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Effect of Method Additions with and without Soaking in Phosphatic Fertilizers on Faba Bean Plant

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ABSTRACT

A pot experiment was conducted at the Experimental Farm of Fertilizers Development Center, El-Delta Company for Fertilizers and Chemical Industries (ASMEDA) in Talkha, Dakahlia Governorate, Egypt during the winter season of 2015/2016 to enhancement of phosphate fertilizer using different methods of application. In addition, determining the optimum methods of application of phosphorus fertilizers for growth, yield and yield components and the availability of nutrients for faba bean Giza 716 cultivar .The experiments was carried out in a factorial experiment in a complete randomized block design with three replications. The results show that the most efficient treatment was mixing single- superphosphate (6.34 P) with soil with soaking seeds in a saturated solution of single- superphosphate (6.34 P) MSM soaking [.These results may be due to the fact that delayed phosphate fertilization after the early growth stages tends to reduce plant uptake of phosphorus, which leads to low concentration of phosphorus in grains.

Keywords: Faba bean, Phosphorus fertilizer, Soaking, methods of application, Yield, Quality, Nutrients uptake.

INTRODUCTION

Phosphorus (P) is one of the major nutrients required for plant growth and reproduction. Phosphorus, such as carbon and nitrogen is an essential element in all living systems. It is often referred to phosphorus as the "energizer" since it helps store and transfer energy during photosynthesis. Phosphorus is required to synthesize DNA molecules (DNA, RNA). Also A vital bioenergy component of the adenosine triphosphate (ATP) molecule as the phosphate groups of water form and key elements in cell membranes (Marschner, 2012). Crops deficient in phosphorus tend to develop slower, exhibit limited growth potential, and yield less than expected (Johnston, 2001). Phosphorus is often found in fixed chemical forms that cannot immediately be absorbed by plants.

Faba bean (*Vicia faba* L.) is grown world-wide as a protein source for food and feed. Its seeds are high in protein, vitamins, and minerals. At the same time faba bean offers ecosystem services such as renewable inputs of nitrogen into crops and soil enhancing its richness via biological N_2 fixation and a diversification of cropping systems (Jensen *et al*., 2010). Faba bean is considered one of the most important seed legume crops grown in winter season at different types of soils in Egypt. Production of faba bean in Egypt is still limited and falls to face the increasing local consumption the crop, this is related to the cultivated area by faba bean in Egypt is relatively small and decreased dramatically in last decade. This is due to the strong competition between faba bean and other strategic winter season crops such as wheat and clover on the limited arable land in Nile valley and Delta.

Egyptian Government is pressing hard to increase the yield and quality of faba bean plant through improving agricultural practices such as enhancement of phosphate fertilizer using different methods of application under different Egyptian soil conditions.

The method of application of phosphorus fertilizer should be taken into account to obtain profitable results in crop growth. Phosphorus fertilizer could be used broadcasting and incorporate prior to seeding of legume crops. However, it could use placement method which positively affect the phosphate recovery and yield obtained (Turk and Tawaha, 2001). Slaton *et al*. (2002) showed that broadcast application of phosphorus fertilizer to the soil surface between seeding and active tillering were equally effective at increasing rice yields and optimizing phosphorus uptake on the P deficient soils. Turk and Tawaha (2002) found that methods of phosphorus application (banding and broadcasting) had only a significant effect on seed yield and seed weight per plant. Highest yields were obtained by application of phosphorus fertilizer as drilled with the seed after cultivation (banded). El-Ghamry *et al*. (2009) showed that adding half the recommended phosphorus fertilization rate at sowing and the other half before the first irrigation was the most efficient treatment to enhance phosphorus fertilizer use efficiency, contributing to an increased uptake of phosphorus by cowpea, reflected in the higher phosphorus concentration in the grains. Increased phosphorus uptake also caused an increase in the nitrogen and potassium concentrations in cowpea grains, whereas the zinc and iron concentrations decreased. Esmail and Miran (2012) indicated that the highest values of plant height, dry matter weight, yield , number of active nodules, phosphorus and protein content were recorded from combination application of 100 mg phosphorus per kg soil and application of ½ of applied phosphorus to the soil and foliar application of other half.

