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EFFECT OF ORGANIC MANURES AND PHOSPHORUS FERTILIZER ON FABA BEAN PLANT AND SOME PHYSICAL PROPERTIES OF SANDY AND ALLUVIAL CLAY SOILS

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ABSTRACT

Two field experiments were carried out during the two winter growing seasons of 2006/2007 and 2007/2008 at the South Tahrir. Agric. Res. Station, (ARC), Ali Moubark village, El-Bustan Region, El-Behira Governorate (Sandy soil) and Abo El-Ghar village, Kafer El-Zayat District, Gharbia Governorate (alluvial clay soil) to study the effect of organic manures (farmyard manure and chicken manure) applied at a rate of 30 m^3/fed and phosphorus fertilizer at rates of 0, 15 and 30 kg P_2O_5/fed on faba bean crop and some physical properties of the soils under investigation.

The obtained results could be summarized as follows:

- All faba bean characteristics (number of seeds/plant, seeds weight/plant and 100-seeds weight), seeds and straw yields and mineral compositions of seed and straw were significantly increased due to the application of organic manures compared to the control. Application of chicken manure induced the superior treatment.
- Raising the phosphorus application rates gradually increased the quantity and quality of faba bean yield.
- Application of chicken manure combined with the high rate of P-fertilizer produced the highest faba bean yield.
- Alluvial clay soil was the best soil for cultivating faba bean and to achieve the highest yield compared to sandy soil.
- Application of organic manures improved the physical soil properties (bulk density, total porosity and hydraulic conductivity), reduced the bulk density values and increased the total porosity % in both sandy and alluvial clay soils. For hydraulic conductivity, the values were increased with the application of organic fertilizers compared to the control in alluvial clay soil. On the contrary, the hydraulic conductivity values were decreased due to the use of fertilizers compared to the control in sandy soil. Application of the chicken manure gave the best results.
- Finally, it could be concluded that the application of chicken manure at a rate of 30 m^3/fed combined with 30 kg P_2O_5/fed in both tested sandy and alluvial clay soils gave the best quantity and quality of faba bean crop and improved physical soil properties.

Keywords: Organic manures, P-fertilizers, faba bean, Physical soil properties.

INTRODUCTION

In Egypt, Faba bean (*Vicia faba* L.) is widely grown as a source of cheap available protein seed for human and animal feeding. In addition, it increases soil fertility by bacterial nodules. Now, the area cultivated by this crop increased in the Nile Delta and the newly reclaimed soils (sandy and calcareous soils), which are considered as a main aim for future expansion and attention should be taken with respect to their nutritional status and the suitable management of the proper fertilization.

Organic matter application to soils is known to improve soil properties and consequently the plant growth. Among the types of organic matter, (farmyard manure and chicken manure) are natural amendments, which correct and improve both physical and chemical properties of the soils, especially the heavy texture one. Several investigators indicated that the addition of 30 m^3 FYM/fed reduced the bulk density and increased the hydraulic conductivity and total porosity in clay soil (El-Maddah, 2000, Hanna and El-Awag, 2000 and El-Naggar *et al.,* 2002). Organic fertilizer is considered as an important source of humus, macro and micro elements carrier and at the same time increases the activity of the useful microorgamisms (El-Gizy, 1994). Dahdouh *et al*. (1999) found that organic manures play an important role in nutrients solubility as activate physiological and biochemical processes in plant leading to an increase for the plant growth and nutrients uptake. The best means of maintaining soil fertility and productivity level could be achieved through periodic addition of proper organic materials in combination with inorganic fertilizer (Sakr *et al.,* 1992).

Phosphatic fertilization is important for different crops. This in fact is due to the fundamental role of P in a large numbers of enzymatic reactions depending on phosphorylation and in the synthesis of various organic compounds in the plant (Nassar *et al.*, 2001). Moreover, P has an enhancing impact on plant growth and the resultant crop through its importance as energy storage and transfer necessary for the metabolic processes (Nassar *et al.,* 2005 and El-Shouny *et al.,* 2008).

The present study is carried out to investigate the effect of organic fertilizer and phosphorus fertilizer on faba bean yield and some physical properties of sandy and alluvial clay soils under investigation.

