

RESPONSE OF FABA BEAN CULTIVARS TO RHIZOBIUM INOCULATION, PHOSPHOROUS FERTILIZATION LEVELS ON YIELD AND YIELD ATTRIBUTES

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ABSTRACT:

Two field trials were conducted at extension field on El-Nakaria Village, Zagazig district (Sharkia Governorate) during 2014/2015 and 2015/2016 to study the effect of Rhizobium treatment (treatment and untreated) to phosphorous fertilizer levels (0.0, 15.5, 31 and 46.5kg P₂O₅/Fad) on three cultivars (Misr-3, Sakha-1 and Nubaria-2).

The results showed that rhizobium treatment was superior to untreated in plant height (cm), number of branches/plant, number of pods/plant, number of seeds/pod, seed index (gm), seed weight plant (gm), seed yield (ton/fad), straw yield (ton/fad) and biological yield (ton/fad). All studied characters were differ significantly, except, number of seeds/pod and biological yield in the first season and seed yield (ton/fad) in the second season. Increasing phosphorous levels from 0.0, 15.5, 31 and 46.5 kg P₂O₅/fad. increased significantly the studied characters. In general, adding 46.5kg P₂O₅/fad. gave the highest values, followed by 31 and 15.5 kg P₂O₅/fad. While zero (without applied) was lower in this respect. Significant differences were found between three cultivars. Sakha-1 cv. was tallest in plant height (cm), and highest number of seeds/pod and straw yield (ton/fad). While, Nubaria-2 cv. was highest in number of pods/plant, seed weight plant (gm), seed yield (ton/fad) and biological yield ton/fad.. However, the three cultivars did not significantly affected in seed index (gm) in both seasons and combined.

The results indicated that seed yield ton/fad showed significant and highly significantly correlation with studied characters. i.e. plant height (cm), number of seeds/pod, number of pods/plant and germination index.

Conclusively, all characters studied R- treated surpassed that untreated when all four P- levels. Also, nubaria2 cv. gave the highest straw, seed and biological yields.

Key words: Faba bean cultivars, phosphorous, fertilization, yield and yield components, germination.

INTRODUCTION:

According to the FAO report, world population will reach to about 9.8 billion in 2050 (FAO, 2010). Population growth, food shortages and high food prices have caused the increase in the population of hungry people in the world. So to feed the world's growing population, it is necessary to increase food production (Alipour *et al.*, 2013). Faba bean (*Vicia Faba L.*) is an important feeding crop grown in winter season in Egypt. It's seed not only a cheap source of protein but also a food of high calorific and nutritive value especially in the diet of low income people. Egyptian Government is pressing hard to increase the yield and quality of faba bean plant through improving agricultural practices such as Rhizobium inoculation phosphorous fertilization and cultivars.

Many investigators had reported high variability on faba bean in yield and its attributes and quality (Khisravi and Ramezanpour, 2004; Alipour *et al.*, 2013; Abdallah, 2014; Dubova *et al.*, 2015, Hodua and Bouaziz 2016, Anteneh and Mnoelky 2017).

Phosphorous is major nutrient, especially for legumes. Many researchers showed positive effect of phosphorous fertilization on faba bean. Significant increases were achieved in faba bean yield and its attributes by increasing phosphorous fertilization rate up to 30kg P₂O₅/fad (Khalil *et al.*, 2004 and El-Saady *et al.*, 2011) or 31kg P₂O₅/fad; (Abbas *et al.*, 2012).

Many investigators recorded significant differences between faba bean cultivars in yield and its components. Maha and El-Wakil (2002) reported that the new cultivar Giza 714 produced highest plant height (cm), number of pods/plant, dry weight of plant, biological yield (ton/fad) and straw yield (ton/fad). Amer *et al.*, (2003) curtained the superiority of Sakha-1 faba bean cv. over Giza 461 one in seed yield. Talaat and Abdallah (2008) in Egypt, reported that Sakha-1 significantly surpassed Giza 40 in all previous tested parameters. Abbas *et al.*, (2012). recorded that Sakha-1 produced the highest seed yield compared with Nubria-1 and Giza 843.

Therefore, the aim of the present study was to study the effect of Rhizobium inoculation and phosphorous fertilizer applications on three cultivars of faba bean.

