RESULTS & DISCUSSION

4. RESULTS AND DISCUSSION

Ordinary superphosphate (OSP), is composed of two salts, (a) soluble calcium orthophosphate along with (b) the rather insoluble calcium sulphate. Triple superphosphate (TSP), is a soluble salt of calcium orthophosphate. Mono-ammonium phosphate (MAP) is also a soluble salt of ammonium phosphate.

Three soils were used in this study: a clay soil (soil 1), a sandy loam soil (soil 2), and a calcareous sandy loam soil (soil 3). The three soils varied in their nature and fertility: the clay soil gave greater plant growth, yields of plant components, and nutrient uptake than the other two soils.

4.1 Dry weight of bean plants

4.1.1. Yield of bean seeds (Table 2 and Figs 1, 2 and 3)

All fertilizes in all soils resulted in increases in seed yield. The mean yields of treatments not receiving P were 12.29,10.41,and11.78 g/pot for soils 1, 2, and 3 respectively (soil 1: clay, soil 2: sandy loam, soil 3 calcareous sandy loam). The mean yields for treatments receiving P (mean for all P-sources) were 15.13,14.23 and 14.34 g/pot for the same three soils respectively. Such yields involve increases of 23.1 %, 36.7 % and 21.7 % due to P application for each soil respectively. Such response to P application is a reflection of the need for P fertilizers in these soils. Contents of available P in soils were below 5 mg/kg indicating a positive need for P fertilization according to **Salam and Haleem (1994)** who stated that broad beans grown on soils of Kaliobiya containing <10 mg /kg would respond to P application. The main effect of fertilizer source

Table (2): Effect of applying P fertilizers (in different sources and forms) to broad beans on yield of bean seeds g/pot
(P rate = 50 mg/kg soil)

Soil (A)	P form (C)	P source (B)			
		OSP	TSP	MAP	Mean
		dry weight of seeds g/ pot			
Clay Soil	Powdered	15.31	14.26	14.04	**14.54**
	granular	16.24	16.11	14.83	**15.73**
	mean	**15.78**	**15.19**	**14.43**	**15.13**
Sandy Loam Soil	powdered	14.77	12.54	13.27	**13.53**
	granular	16.10	14.54	14.16	**14.93**
	mean	**15.43**	**13.54**	**13.72**	**14.23**
Calcareous Soil	powdered	13.54	14.21	12.39	**13.38**
	granular	16.32	15.10	14.51	**15.31**
	mean	**14.93**	**14.66**	**13.45**	**14.34**
G.mean		15.38	**14.46**	**13.86**	
Mean of P--form					
	Powdered	14.54	13.67	13.23	**13.81**
	granular	16.22	15.25	14.50	**15.32**

LSD : 0.05 A:0.41 B: 0.41 C:0.33 AB:0.71
AC:NS BC:NS ABC:1.00

No P treatments :

Clay : 12.29
Sandy loam : 10.41
Calcareous : 11.78
Mean : 11.49

Notes: **OSP :Ordinary Ca-superphosphate 6.8%P. TSP : triple Ca-superphosphate 15.9%P. . MAP: mono-ammonium phosphate 25.5%P , 11% N . (each of TSP and OSP treatments received N equal to the amount involved in MAP treatment.)**

Figure (1):Main effect of applying P fertilizers on bean seed yield of different soils
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)

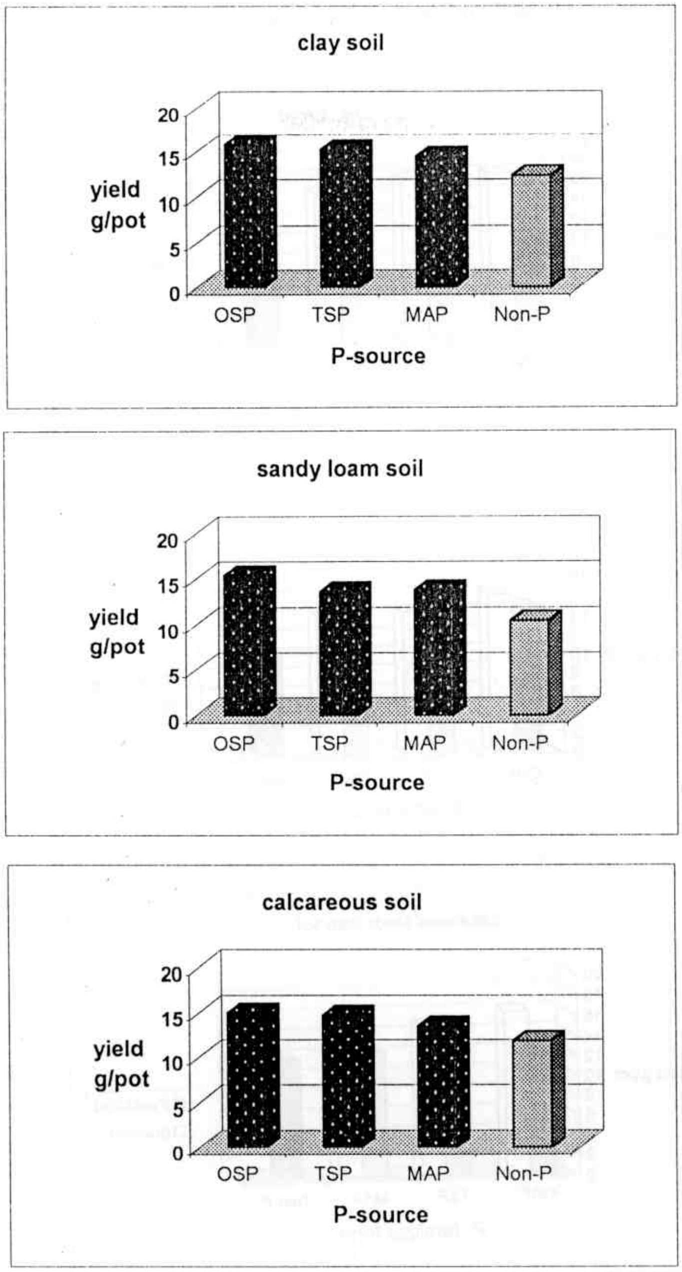


Figure (2) : Effect of applying P fertilizers (powdered and granular on bean seeds yield of different soils
(P rate 50 mg /kg soil; OSP: ordinary superphosphate, TSP:triple superphosphate, MAP:monoammonium phosphate)

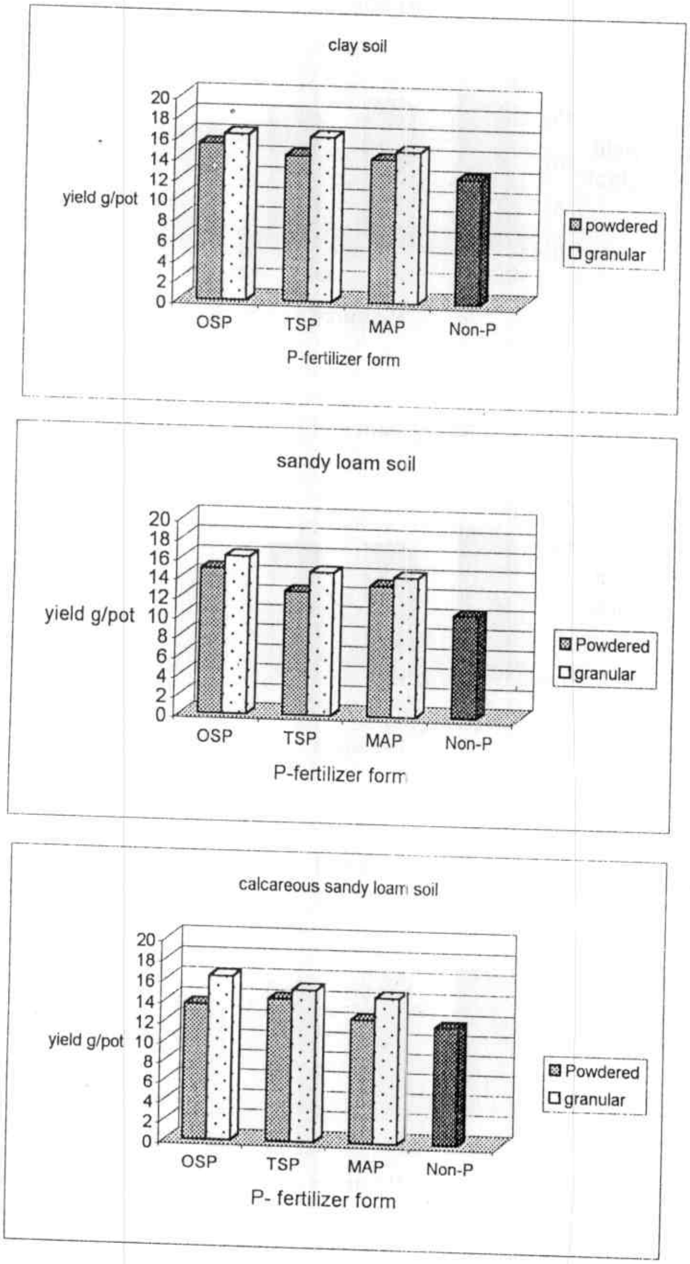
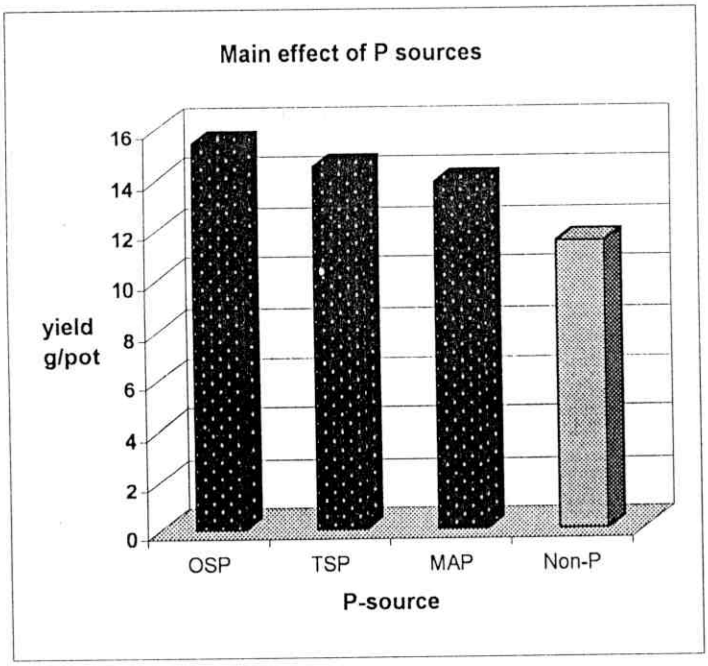
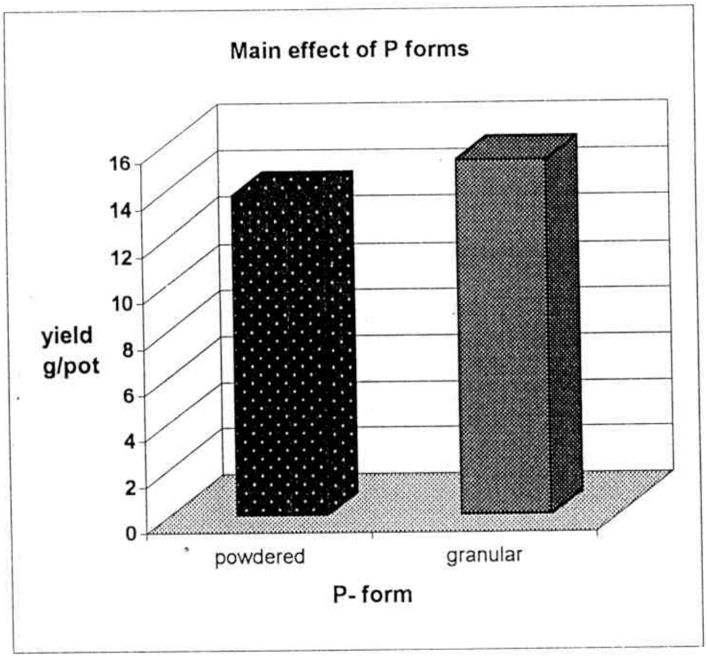