MATERIALS AND METHODS

Two field experiments were conducted during the two winter growing seasons of 2006/2007 and 2007/2008 at the south Tahrir Agric. Res. Station Agric. Res. Center (ARC). Ali Moubark Village. El-Bustan Region, El-Behara Governorate (Sandy soil) and Abo El-Ghar Village, Kafer El-Zayat District, Gharbia Governorate (alluvial clay soil). Chemical and physical analyses of the experimental soils were determined and presented in Tables (1a & b) as described by Black (1965). The chemical properties of the applied organic manures (Chapman and Pratt, 1978) are presented in Table (1c). The organic manures (Farmyard manure and chicken manure) and P-fertilizers were basically mixed with the surface soil layer (0-30 cm depth). The layout of the experiment was split plot design with three replicates. Each replicate was divided into two main plots, which were treated with farmyard manure in the first plot and chicken manure in the second plot at a rate of 30 m^3/fed each. Each plot was randomly subdivided into three sub plots, which were treated with phosphorus fertilizer as mono calcium phosphate (15.5 % P_2O_5) at rates of 0, 15 and 30 kg P_2O_5 /fed. The sub plots area was 10.5 m^2 with 5 rows, each of 3.5 m long and 0.6 m apart. Basic application of N and K fertilizers were applied to all plots in forms of ammonium sulphate 20.5% at a a rate of 30 kg N/fed and potassium sulphate (48% k_2O) at a rate of 100 kg/fed. The other usual cultural processes of faba bean plants were practiced as recommended by the Ministry of Agriculture and Land Reclamation.

Faba bean seeds Giza (2) cultivar were sown at a rate of 80 kg/fed on 10th and 15th November for the 1st and 2nd seasons, respectively. At maturity, ten plants were randomly collected from each plot to determine yield attributes. Both seed and straw yields/fed were estimated. Samples of seeds and straw were taken and their contents of N, P and K were determined according to Chapman and Pratt (1978) and converted into kg/fed. Data obtained were statistically analyzed according to Gomez and Gomez (1984). Means of different treatments were compared by L.S.D. at 5% level.Soil samples were collected from the surface layer of each plot (0-30 cm) to determine soil physical analysis according to Hesse (1971), Lovenday (1974) and Black and Hartage (1986). Total porosity (TP) was calculated from the equation TP= I-BD/PD.

Where particle density PD = 2.67 g/cm^3 and BD = Bulck density.

Table (1-a): Some physical properties of the experimental soils

Soil type	Partial size distribution, (%)			Soil texture class	O.M. (%)	Total porosity (%)	Bulk density (g/cm^3)	Hydraulic conductivity (Cm/hr)
	Sand	Silt	Clay					
Alluvail	15.75	32.60	51.65	Clayey	2.65	52.60	1.25	0.65
Sandy	90.05	6.28	3.67	Sandy	0.18	38.9	1.63	11.51

Table (1-b): Some chemical properties of the experimental soils

Soil type	Soluble cations (meq/L)				Soluble ions (meq/L)*				Ec* dSm^{-1}	PH 1,2.5 susp.	C.E.C (meq/ 100 g)	Available NPK (ppm)		
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO^{-}_{3}	HCO^{-}_{3}	Cl^{-}	$SO^{=}_{4}$				N	P	K
Alluvail	15.10	10.35	5.30	1.15	-	1.22	16.90	13.78	2.65	7.95	60.15	35.60	11.20	350
Sandy	2.75	1.42	4.15	0.29	-	1.1	4.84	2.67	0.68	7.60	7.15	11.50	2.35	80

*** In soil past extract**

Table (1-c): Characteristics of different used organic manure

Properties	Farmyard manure	Chicken manure	Properties	Farmyard manure	Chicken manure
PH (1: 10) organic manure: water	7.15	8.10	Available Ca%	0.12	0.05
EC dSm^{-1} (1:10) organic manure: water	1.35	2.15	Available Mg%	0.17	0.12
$CaCO_3$ %	1.30	4.95	Available Fe (ppm)	42.10	90.50
O.M. % O.C. %	8.53 4.95	34.11 19.78	Available Mn (ppm)	78.60	97.30
Total N % C/N Ratio	0.68 1 : 7	1.55 1 : 13	Available Cu (ppm)	7.35	13.40
Available P %	0.12	0.15	Available Zn (ppm)	25.50	77.30
Available K%	0.85	1.85			

RESULTS AND DISCUSSION

I. Faba bean yield and its components :

Data in Table (2) show the effect of organic manures (FYM or chicken manure) and phosphorus fertilizer rates, their interaction on yields (seeds and straw) as well as yield components of faba bean crop under sandy and alluvial soils. All studied characteristics, seed and straw yields and number of seeds/plant, seed weight/plant and 100-seeds weight were significantly increased by the application of organic manures. However, the application of chicken manure induced the superior treatment for increasing faba bean yields, yield components compared to untreated soil treatments in both sandy and alluvial soils. Similar results were obtained by El-Nagar *et al.* (2002) and El-Shafie and El-Shikhah (2003). Raising the phosphorus application rate gradually increased the quantity and quality of faba bean yield.