Therefore, the present work aims to enhancement of phosphate fertilizer user efficiency using different methods of application. In addition, determined the optimum methods of application of phosphorus fertilizers for growth, yield and yield components and the availability of nutrients for faba bean.

MATERIALS AND METHODS

Materials of study

Surface soil samples (0-30 cm) were collected from the Experimental Farrm of El-Delta Company for Fertilizers and Chemical industries (ASMEDA) in Talkha, Dakahlia Governorate, Egypt. Physical and chemical characteristics of the investigated soil were determined according to (Dewis and Fertias, 1970). Hesse (1971). Faba beans (Giza 716) were kindly obtained from Agricultural Research Station in Sakha City, Kafr El - Sheikh Governorate Seeds were then inoculated with Okadin ;(Rhizobium sp.).at a rate of 100 kg per fidden, 1.2 gm per pot. fidden using inoculation of seeds with rhizobium as an adhering material.

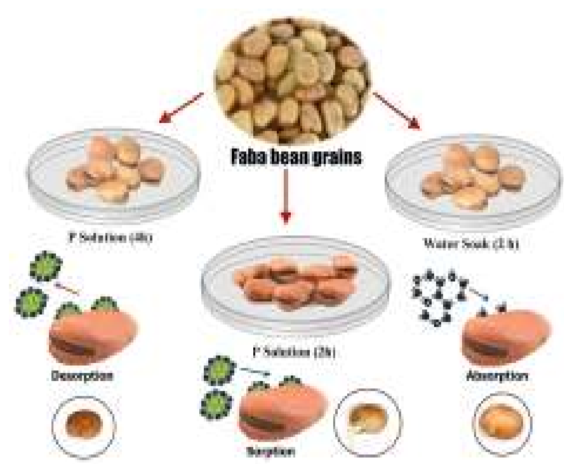
Method of Study

A pot experiment was conducted at the greenhouse conditions of the fertilizers Development Department, El-

Delta Company for Fertilizers and Chemical industries (ASMEDA) during the winter season of 2015/2016 to find out the optimum method for applying P-fertilizers on the yield outcome and yield components of faba beans. The uptake of NPK by the grown plants was also a matter of concern in the current research. To attain these aims, plastic pots (30 cm diameter × 35 cm length) were uniformly packed with soils equivalent to 12 kg. Physical and chemical characteristics of the investigated soils are presented in Table 1. Pots were then cultivated with bean seeds at a rate of 8 seeds per pot on the 28th of October 2015. Plant density was adjusted 20 days latter, by thinning plants to leave only 5 healthy plants in each pot. Soil moisture was maintained at the field capacity throughout the experimental period. All pots received NPK fertilizers at the recommended rate of the Ministry of Agriculture and Land Reclamation. Nitrogen was applied in the form of ammonium nitrate (33.5 % N) at a rate of 15 mg N kg^{-1} which is equal to 0.18 g pot^{-1} as a starter dose before thinning to stimulate the activities of Okadin ;(Rhizobium sp.) bacteria. Potassium sulphate (40%K) was amended at a rate of 100 g kg^{-1} which is equal to 1.2 g pot^{-1}, 43 days after seedling and before the second irrigation. Mono-calcium phosphate (6.34% P) was amended at a rate of 150 g kg^{-1} which is equal to 1.80 g pot^{-1}; however, the method of application was a matter of concern in the current study. The experiment was carried out in complete randomized block design (CRBD) with three replicates. The first factor was the effect of soaking seeds for 2 hours in a saturated solution of mono-calcium superphosphate (63.4 g P kg-1) prepared at a rate of 100g L^{-1}, afterwards, seeds were air dried. The second factor was the timing of phosphate application i.e. before sowing and after seedling emergence. Plants were sampled from each treatment at 45 and 135 days after sowing to measure the following growth parameters i.e. plant height, total chlorophyll content (SPAD, assessed in the third leaf of main stem by SPAD-502), fresh and dry weights. Plants were harvested at the physiological maturing growth stage, attained at 203 days after sowing. The following growth parameters were determined seed yield per plant, number of pods per plants, pod weight per plant, number of seeds per plant, 100-seed weight. The plant material was then oven dried on 70 C for 48h; afterwards, the dry weights were determined. The dried materials were grounded, digested by an acid mixture of sulfuric and perchloric acid as described by Peterburgski (1986). The oven dry plant samples were ground and wet digested by sulphuric perchloric acid mixture as described by Peterburgski, (1986). Total N, P, K, Fe, Zn and Mn ,Total nitrogen (%) , Total phosphorus percentage (%) , Potassium percentage (%) and crude protein percentage (%) was determined in the dry seeds by determination of N% and was multiplied in 5.75 according to AOAC (2007). Total micronutrients (Fe, Zn and Mn) contents (ppm) were determined according to Mathieu and Pieltain, (2003).