Figure (3): Main effect of applying P fertilizers and forms (average of 3 soils) on bean seed yield
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)





showed the following pattern: OSP>TSP>MAP .the mean yields given by P sources were 15.38, 14.46, and 13.86 g/pot for OSP, TSP, and MAP respectively. Increases caused by these sources amounted to 33.9 %, 26.7%, and 20.6 % for each of the aforementioned sources respectively.

Superiorty of the OSP source was particularly apparent in the two sandy loam soils. In the clay soil both OSP and TSP sources were rather similar. In all soils MAP was inferior to both OSP and TSP. Therefore ordinary superphosphate seems to have an advantage over triple superphosphate and ammonium phosphate especially when used in the light textured soils. This may probably be due to the contents of calcium sulphate in the OSP fertilizer. Sandy soils are usually of low buffering capacity. Also superiorty of OSP over the others was particularly obvious with the granulated form and in the calcareous soil .This stresses, the benificial effect of granulation of phosphate fertilizers in soils of high fixing capacity for P ,calcareous soils in particular.

Granulated form of P fertilizers gave greater yields over the powdered form. The mean yield for the former was 15.32 g/pot as compared with 13.81 g/pot given by the latter form; an increase of about 11 % due to granulation.

The clay soil gave the highest yield and the sandy loam soil gave the lowest. Mean values of yields given by the fertilized soils were 15.13, 14.23,and 14.34 g/pot for the clay, sandy loam, and calcareous sandy loam soils respectively.

4.1.2. Yield of plant straw (Table 3 and Figs 4,5 and 6)

As occurred with yield of seeds, all fertilizers in all soils resulted in increases in the yield of plant straw .The mean yields of treatments not receiving P were 9.58,11.34 and 9.95 g/pot for soils 1, 2, and 3 respectively. The mean yields for treatments receiving P (means over the three P-sources) were 11.10, 16.78, and 13.78 g/pot for the same soils respectively; therefore P application showed increases of 15.9 %, 47.9 % and 38.5 % for the three soils respectively, this is an indication to an acute need for P in all of the three soils.

The main effect of fertilizer source showed the following pattern: OSP > TSP > MAP. The mean yields for OSP, TSP, and MAP were14.17, 13.94, and 13.55 g/pot respectively. Increases caused by these sources were 37.8 %, 35.5 %, and 31.7 % for each of the aforementioned sources respectively.

Regarding straw yield, superiorty of OSP over TSP occurred in soil 1 and soil 2. However in soil 3 where TSP was superior to OSP. This indicates that in calcareous soils triple superphosphate may increase plant growth more than ordinary superphosphate, giving more straw yields.

MAP gave greater straw yield as compared with the other two sources in the clay soil only in the two sandy loam soils MAP gave less yields than the others. Superiorty of MAP in the clay soil may have been due to less losses of nitrogen from this source of fertilizer in this soil, thus rendering MAP more productive for plant growth .In the other two soils which are sandier (and one of them is calcareous) MAP may have suffered

Table (3): **Effect of applying P fertilizers (in different sources and forms) to broad beans on yield of bean straw g/pot (P rate =50 mg/kg soil)**

Soil (A)	P form (C)	P source (B)			
		OSP	TSP	MAP	Mean
		dry weight of straw g/pot			
Clay Soil	Powdered	10.46	10.41	10.23	**10.36**
	granular	11.99	10.98	12.53	**11.85**
	mean	**11.23**	**10.70**	**11.38**	**11.10**
Sandy Loam Soil	Powdered	19.45	18.84	17.46	**18.58**
	Granular	16.54	14.33	14.07	**14.98**
	mean	**18.10**	**16.59**	**15.77**	**16.78**
Calcareous Soil	Powdered	13.14	14.67	13.20	**13.66**
	Granular	13.44	14.43	13.82	**13.89**
	mean	**13.29**	**14.45**	**13.51**	**13.78**
G.mean		**14.17**	**13.94**	**13.55**	
Mean of P-from					
	Powdered	14.35	14.64	13.13	**14.21**
	granular	13.99	13.25	13.97	**13.57**

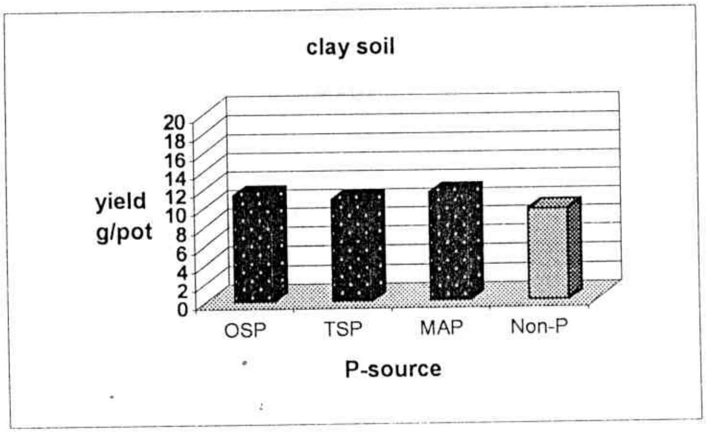
LSD : 0.05 A : 0.39 B :0.39 C : 0.32 AB : 0.67
AC : 0.55 BC : 0.55 ABC : 0.95

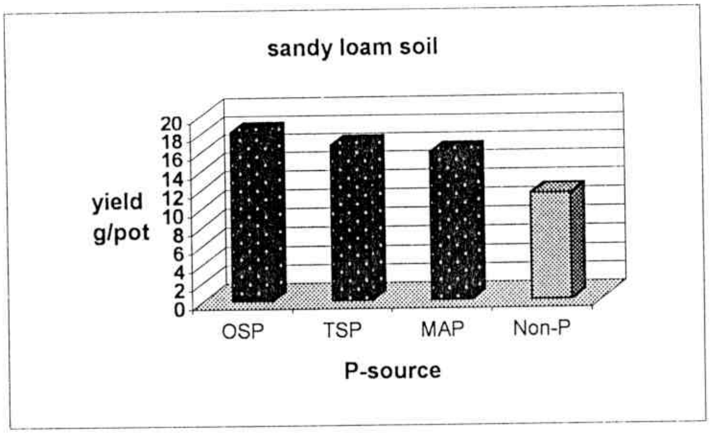
No P treatments :

Clay	: 9.58
Sandy loam	:11.34
Calcareous	: 9.95
Mean	:10.29

Notes: **OSP: OrdinaryCa-superphosphate 6.8%P. TSP : triple Ca-superphosphate 15.9%P. MAP: mono-ammonium phosphate 25.5%P , 11% N . (each of TSP and OSP treatments received N equal to the amount involved in MAP treatment.)**