MATERIALS AND METHODS:

Two field experiments were conducted at extension field in El-Nakaria Village. Zagazig district (Sharkia Governorate) during the two successive seasons of 2014/2015 and 2015/2016 to study the effect of

Rhizobium inoculation and phosphorous fertilizer levels on three cultivars of faba bean.

The experiment included 24 treatments, which were the combinations of two Rhizobium treatments (treated and untreated), four levels of phosphorus (Zero, 15.5, 31.0 and 46.5kg P₂O₅/fad) applied as calcium superphosphate fertilizer (15.5% P₂O₅) in two equal doses 15 days after planting and before first irrigation on three cultivars faba bean (Misr3, Sakha-1 and Nubaria-2) during planting in the two growing seasons.

A split-split plot design with three replicates used with sub-sub plot area of 10.5m² having 6 ridges 3m in length 0.60m in width.

Faba bean seeds, previously inoculated before planting with the specific strains of Rhizobium leguminosarm, were sown on 15 November in the two successive seasons, respectively in hills, 20cm apart, two seeds were inserted in hills. The two Rhizobium treatment were assigned to main plots, the sub-plots included four levels of phosphorus fertilizer and sub-sub plots for the three cultivars (Misr-3, Sakha-1 and Nubaria-2).

At harvest on 27 and 18 April in first and second growing seasons, respectively, ten guarded plants were randomly taken to determine the following yield attributes: plant height (cm), number of branches/plant, number of pods/plant, number of seeds/pod, seed index (gm), seed weight plant (gm). In addition, the central two ridges of each plot were harvested to measure: seed yield (ton/fad.), straw yield ton/fad and biological yield (ton/fad.). Analysis of variance was performed according to SAS. (2008) system for windows. The interaction, capital letters were used to compare means in rows whereas, small ones were used to compare means in column of Duncan (1955). Further, the correlation coefficients among all possible combinations of characters were calculated using the method of Svab (1973).

RESULTS AND DISCUSSION:

1- Effect Rhizobium treatments:

The combined data in Table (1) show that Rhizobium treatment had the maximum values plant height, number of branches/plant and number of pods/ plant in both seasons and combined. It's recorded higher values of 100.50 (cm) 4.00 and 25.50, respectively in the combined.

The data presented in Table (2) indicate the varietal differences in the average number of seeds/pod, seed index (gm) and seed weight plant (gm). It is clear that Rhizobium treatment produced higher number of pod/plant,

Table (1): Plant height (cm), Number of branches/ plant and Number of pod/Plant of *Faba* bean as affected by Rhizobium inoculation, P-fertilization levels of *Faba* bean cultivars and their interactions in two seasons and their combined

Main effects and interactions:	Plant height (cm)			Number of branches/ plant			Number of pods / Plant		
	First season 2014/2015	Second season 2015/2016	Combined	First season 2014/2015	Second Season 2015/2016	Combined	First season 2014/2015	Second season 2015/2016	Combined
Rhizobium treatment: (R)									
Treated	100.00	101.00	100.50	4.00	5.00	4.50	27.00	24.00	25.50
Un treated	95.00	96.00	95.50	3.00	3.00	3.00	20.00	22.00	21.00
F. test	*	*	*	*	*	*	*	*	*
P-fertilizer levels (kg/fad): (P)									
Zero (check)	82.50c	83.40c	82.95c	2.00c	2.00c	2.00c	20.00c	20.00c	20.00c
15.5 Kg P ₂ O ₅ /Fad	98.85b	96.80b	97.82b	3.00b	3.10b	3.05a	22.00b	21.20b	21.60b
31. Kg P ₂ O ₅ /Fad	103.00b	104.70b	103.85b	3.10b	4.00b	3.55a	23.00b	22.50b	22.75b
46.5Kg P ₂ O ₅ /Fad	109.00a	108.00a	108.50a	4.00a	5.00a	4.50a	27.00a	27.90a	27.75a
F. test	*	*	*	*	*	*	*	*	*
Cultivars: (C)									
Misir-3	96.70b	95.10b	95.92b	4.00	5.00a	4.50	20.00	19.80c	19.95c
Sakha-1	99.10a	103.90a	101.50a	3.10	4.00b	3.55	23.00	23.50b	23.25b
Nubaria-2	95.95b	97.00b	96.47b	3.80	3.10b	3.05	27.00	26.00a	26.50a
F. test	*	*	*	NS	*	NS	NS	*	*
Interactions:									
R×P	**	*	NS	NS	NS	NS	NS	NS	NS
R×C	NS	NS	NS	NS	NS	NS	NS	NS	NS
P×C	NS	NS	NS	NS	**	NS	NS	NS	NS
R×P×C	NS	NS	NS	NS	NS	NS	NS	NS	NS