The positive impact of organic manures on faba bean production is mainly due to improving the soil physical and chemical properties, preparing the suitable bed for germination and development of plant growth that reflect on the net yield. Moreover, organic manure is considered as an important source of humus, macro and microelements carrier, and on the same time, increases the activity of the useful microorganisms. Similar results were gained by Nassar *et al.* (2004), Ali *et al.* (2005) and El-Shouny *et al.* (2008). The role of phosphorus for increasing the faba bean yield and its components, this could be attributed to a fundamental role of P in raising the efficiency of plants to photosynthetic metabolic (Marschner, 1998), activating large numbers of enzymatic reactions depending on phosphorylation (Nassar *et al.,* 2005) and increasing the plant meristematic tissues, which absorb much of P in the early stages. As a result, root development as well as macro-and micronutrients uptake by the plant increased yield quantity and quality (Nassar *et al.*, 2001 and Nassar *et al.*, 2005).

Considering the intraction effect between organic fertilization and phosphorus rates, data in Table (2) revealed that the highest value was due the use of 30 kg P_2O_5/fed combined with chicken manure especially with alluvial soil in both tested seasons. Data also, showed that alluvial clay soil was the best soil for cultivating faba bean plants and to achieve the highest yield compared to sandy soil.

N, P and K contents in faba bean seed and straw:

Data inTable (3) show the effect of the applied organic fertilizers and phosphorus fertilizer rates on NPK contents of faba bean seeds and straw. Data revealed that NPK contents of both seeds and straw were increased along with the application of organic fertilization. Application of chicken manure gave the best values of NPK contents compared to FYM application due to both alluvial and sandy soils. Seeds and straw contents of NPK were increased by raising phosphorus rates from 0 to 30 kg P_2O_5/fed in both tested soils. However, alluvial soil was the best soil for cultivating faba bean and to achieve the highest yield compared to sandy soil.

T2

T3

Similar results were obtained by Behiry (2005) and El-Shikhah and Gaafar (2006). Further perusal of the studied characters, the productivity potential varied at different sites according to the prevailing agroclimatic conditions, the level of soil fertility and the physico-chemical characters of the soil. The order of all studied characters increases was as the following: alluvial soil > sandy soil. Two reasons can be presented to explain this result. The first reason is physical, where water movement in sandy soils is accelerated by the open structure of the soil, and thus water with dissolved fertilizers moves readily from the surface downward. The second reason is chemical, where clayey soils with their extensive surface area offer many sites and pathways for soil chemical reaction with the added fertilizers (Behiry, 1991).

Effect on some soil physical properties:

1. Soil bulk density and total porosity:

Bulk density depends on soil structure and it is an indicator of soil compaction, aeration and development case of roots, especially, in soils with high clay contents. Data of bulk density value (Bd) and total porosity (P) percentage under the organic fertilizers application are presented in Table (4). Results indicated that the application of organic fertilizers led to a reduction in bulk density, while the total porosity percentages were increased. The relatively high value obtained of bulk density was due to untreated soil. The best improved effect was subjected to chicken manure application. This decrease in bulk density may be attributed to the high content of organic matter in chicken manure (Table 1c), which refers to the formation of soil aggregates.

Similar results were obtained by Abdel-Aziz *et al.* (1998), El-Naggar *et al.* (2002) and Celik *et al.* (2004). Concerning total porosity as affected by organic fertilizers in both sandy and alluvial soils, obtained results cleared vice versa with bulk density. These results are in harmony with those recorded by Paul and Clark (1996), Nyakatawa *et al.* (2001) who attributed the lower bulk density value to higher organic matter content. Furthermore, Marinari *et al.* (2000) reported that total soil porosity percentages increased with organic fertilizer and compost depending on the amount of the organic materials applied.