Figure (4):Main effect of applying P fertilizers on bean straw yield of different soils
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)





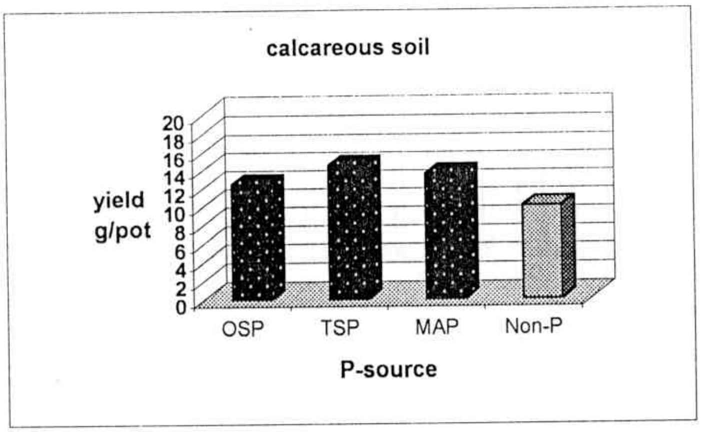


Figure (5) : Effect of applying P fertilizers (powdered and granular on bean straw yield of different soils
(P rate 50 mg /kg soil; OSP: ordinary superphosphate, TSP:triple superphosphate, MAP:monoammonium phosphate)

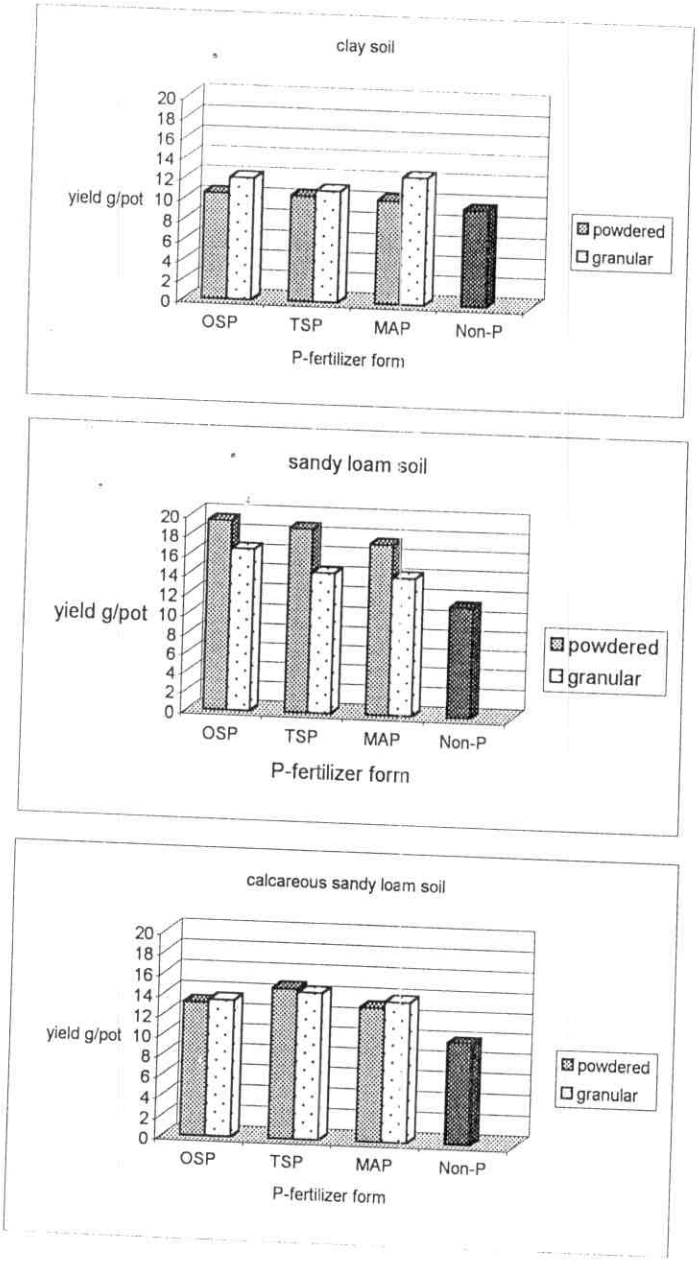
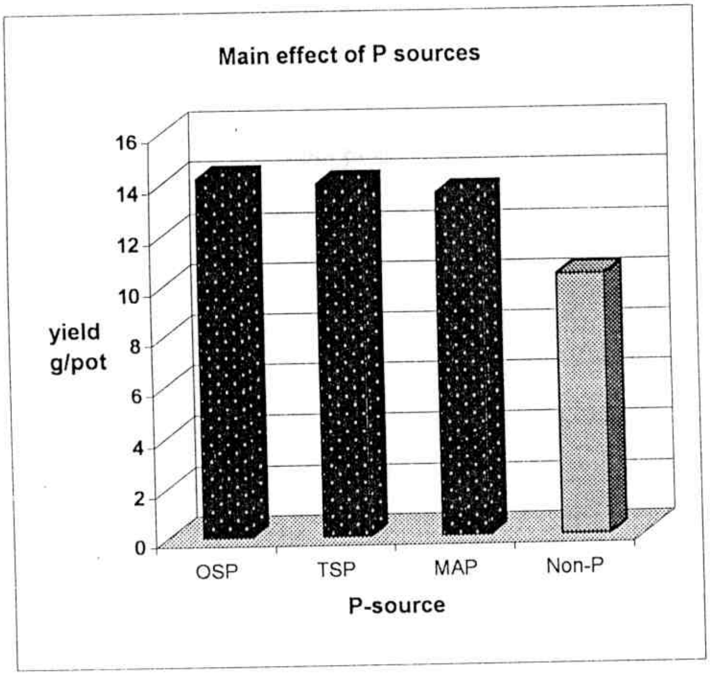
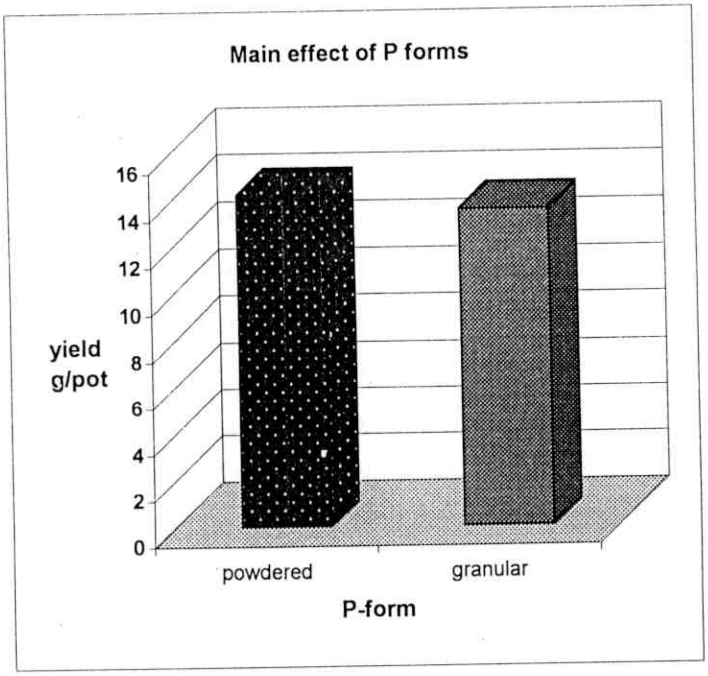


Figure (6): Main effect of applying P fertilizers and forms (average of 3 soils) on bean straw yield
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)





more N losses due to the coarse texture of the soils. Such conclusion may be confirmed by the fact that MAP inferiority in the light soils was apparent when the fertilizers were powdered. Calcium carbonate in the calcareous sandy loam would contribute in volatilization losses of NH3 from ammonium phosphate fertilizers **(Tisdal and Nelson 1993)**. According to **Stumpe et al 1984)** urea phosphate mixtures were not recommended due to NH3 loss by volatilization on highly calcareous soils, but cloud be used on noncalcareous soils. Therefore MAP may have serious disadvantages stemming from volatilization losses of its nitrogen nutrient. Such conclusion is confirmed by inferiority of MAP compared with OSP or TSP when all fertilizers were in powdered forms and in the two coarse soils (soil 2 and 3) particularly with the calcareous one. In the calcareous sandy loam, powdered MAP gave a yield, which was about 10 % lower than powdered TSP; in the clay soil the comparable decrease was little only about 1%.

Powdered forms (judging by the main effect) gave more straw yield as compared with the granulated forms.

The greater straw yield given by the powdered form, as compared with the granulated form, average of about 5 %. However, there was an interaction caused by the soil; such superiorty of powdered forms was most prominent in the coarse sandy loam soil (soil 2) in particular. In this soil the powdered form gave 24 % more straw yield over the granulated form. In the clay soil there was a reverse pattern when the granular form gave r yields 14.4 % greater than given by the powdered form.. Therefore in the sandy soil it is more beneficial to supply P fertilizers in powdered rather than granulated forms. In the clayey soil the reverse is true.

The sandy loam soil gave the highest straw yield and the clay gave the lowest.

