of both leaves and seeds were determined by Kjeldahl's method (Jackson 1958). At the end of the growing season, the plants were harvested and seed yield was recorded.

## Results and Discussion

### Seed Yield

The analysis of variance and the regression analysis for the seed yield data given in Table 1 and Figure 1 indicated that the main effects of P, N, Mn and their interactions were highly significant at 5% level. The equation which describes this relation is presented in Figure 1. Solving the differential form of this equation shows that 35.61 kg P<sub>2</sub>O<sub>5</sub>/acre produces a maximum yield of 426.88 g/m<sup>2</sup>. There was a significant yield increase to each added increment of P fertilizer up to an application rate of 30 kg P<sub>2</sub>O<sub>5</sub>/acre. Further increase in the level of P fertilizer did not exhibit any significant effect on the seed yield. At application rates of 0, 15, 30 and 45 kg P<sub>2</sub>O<sub>5</sub>/acre, the seed yield was 27.76, 65.83, 84.84 and 83.60% of the maximum yield obtained at the 35.61 kg P<sub>2</sub>O<sub>5</sub>/acre. Similar trends were noted by Nangu (1973), Nielson and Barber (1978) and Cassman *et al.* (1981), who found a positive yield response to applied P fertilizer.

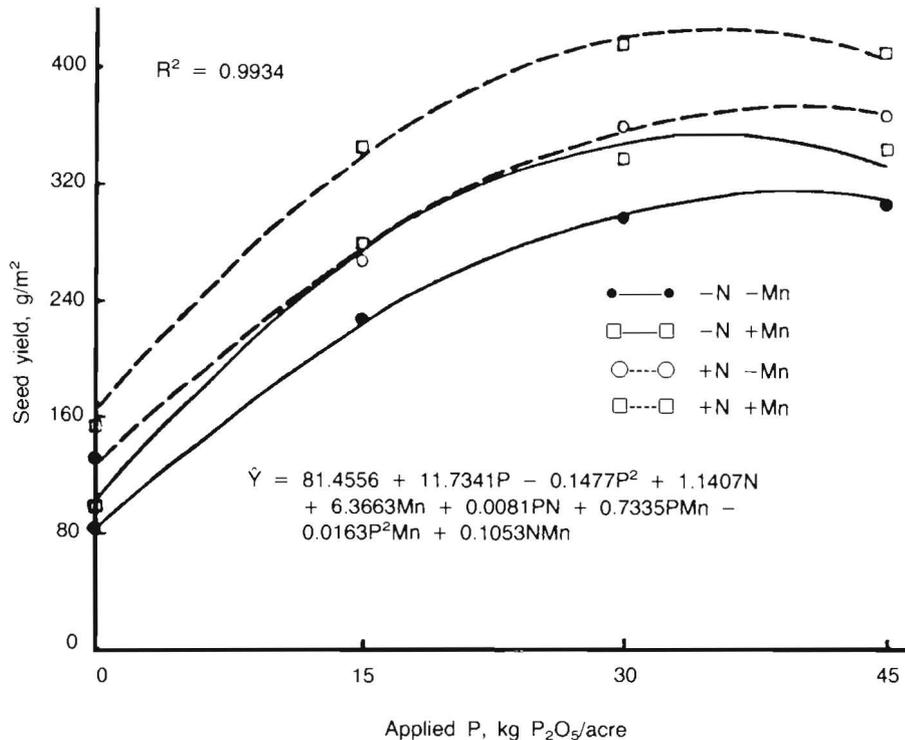


Fig. 1. Effect of P and N fertilization and foliar applied Mn on soybean seed yield.

**Table 1.** Seed yield of soybeans as related to N, P and Mn applications.

Treatments*		Seed yield g/m <sup>2</sup>	Relative yield,** %
P <sub>0</sub>	-N -Mn	83.27	19.51
	+N -Mn	131.70	30.85
P <sub>10</sub>	-N +Mn	100.17	23.47
	+N +Mn	158.49	37.21
Mean		118.49	27.76
P <sub>1</sub>	-N -Mn	228.37	53.50
	+N -Mn	268.83	62.97
P <sub>1</sub>	-N +Mn	280.87	65.80
	+N +Mn	346.07	81.07
Mean		281.03	65.83
P <sub>2</sub>	-N -Mn	296.83	69.53
	+N -Mn	361.47	84.68
P <sub>2</sub>	-N +Mn	338.03	79.19
	+N +Mn	418.13	97.95
Mean		353.62	84.84
P <sub>3</sub>	-N -Mn	308.37	72.24
	+N -Mn	366.50	85.86
P <sub>3</sub>	-N +Mn	342.13	80.15
	+N +Mn	410.47	96.16
Mean		356.87	83.60
L.S.D. (0.05):			
P, N & Mn = 6.33, 4.62 & 4.62 g/m <sup>2</sup>			
N×Mn, P×N & P×Mn = 6.52, 9.22 & 9.22 g/m <sup>2</sup>			

\* P<sub>0</sub>, P<sub>1</sub>, P<sub>2</sub> & P<sub>3</sub> = 0, 15, 30 & 45 kg P<sub>2</sub>O<sub>5</sub>/acre  
 -N & +N = 0 & 40 kg N/acre

-Mn & +Mn = 0 & 3.6 kg MnSO<sub>4</sub>/acre

\*\* Relative yield = actual yield × 100/426.88.