Concerning the effect of phosphorus fertilization rates on bulk density and total porosity, data in Table (4) showed that bulk density tend to decrease as phosphorus rates in the soil increase. Total porosity took the opposite trend. The lowest values of bulk density and the highest parentages of total porosity were due to alluvial soil at 30 kg P_2O_5/fed. With regard to the interaction between the effect of organic manures and P-fertilizer rates on bulk density and total porosity, data in Table (4) showed that addition of chicken manure with 30 kg P_2O_5/fed was the superior treatment that influenced the bulk density and total porosity in the soils under study.

2. Hydraulic conductivity:

(a) For alluvial soil:

Results in Table (4) indicated that the hydraulic conductivity in alluvial soil had increased with the application of organic fertilizers compared to the control (untreated soil). This may be due to the possible stimulating effect on formation of soil aggregates. Generally the effect of chicken manure was better than FYM. The positive effect of the organic fertilizer application on hydraulic conductivity may be related to higher values of total soil porosity. These results are in agreement with those obtained by El-Maddah (2000), El-Naggar *et al.* (2002) and Othman *et al.* (2005).

Table (4): Effect of organic manures and phosphorus fertilizer on some physical properties of sandy and alluvial soils

Organic fertilizer (m^3/fed)	Phosphorus fertilizer P_2O_5 (kg/fed)	Alluvial soil			Sandy		
		Bulk density (g/cm^3)	Total porosity (%)	Hydraulic conductivity (cm/hr)	Bulk density (g/cm^3)	Total porosity (%)	Hydraulic conductivity (cm/hr)
Untreated soil		1.25	53.2	0.65	1.63	38.9	11.51
Farmyard manure	0	1.20	55.05	0.75	1.58	40.80	9.35
	15	1.18	55.80	0.91	1.55	41.90	9.32
	30	1.16	56.50	0.97	1.52	43.07	9.28
Mean		1.18	55.45	0.88	1.55	41.90	9.32
Chicken manure	0	1.19	55.40	0.75	1.55	41.90	8.55
	15	1.16	56.50	0.95	1.51	43.40	8.35
	30	1.13	57.70	0.98	1.48	44.50	8.25
Mean		1.16	56.5	0.89	1.54	42.30	8.38

(b) For sandy soil:

The results in Table (4) indicated that application of organic fertilizers at 30 m^3/fed and increasing the rate of P-fertilizers from 0 to 30 m^3 P_2O_5/fed caused a considerable decrease in hydraulic conductivity in soil. This reduction could be attributed to the migration of the fine particles of organic fertilizers causing the clogging of macropores or a reduction in the pore size. Also, results revealed that the reduction was decreased with increasing P-fertilizer. These results may be explained by that organic manure, which led to elevate the soil water holding capacity and consequently increased the soil matrix potential as a result of increasing soil surface area (Hillel, 1982). The interaction effect between organic fertilizer and P-fertilizer gave a positive significant effect on hydraulic conductivity. Similar results were obtained by El-Nagar *et al.* (2002) and El-Eweddy (2005).

Conclusion:

The beneficial effect of studied organic fertilizers on physical properties and faba bean yield may be explained as the following:

1-The application of the studied organic fertilizer (FYM and chicken manure) caused an obvious reduction in the bulk density values of the cultivated soils due to several alteration in other related physical properties. The enhancement in the physical properties for organic fertilizers application was expected due to the well known effect of organic matter in coating, cementing and acting active bridges among soil particles (Salem, 2003 and El-Shouny, 2006).

2- The positive impact of the organic manures on faba bean yield, yield components and mineral composition are mainly due to improving the soil physical, chemical and biological properties and preparing suitable bed for germination and development of plant growth that is reflected on the net yield. Moreover, the superiority effect of chicken manure may be due to high content of organic matter in chicken manure compared to farmyard manure.

3- Application of organic manures combined with P-fertilizer tended to produce the highest yield of faba bean.

4- The promoting impact of phosphorus on faba bean yield, yield components and mineral composition may be due to the following:

a- The fundamental role of phosphorus found in all important nucleoproteins and in a large number of enzymatic reactions, which depends on phosphorylation (Nassar and Ismail, 1999).

b- P stimulates the activity of rhizobia and positively affects on nodules weight. As a results, N_2 fixation increases. This in turn is reflected on plant metabolism and synthesis of various organic compounds (Nassar *et al.,* 2004).

c- P acts as energy storage and transfer (Osman *et al.,* 2000).