4.1.3.Yield of pods (after removal of seeds) ; (see Table 4 and Figs 7, 8 and 9)

As occurred with yields of seeds and straw, all fertilizers in all soils resulted in an increase in yield of pods. The mean yields of treatments not receiving P were 2.21, 2.85, and 2.54 g/pot for soils 1, 2, and 3 respectively. The mean yields for treatments which had received P (mean of the three P-fertilizers) were 2.86, 3.45, and 3.48 g/pot for the same three soils respectively. Thus P application caused marked increases in pod yield ;such increases amounted to 29.4 %, 21.0 % and 37 % increase for each of the three soils respectively.

The main effect of fertilizer source showed the following pattern MAP > TSP; with TSP giving a yield not significantly from that given by OSP. The mean values for MAP, TSP, and OSP were 3.39, 3.21, and 3.19 g/pot for each of them, respectively. The superiorty of MAP over the others was particularly apparent with plants grown on the clay and the calcareous soils. In the sandy loam the three fertilizer sources did not differ significantly.Therefore the ammonium phosphate source seemed to have given more pod yields than any of the two calcium superphosphate sources in soils, which usually have high fixation capacity for P i.e. clay and calcareous soils, **(Sample et al 1980 and Sadik et al 1996)**. It seems that when a

Table (4): Effect of applying P fertilizers (in different sources and forms) to broad beans on yield of pods g/pot
(P rate =50mg/kg soil)

Soil (A)	P form (C)	P source (B)			
		OSP	TSP	MAP	Mean
		dry weight of pods g/pot			
Clay Soil	Powdered	2.37	2.45	2.92	**2.58**
	granular	2.95	3.32	3.13	**3.13**
	mean	**2.66**	**2.88**	**3.02**	**2.86**
Sandy Loam Soil	Powdered	3.93	3.45	3.34	**3.57**
	granular	3.45	3.15	3.37	**3.32**
	mean	**3.69**	**3.30**	**3.36**	**3.45**
Calcareous Soil	Powdered	4.05	3.15	3.75	**3.65**
	granular	2.39	3.76	3.78	**3.31**
	mean	**3.22**	**3.45**	**3.76**	**3.48**
G.mean		**3.19**	**3.21**	**3.38**	
Mean of P- form					
	powdered	3.45	3.02	3.34	**3.28**
	granular	2.93	3.41	3.43	**3.25**

LSD : 0.05 A:o.16 B:0.16 C:NS AB:0.27
AC :0.22 BC:0.22 ABC:0.38

. No P treatments :
Clay : 2.21
Sandy loam : 2.85
Calcareous : 2.54
Mean : 2.53

Notes: **OSP :Ordinary Ca-superphosphate 6.8%P. TSP : triple Ca-superphosphate 15.9P. :MAP : mono-ammonium phosphate 25.5%P , 11% N . (each of TSP and OSP treatments received N equal to the amount involved in MAP treatment.)**

Figure (7):Main effect of applying P fertilizers on bean pods yield of different soils
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)

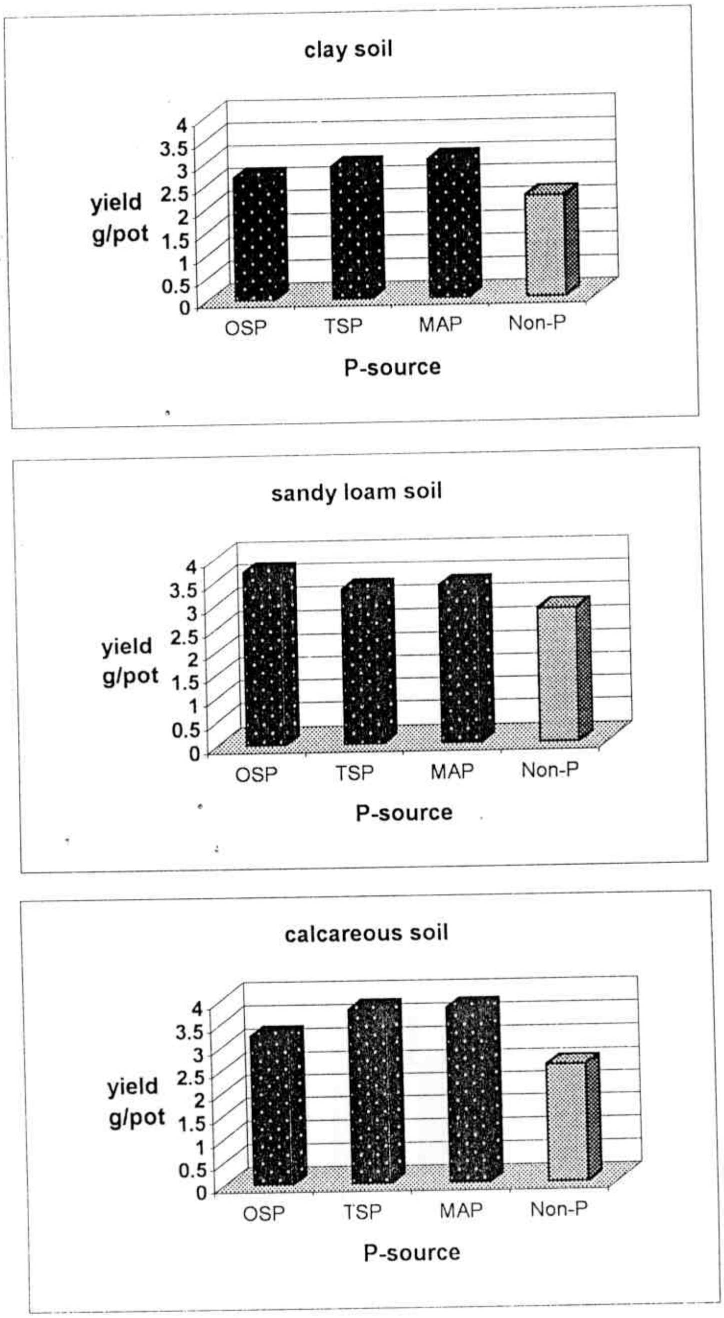


Figure (8) : Effect of applying P fertilizers (powdered and granular on bean pods yield of different soils
(P rate 50 mg /kg soil; OSP: ordinary superphosphate, TSP:triple superphosphate, MAP:monoammonium phosphate)

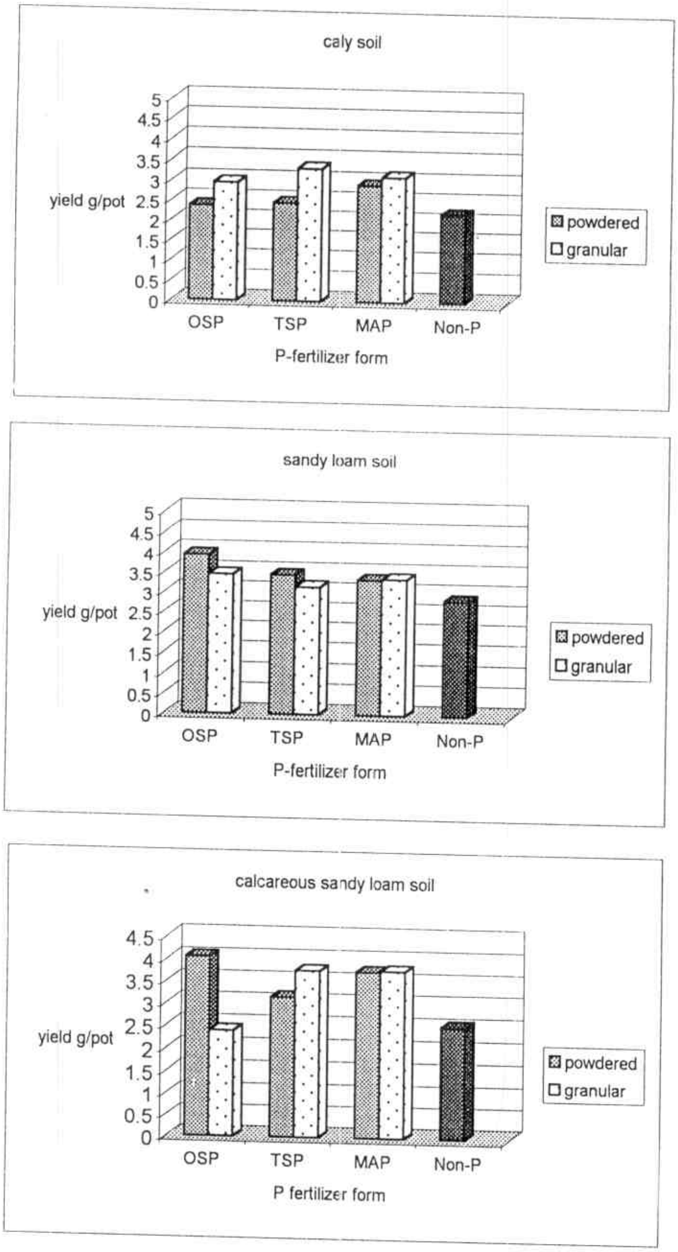


Figure (7):Main effect of applying P fertilizers on bean pods yield of different soils
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)