* Denotes significance at 5% probability level

** Denotes significance at 1% probability level

Table (2): Number of seed/pod, Seed index (gm) and Seed weight/plant (gm) of Faba bean as affected by Rhizobium inoculation, P-fertilization levels of Faba bean cultivars and their interactions in two seasons and their combined

Main effects and interactions:	Number of seeds/pod			Seed index (gm)			Seed weight plant (gm)		
	First season 2014/2015	Second season 2015/2016	Combined	First season 2014/2015	Second season 2015/2016	Combined	First season 2014/2015	Second season 2015/2016	Combined
Rhizobium treatment: (R)									
Treated	3.25	3.00	3.13	75.25	82.60	78.92	20.88	17.52	19.20
Un treated	3.19	2.11	2.65	71.11	78.00	74.55	17.27	13.16	15.21
F test	NS	*	*	*	*	*	*	*	*
P-fertilizer levels (kg/fad): (P)									
Zero (check)	2.01b	2.05b	2.03b	65.96c	67.70c	66.83c	16.72c	12.27c	14.50c
15.5 Kg P ₂ O ₅ /Fad	3.55a	2.08b	2.82b	69.61c	76.18b	72.89b	18.33b	14.33b	16.33b
31. Kg P ₂ O ₅ /Fad	3.62a	2.90b	3.26b	74.27b	87.60b	80.93b	19.66b	14.83b	17.25b
46.5Kg P ₂ O ₅ /Fad	3.73a	3.00a	3.37a	82.87a	89.80a	86.33a	21.61a	19.94a	20.78a
F. test	*	*	*	*	*	*	*	*	*
Cultivars: (C)									
Misir-3	2.91b	2.23	2.57	73.63	82.00	77.81	17.16b	14.91	16.04b
Sakha-1	3.59a	3.04	3.32	72.64	79.50	76.07	19.20b	15.00	17.10b
Nubania-2	3.25a	3.29	3.27	73.26	79.40	76.33	20.80a	16.12	18.46a
F. test	*	NS	NS	NS	NS	NS	*	NS	*
Interactions:									
R×P	*	NS	NS	**	**	NS	NS	**	NS
R×C	*	NS	NS	NS	NS	NS	NS	NS	NS
P×C	NS	NS	NS	NS	NS	NS	**	NS	NS
R×P×C	NS	NS	NS	NS	NS	NS	NS	NS	NS

* Denotes significance at 5% probability level

** Denotes significance at 1% probability level

heavier seed index (gm) and seed weight/plant (gm) during both seasons and their combined compared with plant untreated with respect by Rhizobium. While no significant differences was observed during the first season of respect number of seeds/pod.

Data recorded in Table (3) show that over the two seasons, there were highly significant and significant differences between Rhizobium treatment in seed yield (ton/fad), straw yield (ton/fad.) and biological yield ton/fad. in the combined. These results are in agreement with those reported by Hessian (2000); Khisavi and Ramezanpour (2004); Alipour *et al.*, (2013) and Abdallah (2014).

2- Effect of phosphorous fertilization:

Two seasons and combined analysis data presented in Tables (1, 2 and 3) show that increasing level of phosphorous fertilization levels from zero to 46.5kg P₂O₅/fad. had positive and significant effects on all studied yield determinations.

Increasing P-levels from zero to 46.5kg P₂O₅/fad. gradually increased seed yield (ton/fad.) and such increments reached around 7.45, 15.74 and 22.92% when P-level increased from 0.0 to 15.5, 31.0 to 46.5kg P₂O₅/fad/ respectively. Such results indicated the important rule of phosphorous in improving the productivity of faba bean crop.