Data Analysis

All obtained data were subjected to the statistical analysis according to the technique of analysis of variance (ANOVA) for the factorial experiment in complete randomized block design (CRBD) as published by Gomez and Gomez, (1984) by means of Co-STATE Computer Software. Least significant of difference (LSD) method was used to test the differences between treatment means at 5 % level of probability as described by Snedecor and Cochran, (1980).



Effect of soaking in water and single-superphosphate (6.34 % P) on faba bean seeds.

Table 1. Physical and chemical properties of the studied soil before faba bean sowing.

Particle sizze distribution %				Texture class	OM (g kg^{-1})	$CaCO_3$ (g kg^{-1})	F.C %	Available ($mgkg^{-1}$)		
C. Sand (%)	F. Sand (%)	Silt (%)	Clay (%)					N	P	K
1.7	19.8	28.4	50.1	clay	11.0	40.0	35.0	48.5	3.90	189.5

pH*	EC** dS m^{-1}	Soluble ions conc. meg/100g soil***							
		Cations				Anions			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{-}	HCO_3^{-}	Cl^{-}	SO_4^{--}
7.80	1.19	3.80	1.00	6.10	1.00	--	0.90	5.40	5.60

C. sand: Coarse sand F. sand: Fine sand F.C: Field capacity
*** Soil pH was determined in soil paste.**
**** Soil Electrical Conductivity (EC) was determined in soil paste extract.**
***** Soluble ions were determined in 1:2.5 soil water suspensions.**

RESULTS AND DISCUSSION

Plant growth parameters and yield components as affected by soaking and time of P treatment

Data presented in Table 2 show that the vegetative growth parameters of faba beans plant high flowering and harvest (cm), 100 Seed dry weight (g) and Pods dry weight (g)) Were significantly affected by soaking seeds in P solution as well as the time of P-application. Soaking seeds in P solution increased significantly the fresh and dry weights of plants. Likewise, amending soils with P-fertilizer increased significantly the fresh and dry weights of plants. The positive effects for both seed soaking and time of P-application were investigated by Sorour (1993) and Abdel-Haleem (1994). It is well known that phosphorus plays important roles in plant growth and cell division

(Hashemabadi, 2013), thus plant height increased with application of P amendment (Afzal *et al*., 2010). However, the interactions between these two factors. P-fertilizer * seed soaking were also of significant effect. Although, soaking seeds in P solution decreased plant height for those grown in soils not amended with P or those received P-fertilizer after the emergence of seedling; however, the soaking treatment seemed to be of significant affect only if the soaked seeds were grown in soils amended with P before sowing seeds (compared with the un-soaked ones). There is no wonder to find out that the pod yield per plant increased when soils amended with phosphate before seedling compared with those received P after seedling emergence. However, 100-seed weight seemed to be relatively lower in the first treatment than in the second one.

Table 2. Vegetative growth characters (plant high flowering and harvest (cm), 100 Seed dry weight (g) and Pods dry weight (g) of faba bean as affected by soaking seed treatments and the time of phosphorus application.

	Cont	DPM	MSM	Mean	Cont	DPM	MSM	Mean
	P.H flowering cm				**P.H harvest cm**			
Without Soak	35.1	41.75	36.3	37.72	61.72	66.63	62.32	63.5567
Soak	34.9	39.47	44.4	39.59	56.87	65.8	79.33	67.3333
Mean	35	40.61	40.35	38.65	59.295	66.215	70.825	65.445
LSD5%	1.41				1.16			
	100 Seed dry weight (g)				Pods dry weight (g)			
Without Soak	63.31	68.71	77.64	69.8867	61.15	91.12	81.02	77.7633
Soak	90.42	121.88	108.52	106.94	45.08	60.48	80.21	61.9233
Mean	76.865	95.295	93.08	88.4133	53.115	75.8	80.615	69.8433
LSD5%	2.84				3.74			