The results also showed that the average seed yield for the N-supplied and Mn-sprayed plants was relatively higher than for the untreated plants. The yield increase was 14.17 and 10.23% for N and Mn applications, respectively. In this respect, Cassman *et al.* (1981) showed that N application increased the maximum yield by 30%. It is known that cultivars of soybean differ widely in their response to mineral nutrition and seed yield. It is believed that the different behaviour of soybean cultivars might explain the variation of the results.

In all treatments, in which P was applied, soybean seed yield was significantly higher for Mn-sprayed plants than the Mn-untreated plants under both levels of

applied N. A similar trend was also obtained for +N and -N treatments at comparable Mn levels. The results confirmed the conclusion reached by Cassman *et al.* (1980 and 1981). They indicated that the nodulated soybean plants, grown without combined N in nutrient solution, had less root length than plants provided with combined N and the differences in root development were associated with higher P uptake and seed yield. Similar results were also reported (deMooy and Pesek 1971) on the effects of foliar applied Mn on seed yield, but the plant response to N was more pronounced than to Mn applications.

#### *Nutrient Levels in Leaves and Seeds*

The results presented in Tables 2 and 3 show that P concentrations in both leaves and seeds were highly correlated with P fertilizer ( $R^2 = 0.9376$  and  $0.9368$ , respectively). Regardless the Mn foliar application, N treatments did not influence the P level when no P was applied (Table 2). At any given level of applied P and Mn, the P concentrations were significantly higher in +N than -N treatments. It is believed that the stimulating effects of N fertilization on root growth and development may increase P mobilization. It is noteworthy that the P content in leaves was also decreased by Mn foliar application. This could be attributed to the effects of Mn on increasing the vegetative growth of leaves.

Nitrogen content in leaves and seeds increased with the N treatment, but the N% in seeds was higher than the comparable N% in leaves. Phosphorus and Mn applications did not influence the N concentration in either leaves or seeds (Table 2).

The analysis of variance and the regression/correlation analyses (Tables 2 and 3) indicated that P and Mn applications significantly affected the Mn content in leaves and seeds. Increasing rates of P fertilizer tended to decrease the Mn content in leaves and seeds. Leaf Mn ranged from 9.5 to 10.8 ppm for -Mn treated plants and from 23.6 to 28.8 ppm for +Mn treated plants. Seed Mn behaved similarly, but the Mn level was relatively lower than the corresponding Mn content in leaves.

According to Ulrich and Hills (1973), the critical leaf concentration of an element is the concentration of a particular nutrient in leaves corresponding to a yield which is 90% of the maximum yield. Since the experimental data showed that the yield of -Mn treated plants was 10.2% below the maximum, it may be concluded that this study supports the view of Ulrich and Hills, because Mn foliar application at a rate of 3.6 kg  $MnSO_4$  per acre had a significant effect on increasing yield.

**Table 2.** Phosphorus, N and Mn content in leaves and seeds of soybean as related to P, N and Mn applications.

Tr'ts.	P content, %				N content, %				Mn content, ppm								
	Leaves		Seeds		Leaves		Seeds		Leaves		Seeds						
	-Mn	+Mn	-Mn	+Mn	-Mn	+Mn	-Mn	+Mn	-Mn	+Mn	-Mn	+Mn					
P <sub>0</sub>	-N	0.29	0.25	0.35	0.33	4.32	4.32	6.18	6.25	10.0	28.8	9.2	18.5				
	+N	0.28	0.24	0.40	0.38	4.52	4.52	6.50	6.55	9.5	27.2	8.8	18.5				
P <sub>1</sub>	-N	0.35	0.33	0.42	0.40	4.28	4.30	6.20	6.20	10.0	27.5	9.2	18.0				
	+N	0.43	0.37	0.59	0.55	4.52	4.60	6.60	6.65	10.0	26.0	9.2	18.5				
P <sub>2</sub>	-N	0.44	0.36	0.48	0.42	4.28	4.28	6.18	6.22	10.8	25.5	8.8	17.5				
	+N	0.50	0.42	0.62	0.58	4.60	4.52	6.60	6.60	10.4	25.0	9.2	17.5				
P <sub>3</sub>	-N	0.44	0.40	0.52	0.47	4.30	4.35	6.20	6.22	9.5	24.0	10.2	16.0				
	+N	0.54	0.49	0.68	0.62	4.52	4.52	6.65	6.60	9.5	23.6	8.8	15.5				
	P	= 0.03 %		P = 0.03 %		P	= 0.03 %		N	= 0.07 %		P	= 1.02 %		P	= 0.62 %	
	N	= 0.02 %		N = 0.02 %								Mn	= 0.72 ppm		Mn	= 0.44 ppm	
	Mn	= 0.02 ppm		Mn = 0.02 ppm								P×Mn = 1.44 ppm		P×Mn = 0.88 ppm			
	N×P	= 0.04 %		N×P = 0.04 %													
L.S.D. 5%	The other interactions are not significant for both leaves and seeds.				Mn, P and all interactions are not significant for both leaves and seeds.				N and other interactions are not significant for both leaves and seeds.								