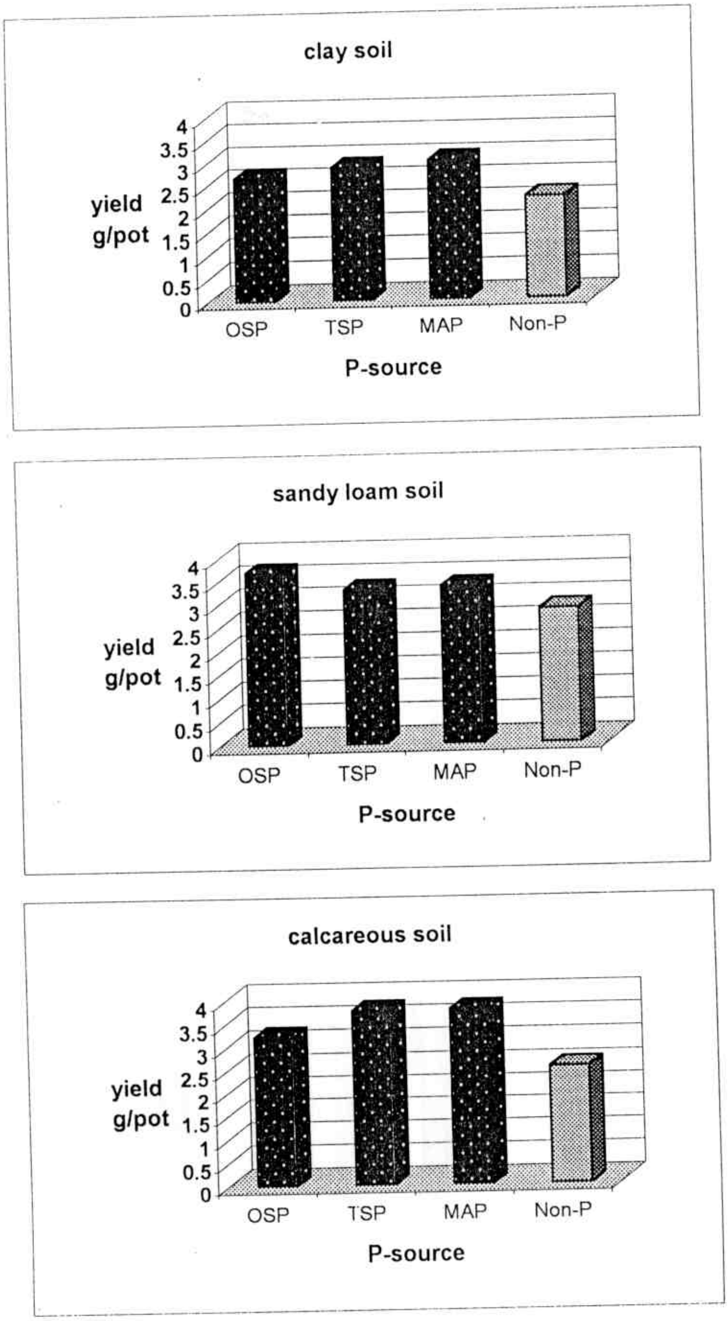


Figure (8) : Effect of applying P fertilizers (powdered and granular on bean pods yield of different soils
(P rate 50 mg /kg soil; OSP: ordinary superphosphate, TSP:triple superphosphate, MAP:monoammonium phosphate)

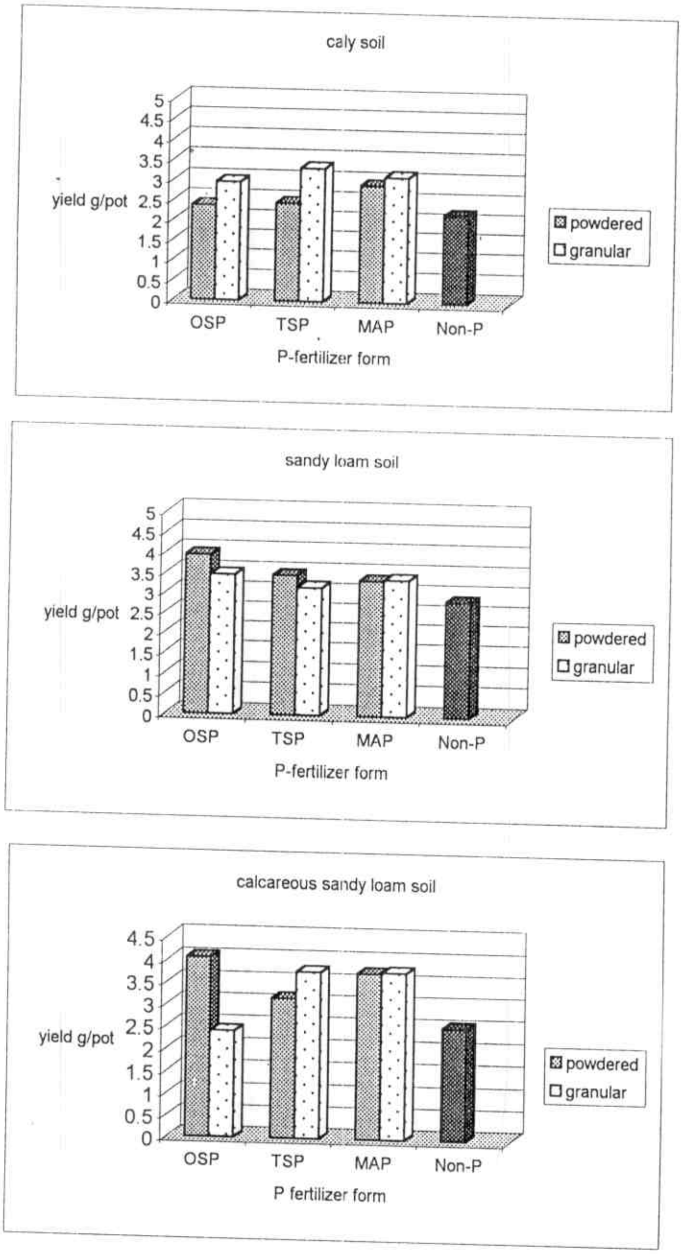
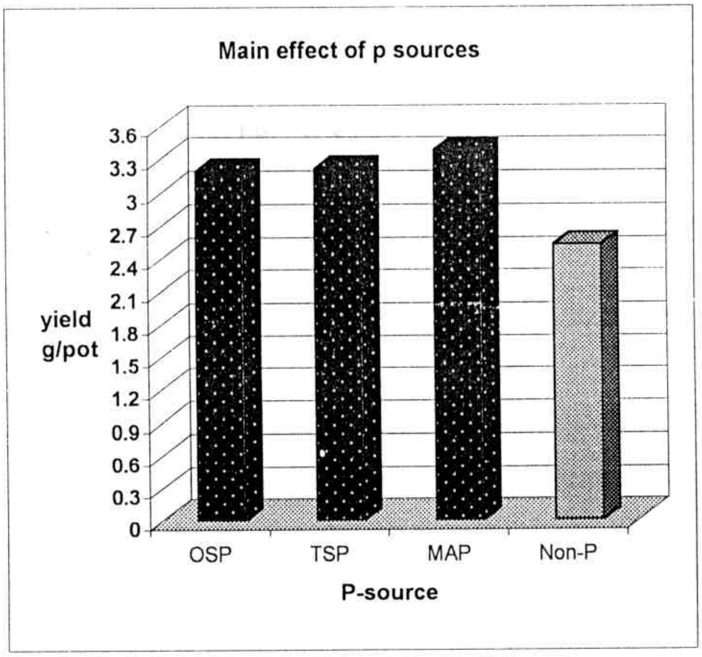
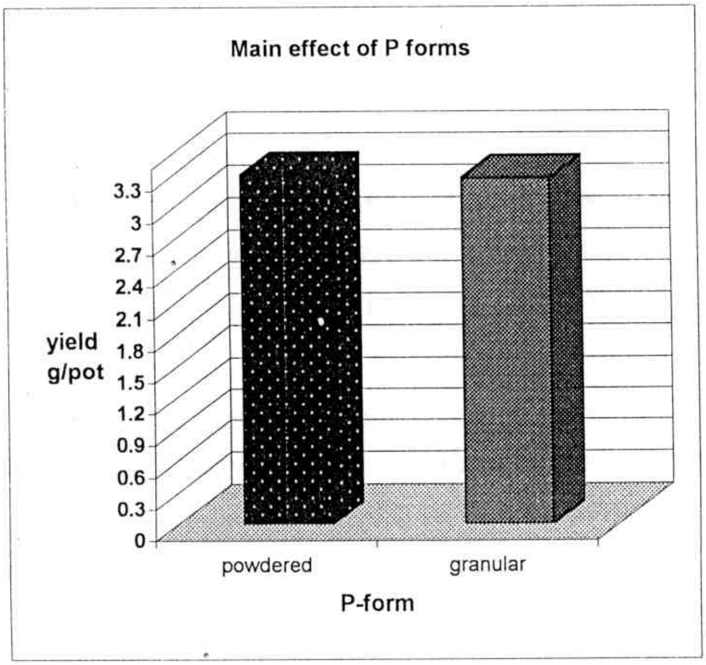


Figure (9): Main effect of applying P fertilizers and forms (average of 3 soils) on bean pods yield
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)





soluble phosphate salt is introduced to such soils in the form of ammonium phosphate it may not turn insoluble as easily as when introduced in a form of calcium phosphate (**Zhou and Huang 1995).** Phosphorus fixation by soils (also termed as "phosphorus tight retention" by soils) in calcareous soils is mainly through transformation of soluble calcium orthophosphate into less soluble forms of dicalcium phosphate or tricalcium phosphate under conditions of high contents of calcium carbonate **(Bear 1964).** In clay soils, phosphate fixation is believed to occur mainly through tight and strong adsorption of the soluble phosphate ions to the colloidal clay of the soil (**Bear 1964 and Guerra et al 1996).** Lower pod yield obtained by TSP in comparison with MAP was prominent when fertilizers were applied to the calcareous soil and the clay soil, in a powdered form and not a granulated form (i.e. giving a 3-factor interaction). This may indicate that pulverization of calcium super phosphate enhances greater fixation of P in soils of high P fixation capacity. In the calcareous soil MAP gave a pod yield which was greater by about 19 % as compared with the TSP treatment (with both fertilizers being powdered). This reflects a greater P fixation of the TSP sources, or a preference for MAP over TSP for pod production in calcareous soils when both sources are powdered.