Likewise, increasing P-levels increased straw and biological yields (ton/fad.) by 27.92 and 22.92% when P-level increased from 0.0 to 46.5 kg P₂O₅/fad. for straw and biological yields (ton/fad.) as in the combined data. These results are agreement with those reported by Maha and El-Wakil (2002); Abdalla (2002); Nawar and Mousa (2002); Khalil *et al.*, (2004); Abd-Elaziz, El-Set (2005); Attia (2009); Ibrahim (2009); El-Saady *et al.*, (2011); Abbas, *et al.*, (2012) and Abou-Amer *et al.*, (2014), who's found that faba bean seed yield and it's attributes were significantly increased with increasing the rate of phosphorous fertilization. In this connection, Halimak and Barber (1984) reported that adding P-fertilizer significantly increased root surface area and this was important in supplying the nutrient need by plants. It is well established also that phosphorous is an essential and principal element in energy compounds.

3- Cultivar Variation:

The combined data in Tables (1, 2 and 3) show that Sakha-1 cv. had the maximum values of taller plants height, number of seeds/pods and straw yield "ton/fad". Sakha-1 recorded higher values of plant height 101.50(cm), number of seeds/pods 3.32 and straw yield (ton/fad.) 1.392 in combined, respectively.

Table (3): Seed yield (ton) /fad, Straw yield (ton) /fad and Biological yield ton /fad. of Faba bean as affected by Rhizobium inoculation, P-fertilization levels of Faba bean cultivars and their interactions in two seasons and their combined.

Main effects and interactions:	Seed yield(ton)/ fad			Straw yield (ton)/ fad			Biological yield(ton)/ fad		
	First season 2014/2015	Second season 2015/2016	Combined	First season 2014/2015	Second season 2015/2016	Combined	First season 2014/2015	Second season 2015/2016	Combined
Rhizobium treatment: (R)									
Treated	1.523	1.391	1.457	1.854	1.567	1.711	3.377	2.958a	3.167a
Un treated	1.235	1.334	1.285	1.132	1.369	1.251	2.367	2.703b	2.535b
F. test	*	NS	**	**	**	*	NS	*	*
P-fertilizer levels (kg/fad):(P)									
Zero (check)	1.142b	1.271	1.207b	1.227b	1.200c	1.214c	2.369c	2.471c	2.421c
15.5 Kg P ₂ O ₅ /Fad	1.309b	1.286	1.298b	1.295b	1.390b	1.343b	2.604b	2.676b	2.641b
31. Kg P ₂ O ₅ /Fad	1.441a	1.353	1.397a	1.495a	1.499a	1.497a	2.936a	2.852a	2.894a
46.5Kg P ₂ O ₅ /Fad	1.469a	1.377	1.423a	1.566a	1.539a	1.553a	3.035a	2.916a	2.976a
F. test	*	NS	*	*	*	*	*	*	*
Cultivars: (C)									
Misir-3	1.376	1.220c	1.298b	0.971c	1.524a	1.248c	2.347b	2.744	2.545
Sakha-1	1.376	1.350b	1.363b	1.358b	1.426b	1.392b	2.734a	2.776	2.755
Nubiana-2	1.384	1.387a	1.385a	1.962a	1.425b	1.694a	3.346b	2.812	3.079
F. test	NS	*	*	*	*	*	*	NS	NS
Interactions:									
R×P	**	**	NS	**	**	NS	**	**	NS
R×C	NS	NS	NS	NS	NS	NS	*	**	NS
P×C	NS	**	NS	NS	*	NS	NS	**	NS
R×P×C	NS	NS	NS	NS	NS	NS	NS	NS	NS

* Denotes significance at 5% probability level

** Denotes significance at 1% probability level

The data presented in Tables (1, 2 and 3) show that Nubaria-2 cv. had higher number of pods/plant, seed weight/plant (gm), seed yield (ton/fad.) and biological yield (ton/fad.). Nubaria-2 recorded higher and heavier plants during both seasons and their combined compared with Misr-3 and Sakha-1. The three cultivars did not significantly differ in seed index (gm) during both seasons and the combined. These results are in agreement with those reported by Metwally *et al.*, (2000); Saad and El-Kholoy (2000); Awaad (2002); Maha and El-Wakil (2002); Abd El-Hakim (2003); El-Galfy (2005); Talaat and Abdallah (2008); El-Sayed (2010) and Abbas *et al.*, (2012).