**Table 3.** Phosphorus, nitrogen and manganese content in leaves (L) and seeds (S) as a function of P, N and Mn applications.

Parameter	Regression equation	R <sup>2</sup>
P <sub>L</sub>	$\hat{Y} = 2839.2 \times 10^{-4} + 71.0 \times 10^{-4}P - 0.8 \times 10^{-4}P^2 + 1.9 \times 10^{-4}N - 138.9 \times 10^{-4}Mn + 0.5 \times 10^{-4}PN$	0.9376
P <sub>S</sub>	$\hat{Y} = 2981.9 \times 10^{-4} + 175.9 \times 10^{-4}P - 7.0 \times 10^{-4}P^2 + 0.1 \times 10^{-4}P^3 + 14.0 \times 10^{-4}N - 107.6 \times 10^{-4}Mn + 1.8 \times 10^{-4}PN - 0.03 \times 10^{-4}P^2N$	0.9368
N <sub>L</sub>	$\hat{Y} = 43045.9 \times 10^{-4} + 58.8 \times 10^{-4}N$	0.8286
N <sub>S</sub>	$\hat{Y} = 62062.6 \times 10^{-4} + 96.9 \times 10^{-4}N$	0.7804
Mn <sub>L</sub>	$\hat{Y} = 99850.1 \times 10^{-4} - 10.0 \times 10^{-4}P + 50222.1 \times 10^{-4}Mn - 258.3 \times 10^{-4}PMn$	0.9784
Mn <sub>S</sub>	$\hat{Y} = 91500.3 \times 10^{-4} - 4.4 \times 10^{-4}P + 27638.8 \times 10^{-4}Mn - 194.4 \times 10^{-4}PMn$	0.9635

Due to the positive response of the soybean cultivar Calland to P fertilizer, it was demonstrated that an application rate of 35 kg P<sub>2</sub>O<sub>5</sub>/acre would produce maximum seed yield under our experimental conditions. On the other hand, the design of this experiment did not permit the estimation of N or Mn required for maximum yields, so it is recommended that further experiments be conducted to estimate the applied levels of N and Mn that maximize seed yield under an optimal P application of 35.6 kg P<sub>2</sub>O<sub>5</sub>/acre.

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## تأثير التسميد الآزوتي والفوسفاتي والمنجنيز المضاف عن طريق الرش على محصول فول الصويا ومكوناته من العناصر

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مختبر ملوحة التربة - مركز البحوث الزراعية  
باقوس - الإسكندرية - مصر

نفذت هذه الدراسة في بيوت زجاجية على أرض طمية طينية ذات درجة حموضة ٧,٨ لدراسة تأثير التسميد الآزوتي والفوسفاتي والمنجنيز المضاف عن طريق الرش على محصول فول الصويا ومحتوى مكونات أوراقه وحبوبه من العناصر الغذائية.

أمكن الحصول على زيادة معنوية في المحصول لكل إضافة من سماد السوبر فوسفات حتى ٣٠ كجم  $P_2O_5$  إيكار. عند إضافة صفر، ١٥، ٣٠، ٤٥ كجم  $P_2O_5$  إيكار. كان المحصول الناتج منسوباً إلى أقصى محصول محسوب عند أقصى معدل فوسفاتي هو ٢٧,٨، ٢٧,٨، ٦٥,٨، ٨٤,٨، ٦,٨٣٪ على التوالي. تراوح مقدار الزيادة في المحصول الراجع إلى تأثير النتروجين والمنجنيز بين ٢,١٤ - ٢,١٠٪. وجد أن محصول الحبوب الناتج في جميع المعاملات التي أدمج فيها إضافات الفوسفور أعلى إذا ما قورنت بكمية المحصول الناتجة عند إضافة الفوسفات أو النتروجين فقط.

كان هناك ارتباط موجب بين محتوى الأوراق والحبوب من الفوسفور، النتروجين والمنجنيز مع إضافات محتوى هذه

الأسمدة من هذه العناصر. عند إضافة أي مستوى من الفوسفور والمنجنيز، كان تركيز الفوسفور أعلى معنوياً من المعاملات التي تلقت إضافات من النتروجين عن تلك التي لم يضاف إليها نتروجين. بإضافة المنجنيز إنخفض تركيز الفوسفور والنتروجين في الأوراق والحبوب. بالرغم من أن إضافات الفوسفور والمنجنيز أثرت على محتوى المنجنيز في كل من الأوراق والحبوب، إلا أنها لم تؤثر على النسبة المئوية للنتروجين.