The MAP source was also superior to the OSP source (when both were granular) and this was particularly manifested in the clay soil as well as the calcareous soil; increases by MAP over OSP were 13.5% in the clay soil and as much as 58 % in the calcareous soil.

Granulated fertilizers gave more pod weight than the powered fertilizers when TSP was used, and *vise versa* when OSP was used. Therefore, granulation may be preferred to pulverization of P fertilizer in soils that have high capacity for converting soluble phosphate into insoluble phosphate (such as calcareous and clayey soils). This is clearly shown with regard to pod yield in the clay soil and the calcareous sandy loam soil; and particularly with triple superphosphate when the granulated form gave greater yield over the powdered one amounting to 35.5 % in the clay soil and 19.4 %in the calcareous soil.

The calcareous sandy loam soil (soil3) gave the highest yield of pods and the clay soil (soil 1) gave the lowest.

4.1.4. Yield of (seeds + straw + pods) :' Table 5 and Figs 10, 11 and 12 :'

Total yield of the above-soil plant parts (i.e. seeds + straw + pods) show that application of P resulted in increased plant growth and yields of plant parts due to P application. Plants not receiving P gave yields, which were 24.70, 25.43, and 24.76 g/pot for those grown on the clay, sandy loam, and calcareous sandy loam soils respectively. The mean yields for treatments receiving P (means over the three P-sources) were 30.83, 34.45, and 31.65g /pot for the same three soils respectively; giving increases of 24.8 %, 35.4 % and 27.8 % for each of the aforementioned soils respectively.

The high response of plant growth and yield to P application to these soils reflect their need for P application, and the inadequate indigenous contents of available P. The need was

Table (5): Effect applying P fertilizers (in different sources and forms) to broad beans on total yield (seeds +straw + pods) of broad bean g/pot
(P rate =50 mg/kg soil)

Soil (A)	P form (C)	P source (B)			
		OSP	TSP	MAP	Mean
		dry weight of total plants g/pot			
Clay Soil	Powdered	28.31	27.19	27.20	27.57
	granular	31.28	30.45	30.76	30.83
	mean	29.80	28.82	28.98	30.83
Sandy Loam Soil	Powdered	38.21	34.77	34.13	35.70
	granular	36.08	32.05	31.47	33.20
	mean	37.15	33.41	32.80	34.45
Calcareous Soil	Powdered	31.71	31.99	29.25	30.98
	granular	32.14	32.90	31.92	32.32
	mean	31.93	32.45	30.59	31.65
G.mean		32.96	31.56	30.79	
Mean of P –form					
	powdered	32.56	31.32	30.19	31.36
	granular	33.17	31.80	31.38	32.12

LSD : 0.05 A: 0.51 B:0.51 C:0.42 AB:0.88
AC:0.72 BC:0.72 ABC:NS

No P treatments :
Clay : 24.70
Sandy loam : 25.43
Calcareous : 24.76
Mean : 24.76

Notes: **OSP :Ordinary Ca-superphosphate 6.8%P:TSP : triple Ca-superphosphate 15.9%P :MAP : mono-ammonium phosphate 25.5%P , 11% N . (each of TSP and OSP treatments received N equal to the amount involved in MAP treatment.)**

Figure (10):Main effect of applying P fertilizers on total yield of broad bean (seeds + srtaw + pods) of different soils (P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)

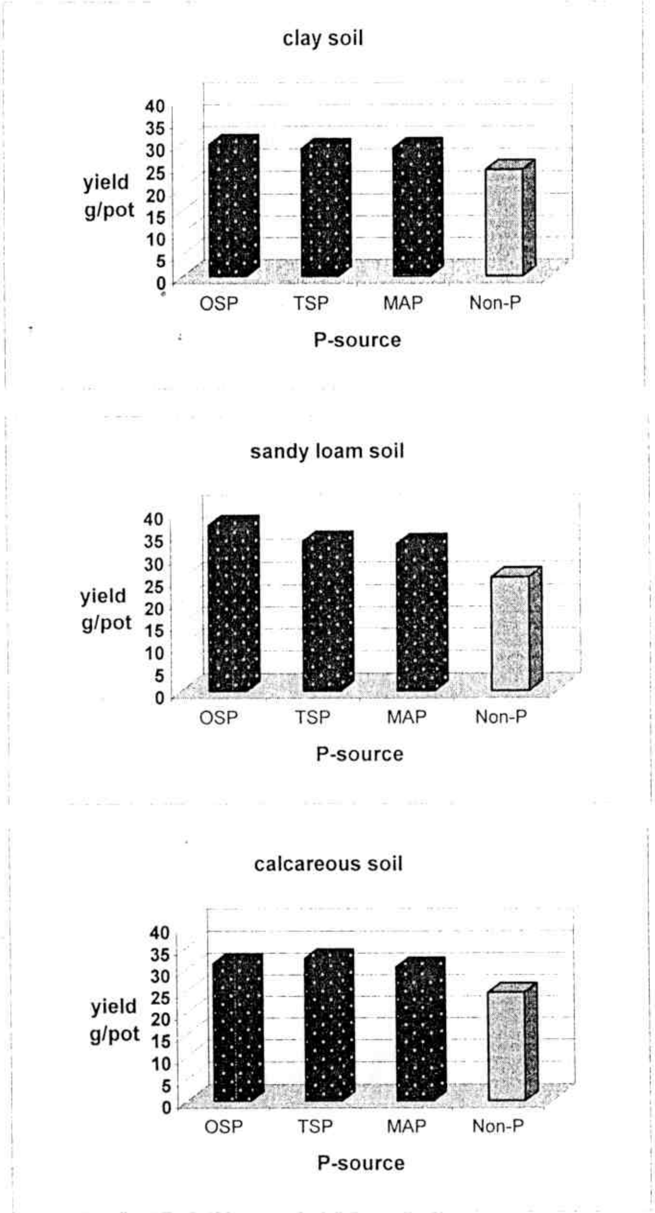


Figure (11) : Effect of applying P fertilizers (powdered and granular on total plant parts yield (seeds+ straw + pods)of different soils (P rate 50 mg /kg soil; OSP: ordinary superphosphate, TSP:triple superphosphate, MAP:monoammonium phosphate)