4- Effect of Interaction

a) Rhizobium X P-levels:

Interaction effects of Rhizobium treat X P-levels on some yield attributes and yields in the second season are shown in Table 4. Plant height (cm), seed

Table (4): Effect of Rhizobium inoculation X Phosphour levels interaction on some yield attributes and biological yield in second season.

P-levels kg P ₂ O ₅ /fad Rhizobium treatment	Zero	15.5 kg P ₂ O ₅ /fad	31 kg P ₂ O ₅ /fad	46.5 kg P ₂ O ₅ /fad
	Plant height (cm)			
Treated	D 83.99	C 85.55	B 93.22	A 103.00
Un Treated	D 80.92	C 82.55	B 89.88	A 99.77
Seed index (gm)				
Treated	C 72.00	B 75.39	BC 73.00	A 80.43
Un Treated	B 71.50	A 73.97	A 74.99	A 75.77
Seed weight/plant (gm)				
Treated	D 12.50	C 14.20	B 15.60	A 17.50
Un Treated	C 11.00	B 12.90	AB 12.99	A 13.10
Seed yield (ton/fad)				
Treated	B 1.350	B 1.353	A 1.387	A 1.385
Un Treated	B 1.280	B 1.286	B 1.235	A 1.343
Straw yield (ton/fad)				
Treated	C 0.962	B 1.190	A 1.359	A 1.439
Un Treated	C 0.934	C 1.027	B 1.132	A 1.360
Biological Yield (ton/fad)				
Treated	C 2.232	B 2.338	B 2.346	A 2.817
Un Treated	B 2.205	A 2.817	B 2.322	A 2.657

index, seed weight/plant (gm), seed yield (ton/fad.) straw yield (ton/fad.) and biological yield (ton/fad.) responded to the highest from zero of P-fertilizer (46.5kgP₂O₅/fad.) where as untreated plants showed gradually response to 46.5kgP₂O₅/fad. On the other hand of all characters studied of R-treatment surpassed that un-treatment with all four P-levels.

b) P-levels X Cultivars:

Interaction effects of P-levels X Cultivars on seed, straw and biological yields (ton/fad.) were significant and shown in Table (5). All characters responded significantly to the highest P-level 46.5kg P₂O₅/fed. irrespective to cultivars Sakha-1 which surpassed the two cultivars Misr-3 and Nubaria-2 in seed, straw and bidogical yields "ton/fad." 1.469, 1.540 and 2.817 (ton/fad.), respectively.

Table (5): Effect of phosphorours levels X Cultivars interactions on seed, straw and biological yields (ton/fad.) in the second season.

P-levels Cultivars	Zero	15.5 kg P ₂ O ₅ /fad	31 kg P ₂ O ₅ /fad	46.5 kg P ₂ O ₅ / fad
	Seed yield ton/fad			
Misr-3	D 1.240a	B 1.309	A 1.441a	C 1.286b
Sakha-1	C 1.271a	B 1.377a	B 1.353b	A 1.469a
Nubaria-2	C 1.209a	B 1.343a	B 1.343a	B 1.377a
Straw Yield (ton/fad)				
Misr-3	B 0.961b	B 1.132b	A 1.359b	A 1.466a
Sakha-1	B 1.356a	C 1.027c	B 1.358b	A 1.540a
Nubaria-2	C 0.962b	B 1.360a	A 1.439a	A 1.426a
Biological Yield (ton/fad)				
Misr-3	A 2.80a	C 2.462a	B 2.653a	A 2.755a
Sakha-1	C 2.235b	C 2.337b	B 2.699a	A 2.817a
Nubaria-2	D 2.262b	C 2.460a	B 2.579a	A 2.726a

Correlation coefficients:

The interrelationship among seed yield and its attributes of faba bean as simple correlation are shown in Table 6.

Table (6): Correlation coefficients seed yield and its attributes calculated from combined analysis.