Finally, it could be concluded that the application of chicken manure at a rate of 30 m^3/fed combined with 30 kg P_2O_5/fed in both alluvial and sandy soils under investigation gave the best quantity and quality of faba bean yield and improving physical properties.

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تأثير إضافة الأسمدة العضوية و الفوسفور على نبات الفول البلدي وبعض الخواص الطبيعية لكل من الأراضي الرملية و الرسوبية الطينية

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أجريت تجربتين حقليتين خلال موسمي النمو الشتويين ٢٠٠٦/٢٠٠٧ ، ٢٠٠٧/٢٠٠٨ الأولى بمحطة بحوث جنوب التحرير (قرية على مبارك – منطقة البستان – محافظة البحيرة) ممثلة للأراضي الرملية والثانية بقرية أبو الغر – مركز كفر الزيات – محافظة الغربية ممثلة للأراضي الطينية وذلك لدراسة تأثير كل من السماد العضوي (سماد المزرعة – سماد الدواجن) بمعدل ٣٠م٣ – فدان والسماد المعدني (سماد السوبر فوسفات الأحادي ١٥,٥ فو٢أ٥) بمعدلات صفر ، ١٥ و٣٠ كجم فو٢أ٥/فدان) والتفاعل بينهما على محصول الفول البلدي صنف جيزة ٢ وبعض الخواص الطبيعة للأراضي تحت الدراسة .

ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلي :

- أدت إضافة الأسمدة العضوية لنباتات الفول البلدي إلى زيادة معنوية لمحصول البذور ومعظم الصفات المحصولية المدروسة فى كل من موسمي النمو مقارنة بمعاملة الكنترول وقد أظهرت النتائج تفوق سماد الدواجن على سماد المزرعة في تأثيره على تلك الصفات .
- أدت إضافة السماد الفوسفاتي إلى زيادة معنوية في جميع الصفات المدروسة وكذلك المحتوي العنصري للبذور من N, P, K وكانت الزيادة تدريجية مع زيادة معدلات الإضافة.
- إضافة المستوى الأعلى من الفوسفور مع سماد الدواجن متحدة معا أعطت أفضل النتائج المتحصل عليها وتفوقت الأرض الطينية على الأرض الرملية في زراعة الفول البلدي والحصول على أعلى محصول .
- أدت إضافة الأسمدة العضوية إلى تحسين خواص التربة الطبيعية حيث انخفضت قيم الكثافة الظاهرية وزادت قيم المسامية الكلية للتربة أما بالنسبة للتوصيل الهيدروليكى فقد زادت قيمته في التربة الطينية وانخفضت قيمته في التربة الرملية مقارنة بالكنترول وكانت أفضل النتائج المتحصل عليها عن استخدام سماد الدواجن وخاصة في التربة الطينية ومن ثم يمكن القول بأنه عند استخدام سماد الدواجن بمعدل ٣٠م٣/فدان مع ٣٠ كجم فو٢أ٥ /فدان لكل من التربة الطينية أو الرملية تحت الدراسة يضمن الحصول على أعلى إنتاجية لمحصول الفول البلدي وكذلك تحسين خواص التربة الطبيعية .

Table (2): Effect of organic manures and phosphorus fertilization on yield and yield components of faba bean plants under different soils