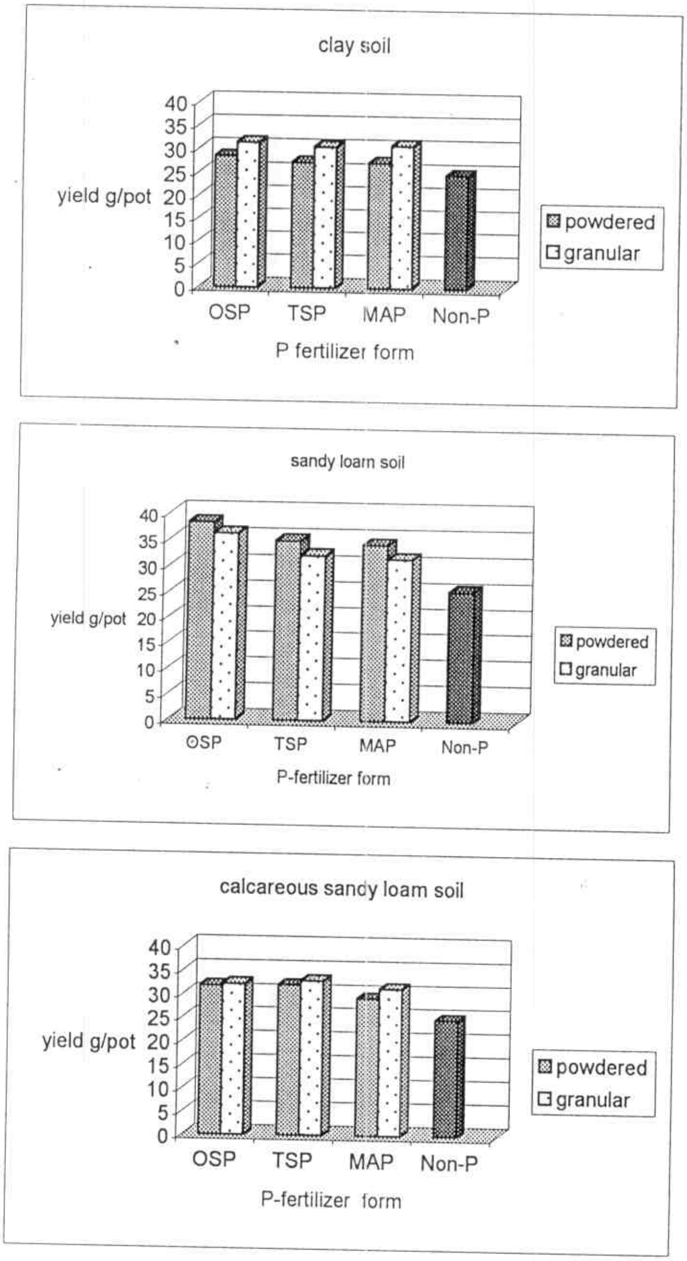
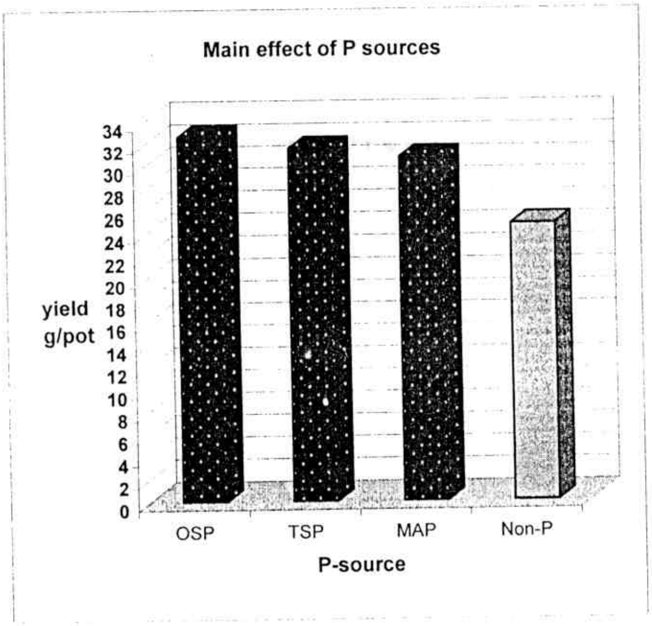
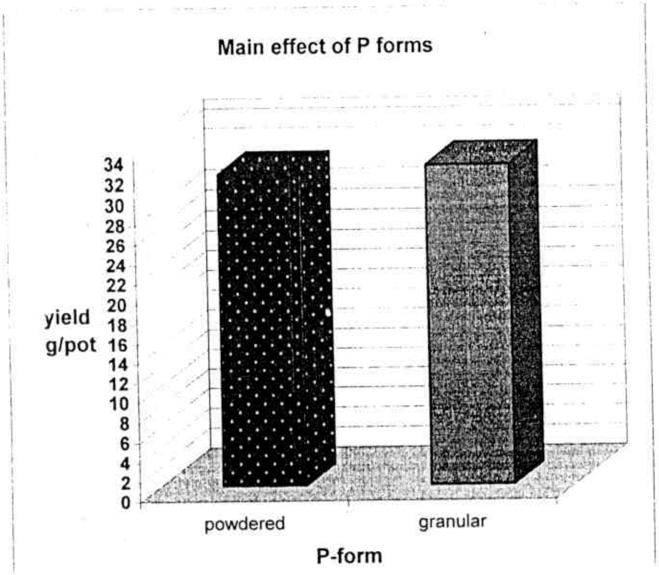


Figure (12): Main effect of applying P fertilizers and forms (average of 3 soils) on total yield (seeds + straw + pods) of broad bean (P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)





particularly evident with the sandy soils, followed by sandy calcareous soil. **Salam and Haleem (1994)** reported that a level of below 10 mg P/kg soil (sodium bicarbonate extract) would indicate a definite need for P application for beans . The main effect of fertilizer source showed the following pattern: OSP>TSP>MAP. The mean yields given by P sources were 32.96, 31.56, and 30.79g/pot for OSP, TSP, and MAP respectively. Increases due to application of these sources were 33.1 %, 27.8 %, and 24.4 % for each of them respectively.

Superiorty of the OSP source over the TSP source was consistent, as occurred with yields of bean seeds, straw, and pods. The superiorty was particularly apparent in the sandy loam soil, which is lowest in fertility. However the TSP source was superior over the two sources in the calcareous sandy loam soil. The apparent superiorty of OSP over the other two sources in each of the clay soil and the sandy loam soil reflects its greater nutritional effect as a source of P as well as S; since OSP is a source of S as well as (P and Ca). The superiority of OSP over TSP and MAP occurred with both the powdered and the granular forms. These results agree with those of **Ibrahim (1995)** who reported that yields of sorghum and barley were greater with OSP and available P in soil after harvest were also greater when OSP was used than when TSP was used. **Maciejewska and Gibczynska (1997)** demonstrated high efficiency of OSP in a sandy soil in presence of 0.5 % calcium carbonate. **Rao et al (1991)** reported superiorty of granulated OSP over granulated TSP in a sandy clay loam soil under wheat (field trials).

Granulation of forms gave greater yields over powdered forms. However this occurred particularly in the clay soil and the calcareous sandy loam soil. In the sandy loam soil the powdered form was superior to the granulated one. Therefore, in the two soils which represent soils of high P- fixation capacity **(Bear 1964, Sample et al 1980, and Sadik et al 1996)** granulation was most beneficial. **Rao et al (1991)** demonstrated superiorty of granulated OSP over powdered OSP. Pulverization of MAP source in the current study may have caused increased loss of its N, particularly when used in two the light –textured soils as compared with granulation. The granular form gave, on average, slightly greater yields of (seeds + straw + pods) over the powdered form .The mean yield for the granular forms was 32.12 g/pot as compared with 31.36 g/ pot given by the powdered forms. Granulation was very effective with the ammonium phosphate source (MAP), and where plants were grown in the clay soil or the calcareous one. In these two soils which convert a high proportion of soluble P into insoluble P **(Bear 1964)** granulation of MAP was superior by 13 % to pulverization However, in the sandy loam soil it was powdered MAP, which gave 8.45 % more yields over granulated MAP. This demonstrates the high effectiveness of granulation in soils of high P-fixation capacity. It also demonstrates that pulverization of ammonium phosphate would be benificial in soils of low P-fixation capacity.

The sandy loam gave the highest plant growth since it showed the highest yields of straw + pods + seeds; and the clay soil gave the lowest. The inferiority of the clayey soil in comparison with the sandy loam soils is mainly concerning straw, and pod yields; where the yield of seeds yield is concerned, it was the clay soil which gave the highest seed yield. This may indicate a more balanced fertility parameters of the clay soil reflected in the most vital organs of the plants (seeds).

4.2.P concentration

Dealing with concentration of a nutrient in plant organs, it is of great importance to a note that a treatment which causes "increase" in concentration may not necessarily indicate efficiency; increased concentration may be due to retarded plant growth. Also a "decrease" in concentration may be caused by enhanced plant growth and increased yield, and this is referred to as the " dilution effect ". However, in some cases an "increase" in concentration may be in line with an increase in plant growth and yield, hence the efficiency of a treatment causing such action would be real. In all cases, the objective assessment of the efficiency of a treatment regarding nutrients in plant would be through evaluation of "uptake" since it embodies both concentration and yield. However, there may be an exception when assessing "percentage" of a specific ingredient in plant organ that has a direct effect on the "quality" of the organ.

4.2.1. P concentration in broad bean seeds) Table 6 and Figs 13, 14,and 15)

All fertilizers in all soils resulted in increases in P-concentration in seeds. The mean P-concentration values for treatments not receiving P were 0.29 %, 0.27%, and 0.30% in seeds of plants grown in the clay soil , the sandy loam soil , and the calcareous sandy loam soil respectively. The mean values for treatments receiving P(mean for all P-sources) were 0.33, 0.32, and 0.32 %for the same aforementioned three soils respectively.

The main effect of fertilizer source showed no significant difference among the three fertilizer sources. Also the main effect of forms showed that the slightly greater concentration in seeds receiving the granular form over the powdered form was not significant. Superiority of granular fertilizers in seed production was manifested in seeds yield as shown in Table 2. In the case of TSP in the clay and sandy loam soils, the lower P concentration shown by the granular form compared with those concerning the powdered form is a manifestation of the "dilution effect" since the granulated form gave far greater seed yield over the powdered form.

The main effect of soils showed no difference in the concentration of P in seeds of plants grown in the three soils

Table (6): Effect of applying P fertilizers (in different sources and forms) to broad beans on P concentration % of bean seeds (P rate = 50mg/kg soil)

Soil (A)	P form (C)	P source (B)			
		OSP	TSP	MAP	Mean
		P concentration of seeds %			
Clay Soil	Powdered	0.337	0.326	0.326	**0.330**
	granular	0.325	0.325	0.324	**0.324**
	mean	**0.331**	**0.325**	**0.325**	**0.327**
Sandy Loam Soil	Powdered	0.304	0.328	0.325	**0.316**
	Granular	0.332	0.319	0.312	**0.321**
	mean	**0.318**	**0.324**	**0.314**	**0.318**
Calcareous Soil	Powdered	0.326	0.318	0.320	**0.323**
	Granular	0.320	0.318	0.322	**0.320**
	mean	**0.323**	**0.318**	**0.324**	**0.322**
G.mean		**0.324**	**0.322**	**0.321**	
Mean of P—form					
	powdered	0.322	0.324	0.322	**0.323**
	granular	0.326	0.320	0.320	**0.327**

LSD : 0.05 A:NS B:NS C:NS BA:NS AC:NS BC:NS ABC:NS

No P treatments :

Clay :0.290

Sandy loam :0.270

Calcareous :0.300

Mean :0.290

Notes: **OSP :Ordinary Ca-superphosphate 6.8%P:TSP : triple Ca-superphosphate 15.9%P :MAP : mono-ammonium phosphate 25.5%P , 11% N . (each of TSP and OSP treatments received N equal to the amount involved in MAP treatment.)**