1-Characters	2	3	4	5	6	7	8	9	10	11	12
1-Seed yield/ to fid	.851**	.795*	.560	.716*	.909**	.780*	.591	.678*	.847**	.721*	.691*
2-straw yield/ ton/fad	1	.711*	.648	.621	.786*	.782*	.520	.622	.816**	.728*	.598
3-Plant height (cm)		1	.751*	.770*	.727*	.808**	.810**	.923**	.949**	.915**	.924**
4-Number of branches/plant			1	.718*	.452	.932**	.702*	.705*	.780*	.664	.800*
5-Number of seeds /pod				1	.755*	.830**	.683*	.808**	.783*	.732*	.856**
6-Number of pods /plant					1	.722*	.576	.707*	.793*	.771*	.692*
7-Seed Index (gm)						1	.687*	.748*	.887**	.729*	.835**
8-Germination (%)							1	.924**	.661	.891**	.916**
9-Good seedling (%)								1	.833**	.962**	.977**
10-Germination index									1	.841**	.855**
11-Seedling dry weight (mg)										1	.910**
12-Protein %											1

* Denotes significance at 5% probability level

** Denotes significance at 1% probability level

Seed yield was positively and highly significant correlated with all characters studied i.e. straw yields ($r=0.851^{**}$), plant height ($r=0.795^*$), number of seeds/pod ($r=0.716^*$), number of pods/plant ($r=0.909^{**}$), germination% ($r = 0.591$), good seedling % ($r = 0.679^*$), germination index ($r = 0.847^{**}$), seedling dry weight (mg) ($r = 0.721^*$) and protein% ($r = 0.691^*$).

These results are in accordance with those reported by Maha and El-Wakil (2002); Fatma and Mehasen (2006) and Alipour *et al.*, (2013).

Conclusively, all characters studied R- treated surpassed that untreated when all four P- levels. Also, nubaria2 cv. gave the highest straw, seed and biological yields.

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استجابة بعض أصناف الفول البلدي للريزوبيوم والتسميد الفوسفاتي علي المحصول ومكوناته

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أقيمت تجربتان حقليتان في حقل إرشادي بقرية النكارية مركز الزقازيق - محافظة الشرقية خلال موسمي ٢٠١٤/٢٠١٥ و ٢٠١٥/٢٠١٦ لدراسة معاملتي العقدين (معامل وبدون معاملة) لأربع مستويات من التسميد الفوسفاتي (صفر، ١٥,٥ ، ٣١ ، ٤٦,٥ كجم فوسفات/هـ) وثلاث أصناف من الفول البلدي (مصر ٣ ونوبارية ٢ وسخا ١).

أظهرت النتائج تفوق المعاملة بالريزوبيوم علي عدم المعاملة في طول النبات (سم) وعدد الفروع/نبات وعدد القرون / نبات وعدد البذور/القرن ودليل البذرة (جم) ووزن بذور النبات (جم) ومحصول البذرة والقش والبيولوجي (طن/ف).

وقد وجدت اختلافات معنوية بين كل الصفات تحت الدراسة ما عدا، عدد البذور/القرن والمحصول البيولوجي (طن/ف) في الموسم الأول ومحصول البذرة (طن/ف) في الموسم الأول. كذلك أدت زيادة مستوى التسميد الفوسفاتي حتى معدل ٤٦,٥ كجم فوسفات/هـ لزيادة كل الصفات تحت الدراسة. حيث أعطى معدل ٤٦,٥ فوسفات/هـ أعلى القيم وتبعه معدل ٣١ ثم ١٥,٥ ثم صفر حيث أعطت الأخيرة أقل القيم لكل الصفات تحت الدراسة.

كما أظهرت النتائج اختلافات معنوية بين الأصناف الثلاثة والصنف سخا ١ أعطى أطول ارتفاع للنبات (سم) وأعلى عدد بذور/القرن ومحصول القش (طن/ف). في حين الصنف نوبارية ٢ كان الأعلى في عدد القرون/نبات ووزن البذور/النبات (جم) ومحصول البذور (طن/ف) والمحصول البيولوجي (طن/ف). بينما الأصناف الثلاثة لم تصل لمستوى المعنوية في دليل البذرة (جم) لموسمي الزراعة.

أيضاً أظهرت النتائج أن محصول البذرة أظهر ارتباط موجب معنوي وعالي المعنوية لأغلب الصفات تحت الدراسة، ومنها طول النبات (سم) وعدد بذور القرن وعدد قرون النبات ودليل الإنبات.

التوصية: أظهرت النتائج تفوق المعاملة بالعقدين على الغير مع معدلات التسميد الفوسفاتي الأربعة. كما انه اعطى الصنف نوبارية ٢ اعلى محصول حش وبذور وبيولوجي (طن / ف).