Organic fertilizer (m^3/ fed)	phosphorus fertilizer dose, kg P_2O_5 /fed	Seed yield components									Yields					
		No. of seeds/ plant			Seed weight (g) plant			100-seed weight (g)			Seed (ardab*/ fed)			Straw (ton/fed)		
		Season		Mean	Season		Mean	Season		Mean	Season		Mean	Season		Mean
		1	2		1	2		1	2		1	2		1	2	
Alluvial soil																
Untreated soil		47.32	48.71	48.01	31.35	30.48	30.91	66.14	65.31	66.12	4.62	4.83	4.72	1.40	1.42	1.41
Farmyard manure	0	56.2	54.0	55.1	36.2	34.6	35.4	78.8	80.6	79.7	6.30	6.80	6.55	1.50	1.78	1.64
	15	62.4	64.6	65.5	48.2	50.6	49.4	85.8	88.6	87.2	7.80	8.50	8.15	1.80	1.78	1.79
	30	65.6	66.2	65.5	52.5	58.3	55.4	92.5	95.5	94.0	8.80	9.30	9.05	1.92	1.96	1.94
Mean		60.7	61.6	61.5	45.6	47.8	46.7	85.7	88.2	87.0	7.60	8.20	7.91	1.74	1.84	1.74
Chicken manure	0	55.5	56.3	55.9	38.6	34.2	36.4	75.5	78.5	77.0	6.50	6.32	6.41	1.52	1.66	1.59
	15	68.6	68.8	68.7	51.6	56.6	54.1	88.2	90.6	89.4	8.30	8.68	8.48	1.86	1.90	1.88
	30	70.4	72.2	7103	55.2	58.2	56.7	90.6	98.6	94.6	9.20	9.40	9.30	1.94	1.98	1.96
Mean		64.8	65.8	65.3	50.5	49.7	49.1	84.8	89.2	87.0	8.03	8.13	8.06	1.77	1.85	1.84
L.S.D 5%	Organic F*	2.35	2.40	2.37	1.80	1.82	1.81	5.50	5.80	5.65	0.55	0.60	0.57	0.40	0.44	0.42
	P-F	2.42	2.43	4.42	1.86	1.92	1.89	6.40	6.50	6.45	0.72	0.70	0.71	0.35	0.30	0.32
	Interaction	3.15	3.20	3.11	2.15	2.10	2.17	8.50	7.50	8.00	0.70	0.82	0.76	0.62	0.60	0.61
Sandy soil																
Untreated soil		30.51	32.60	31.28	26.73	27.51	27.72	60.32	61.36	60.97	3.11	3.47	3.18	0.78	0.82	0.80
Farmyard manure	0	38.5	42.5	40.5	30.5	32.5	31.5	76.5	77.3	76.9	3.50	4.10	3.80	0.95	1.05	1.00
	15	40.0	44.0	42.0	32.5	34.5	33.5	78.5	79.3	78.9	3.70	4.10	3.90	1.18	1.20	1.19
	30	44.5	46.5	45.5	34.0	36.0	35.0	80.0	83.6	81.8	3.82	4.20	4.01	1.25	1.33	1.29
Mean		41.0	44.3	42.8	34.3	34.3	33.3	78.3	80.1	79.2	3.73	4.13	3.90	1.14	1.19	1.16
Chicken manure	0	37.6	43.4	40.5	31.2	33.6	32.4	75.8	76.2	76.0	3.80	4.20	4.00	1.02	0.96	0.99
	15	42.3	45.5	43.8	42.5	43.5	43.0	82.2	83.6	82.9	4.20	4.40	4.30	1.26	1.30	1.28
	30	45.4	48.2	46.7	44.0	46.6	45.3	84.4	86.2	85.3	4.36	4.56	4.46	1.36	1.38	1.37
Mean		41.8	45.7	43.7	39.2	41.3	40.2	80.8	82.0	81.4	4.12	4.39	3.92	1.21	1.21	1.21
L.S.D 5%	Organic F	1.80	1.72	1.76	3.50	3.40	3.45	2.15	2.10	2.12	1.25	1.12	1.18	0.25	0.30	0.27
	P-F	3.50	3.42	3.46	3.10	3.08	3.09	1.40	1.38	1.39	1.35	1.30	1.32	0.30	0.32	0.31
	Interaction	1.60	1.75	1.68	2.50	2.40	2.45	2.50	2.45	2.48	1.80	1.75	1.78	0.62	0.60	0.61

* F = fertilizer   Ardab = 155 kg

Table (3): Effect of organic manures and phosphorus fertilization on NPK contents (kg/fed) of faba bean plants