Elemental composition of the grown plants:

Data in Table 3 show that the chemical composition of faba bean was significantly affected by seed soaking as well as the time of P application. Generally, P-application increased NPK contents in faba plants. Similar results indicate that phosphorus concentration in seeds of faba beans was directly related to the rate of the applied P-fertilizer (Henry *et al.,* 1995). Concurrent increases in N, K, Fe and Zn contents occurred within the investigated plant parts i.e. shoot and seed .This might be attributed to the effect of phosphorus on stimulating root growth (Wen *et al*., 2016) and exhibiting strong physiological root plasticity (Zhang *et al*., 2016), besides of the root exudates e.g. citrate (Ryan *et al*., 2014; Zhang *et al*., 2016)These exudates probably chelated soil micronutrients thus increased their availability and uptake by plants (Pingoliya *et al*., 2015). Lopez-Bucio *et al*., 2002, Koreish *et al*. (1998), El-Shamma *et al*. (2000) reported that the increased rates of phosphate fertilizers led to concurrent increases in nitrogen uptake and consequently higher grain yields.

It is worthy to mention that seed soaking increased slightly nutrient contents in shoot and seed. In this concern, soaking seeds in P –solution did not increase significantly the nutrient content of plant shoots or seeds except for those amended with P-fertilizer before sowing (MSM). The positive effect of seed soaking was also reported by El-Hamdi (1990), Xu *et al*. (2002) and El-Ghamry *et al*. (2009) on cowpea nutrients phosphorus and by Payne *et al*., 1986

There is an antagonism relationship between (phosphorus and zinc) and (phosphorus and iron) absorption by plants and increasing phosphate fertilization leads to a lack of absorption of zinc and iron.

Quality parameters

Table 4 shows that application of P-fertilizer enhanced the chlorophyll content in leaves as well as the protein content in seeds. In this concern, amending soils with P before sowing seeds seemed to be a most efficient treatment than amending soils with P after seedling emergence. Similar results were reported by El-Shamma *et al*. (2000) and Abou Hussien *et al*. (2002) indicating the positive effect of P-fertilizers on the protein content in seeds. The effect of phosphorus on the chlorophyll content in plants was also reported by Jiang *et al*. (2007), Pingoliya *et al*. (2015) and Chrysargyris *et al*. (2016). Concerning the effect of seed soaking on the plant quality parameters, soaking treatment increased both the chlorophyll and protein contents except for plants amended with P before sowing.

Table 3. Chemical composition of faba bean as affected by soaking seed treatments and methods of phosphorus application

Treatment	Shoot				Seed			
	Cont.	**DPM**	**MSM**	**mean**	**Cont**	**DPM**	**MSM**	**mean**
	N, g kg^{-1}							
Without Soak	15.5	25.2	16.2	19.0	33.4	36.4	38.0	35.9
Soak	16.8	22.4	21.2	20.1	33.7	36	43.7	37.8
Mean	16.2	23.8	18.7	19.6	33.55	36.2	40.9	36.9
LSD5%	1.00				0.014			
	P, g kg^{-1}							
Without Soak	0.9	1.2	1.0	1.0	0.8	1.0	1.0	0.9
Soak	0.9	1.1	1.3	1.1	0.7	1.2	1.3	1.1
Mean	0.9	1.15	1.2	1.1	0.75	1.1	1.2	1.0
LSD5%	0.02				0.05			
	K, g kg^{-1}							
Without Soak	23.4	25.9	25.3	24.9	9.6	9.8	9.7	9.7
Soak	21.6	23.5	25	23.4	9.5	10.0	10.0	9.8
Mean	22.5	24.7	25.2	24.1	9.55	9.9	9.9	9.8
LSD5%	0.05				0.01			
	Fe, mg kg^{-1}							
Without Soak	381.6	420.9	352.3	384.93	220.8	194.8	259.5	225.0
Soak	513.1	593.0	570.1	558.7	121.2	338.4	345.1	268.2
Mean	447.4	507.0	461.2	471.86	171.0	266.6	302.3	246.6
LSD5%	7.82				34.48			
	Zn, mg kg^{-1}							
Without Soak	46.5	57.3	65.8	56.5	43.3	37.5	63.6	48.1
Soak	41.3	53.2	52.1	48.9	33.6	39.4	33.9	35.6
Mean	43.9	55.3	59.0	52.7	38.45	38.45	48.75	41.9
LSD5%	2.99				4.15			