Organic fertilizer (m^3/ fed)	Mineral fertilizer dose, kg P_2O_5 /fed	Nitrogen						Phosphorus						Potassium					
		Seed			Straw			Seed			Straw			Seed			Straw		
		Season		Mean	Season		Mean	Season		Mean	Season		Mean	Season		Mean	Season		Mean
		1	2		1	2		1	2		1	2		1	2		1	2	
Alluvial soil																			
Untreated soil		12.2	13.2	12.9	4.10	4.30	4.20	1.60	1.80	1.70	0.27	0.27	0.27	5.32	4.41	4.86	7.6	8.2	7.90
Farmyard manure	0	14.2	16.8	15.4	4.6	5.8	5.2	1.6	2.8	2.1	0.32	0.30	0.31	8.6	8.2	8.4	12.6	12.6	12.6
	15	32.6	38.2	35.4	8.7	8.5	8.6	3.0	3.8	3.4	0.82	0.84	0.83	11.5	12.1	12.3	25.7	27.5	26.6
	30	40.1	40.3	40.2	9.8	9.8	9.7	5.5	5.7	5.6	0.88	0.92	0.90	13.2	13.6	13.7	32.0	33.2	32.6
Mean		28.9	35.0	30.33	7.7	8.0	7.8	3.2	4.1	3.7	0.67	0.69	0.68	11.1	11.3	11.2	24.4	24.8	24.9
Chicken manure	0	19.8	16.6	16.7	5.8	6.2	6.0	8.2	3.0	3.1	0.38	0.40	0.39	9.2	9.4	9.3	13.8	14.2	14.0
	15	33.5	40.2	36.9	9.6	9.2	9.4	4.6	4.8	4.7	0.86	0.90	0.88	13.6	14.2	13.9	25.6	24.8	24.2
	30	42.5	41.3	41.9	11.2	11.6	11.3	6.7	6.3	6.5	0.96	0.92	0.94	15.2	15.8	15.5	36.7	33.1	34.9
Mean		30.9	32.7	31.3	8.5	9.0	8.90	4.8	4.6	4.7	0.68	0.74	0.73	12.6	13.1	12.9	25.4	24.3	24.8
L.S.D 5%	Organic F*	3.50	3.62	3.56	1.20	1.60	1.30	1.3	1.50	1.40	0.21	0.23	0.22	1.80	1.6	1.60	2.10	2.30	2.20
	P-F	2.70	2.76	2.73	1.06	1.10	1.80	1.0	0.90	0.95	0.25	0.27	0.26	1.20	1.6	1.30	1.80	2.0	1.90
	Interaction	3.20	3.40	3.30	1.20	1.16	1.18	1.9	1.20	1.10	0.23	0.26	0.25	1.30	1.36	1.33	1.90	2.0	1.95
Sandy soil																			
Untreated soil		11.7	12.1	11.9	3.1	3.0	3.1	1.0	0.98	1.0	0.24	0.26	0.25	3.8	3.6	3.7	6.8	6.6	6.70
Farmyard manure	0	13.2	13.6	13.4	3.8	3.6	3.7	1.7	1.3	1.4	0.30	0.32	0.30	5.0	4.6	4.8	8.8	8.2	8.5
	15	21.6	21.8	21.7	5.6	6.2	5.9	2.8	2.8	2.8	0.56	0.50	0.53	10.0	9.2	9.6	11.6	12.6	12.1
	30	26.2	25.8	26.0	6.2	6.8	6.6	3.2	3.6	3.4	0.62	0.60	0.61	12.5	12.7	12.6	13.0	15.0	14.0
Mean		20.3	20.4	20.36	5.2	5.5	5.4	2.6	2.5	2.5	0.49	0.47	0.48	9.2	8.3	9.0	11.1	11.9	11.5
Chicken manure	0	14.6	15.0	14.8	4.6	4.8	4.7	1.9	2.3	2.2	0.28	0.30	0.29	5.2	5.8	5.4	9.2	9.0	9.1
	15	26.0	28.0	27.0	6.3	6.9	6.6	3.1	2.9	3.0	0.60	0.62	0.61	10.5	11.1	10.8	13.5	15.1	14.3
	30	29.0	31.2	30.1	7.3	7.7	7.5	4.1	4.3	4.2	0.70	0.68	0.89	12.0	12.6	13.0	12.8	17.2	16.4
Mean		23.2	24.7	23.9	6.6	6.5	6.5	3.3	3.2	3.2	0.53	0.58	0.56	9.20	9.8	9.50	12.8	13.8	13.2
L.S.D 5%	Organic F	2.15	2.31	2.23	2.80	2.92	2.86	1.20	1.30	1.25	0.22	0.18	0.20	1.22	1.20	1.21	1.60	1.40	1.50
	P-F	2.30	2.10	2.20	1.16	1.20	1.18	0.98	0.90	0.93	0.20	0.22	0.21	1.10	0.90	1.00	1.50	1.96	1.53
	Interaction	2.20	2.40	2.30	2.80	2.60	2.70	1.60	1.20	1.70	0.23	0.21	0.22	1.20	1.20	1.20	1.88	1.80	1.53

* F = fertilizer