Data in Table 5 clarifies soil after harvest as affected by soaking seed treatments and methods of phosphorus application on the studied soil during 2015/2016 season. It is noticed that individual effect of application high significance K(mg kg^{-1}), while N(mg kg^{-1}) is significance but P(mg kg^{-1}) is non-significance.The plant absorbs the elements from the soil and also absorbed the phosphorus added before planting with soil settings and added in the way of mixture with soil method (MSM) and phosphorus left the result is added in a way deep placement method (DPM).

Table 4. Quality parameters of faba bean as affected by soaking seed treatments and methods of phosphorus application during 2015/2016 season.

	Cont	DPM	MSM	mean
	Chlorophyll(SPAD) Fresh Weight			
Without Soak	21.8	27.1	29.03	25.9767
Soak	22.57	27.97	26.53	25.69
Mean	22.185	27.535	27.78	25.8333
LSD5%	1.15			
	Protein % in seeds			
Without Soak	20.87	22.77	27.5	23.7133
Soak	21.04	22.52	27.31	23.6233
Mean	20.955	22.645	27.405	23.6683
LSD5%	--			

Table 5. Residual NPK contents in soil after plant harvest as affected by soaking seed and the time of phosphorus application season.

	Cont.	DPM	MSM	mean
	N, mg kg^{-1}			
Without Soak	97.52	124.83	137.67	120.00
Soak	93.99	111.70	136.46	114.05
Mean	95.76	118.27	137.05	117.02
LSD5%	6.80			
	P, mg kg^{-1}			
Without Soak	10.91	12.99	11.79	11.89
Soak	22.70	29.74	26.07	26.17
Mean	16.81	21.37	18.93	19.03
LSD5%	3.27			
	K, mg kg^{-1}			
Without Soak	351.50	474.69	424.89	417.03
Soak	308.59	444.62	373.94	375.72
Mean	330.05	459.66	399.42	396.375
LSD5%	5.86			

CONCLUSION

In conclusion, soaking seeds in P solution prior to cultivation seemed to be the most appropriate method for growing broad beans to attain greater growth of faba beans and improve its yield parameters only if the arable soils were amended with P prior to seed sowing. During imbibition, seeds absorb high quantities of water in short time periods, thus increased the free energy status which initiates biochemical reactions prior to germination (Dragicevic and Sredojevic, 2011). This process is associated with exothermic transformations to increase enthalpy (Shafaei *et al*., 2016). Probably, the increases in the free energy of plant seedlings requires high contents of balanced nutrients to be taken up from soils by the grown plants. Thus, growing soaked seeds in soils of low P content might therefore, decrease the growth of plants, as well as their nutrient contents and quality parameters. Accordingly, the soaked seeds should be grown in soils amended with P-fertilizers before sowing the seeds to attain better plant growth and yield.

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تأثير طرق الإضافة مع وبدون نقع بالأسمدة الفوسفاتية علي نبات الفول

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[١] قسم الأراضي- كلية الزراعة – جامعة المنصورة – مصر
[٢] شركة الدلتا للاسمدة والصناعات الكيماوية

تم إجراء التجربة في أصص بالمزرعة التجريبية لمركز تطوير الأسمدة وشركة الدلتا للأسمدة والصناعات الكيماوية في طلخا بمحافظة الدقهلية خلال موسم الشتاء ٢٠١٥-٢٠١٦ لتعزيز كفاءة استخدام الأسمدة الفوسفاتية بالطرق المختلفة . بالإضافة إلى ذلك، تم تحديد الطرق المثلى لتطبيق الأسمدة الفوسفاتيه للنمو والانتاج ومكونات المحصول وتوافر المغذيات للفول البلدي صنف جيزا ٧١٦. وقد أجريت التجربة في تصميم عشوائي كامل مع ثلاثة مكررات. و قد أظهرت النتائج أن أعلى قيم للنمو الخضري كانت ناتجة عن نقع بذور الفول البلدي في محلول مشبع من السوبر فوسفات الاحادي P) ٦.٣٤ %) بالمعدل الموصى به.