Figure (13):Main effect of applying P fertilizers on P concentration % of bean seeds of different soils
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)

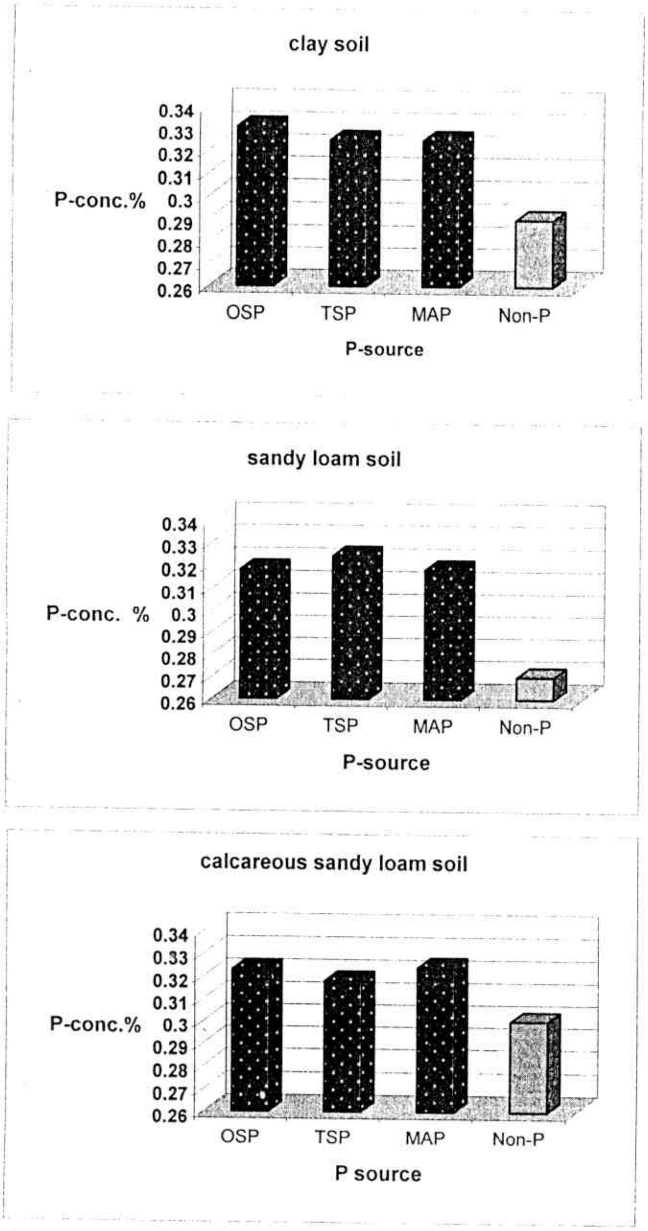
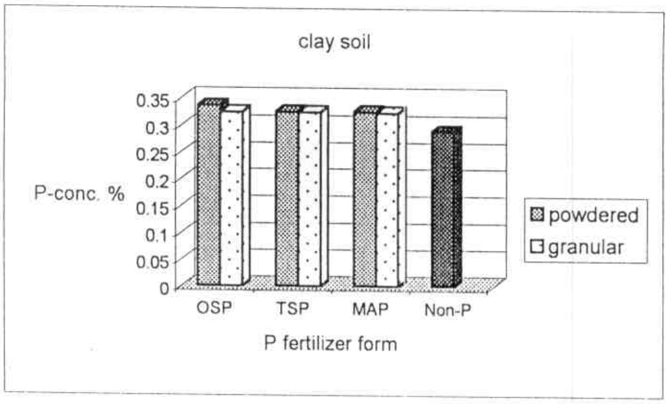
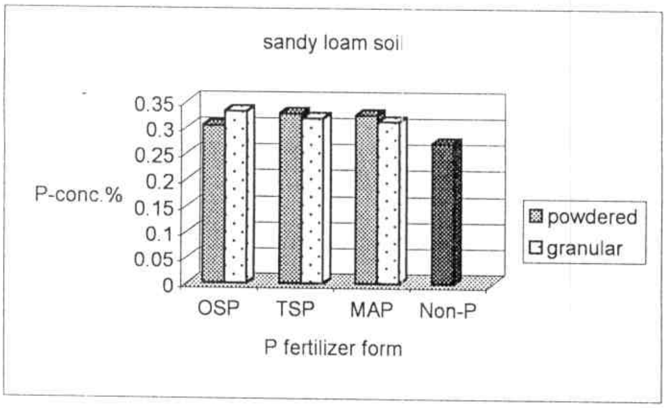


Figure (14) : Effect of applying P fertilizers (powdered and granular on P concentration in bean seeds of different soils
(P rate 50 mg /kg soil; OSP: ordinary superphosphate, TSP:triple superphosphate, MAP:monoammonium phosphate)





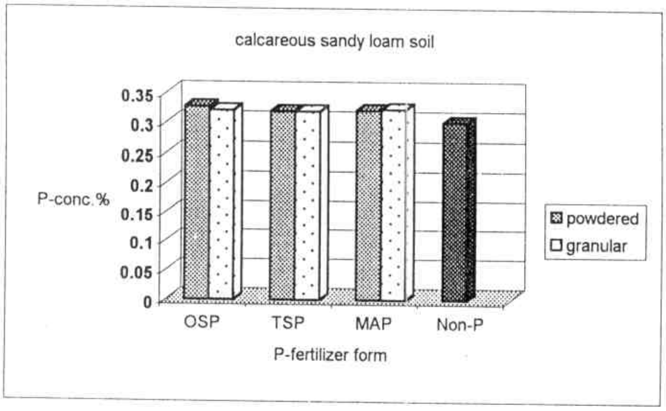
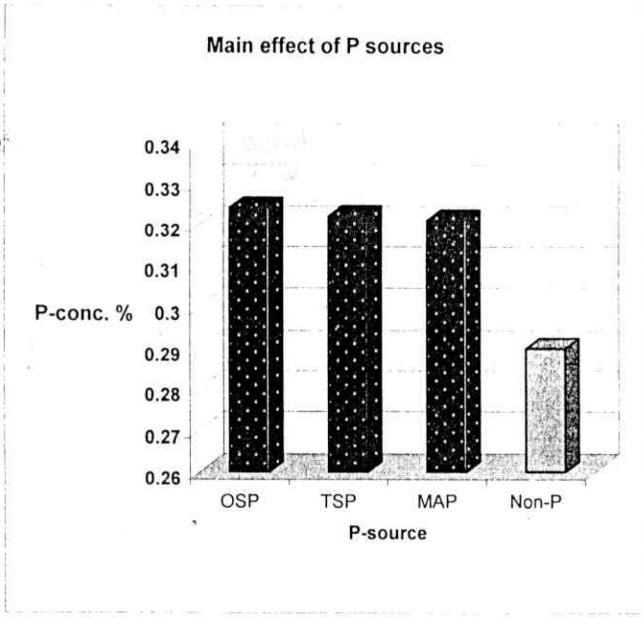
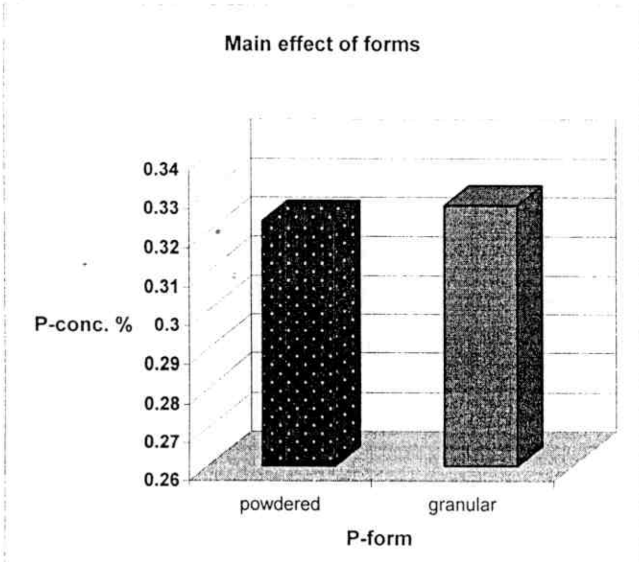


Figure (15): Main effect of applying P fertilizers and forms (average of 3 soils) on P concentration % of bean seeds
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)





4.2.2. P concentration in plant straw (Table 7 and Figs 16, 17, and 18)

As occurred with seeds, all fertilizes, generally, resulted in increases in P-concentration in straw .The mean P-concentration values for treatments receiving no P were 0.086 %, 0.087 %, and 0.115 % in straw of plants grown in the clay, sandy loam, and calcareous sandy loam soils respectively. The mean values for treatments receiving P for the same three soils (mean for all P-sources) were 0.101, 0.106, and 0.114 % for each soil respectively.

The main effect of fertilizer source showed no significant difference between sources. On the other hand there was a significant difference between the powdered and granulated forms. The powdered form resulted in straw with greater P concentration than the granulated form. There was significant interaction between the source and the form of fertilizers. The powdered form gave straw of greater P concentration over the granulated form only where the source was MAP. With other sources, the difference was not significant. There was a 3-factor interaction when MAP gave the straw of highest P - concentration over the others where the soil was clay and the form was powdered; OSP gave the highest P concentration where the soil was calcareous and the form was granular.

Table (7): **Effect of applying P fertilizers (in different sources and forms) to broad beans on P concentration % of bean straw (P rate = 50 mg/kg soil)**

Soil (A)	P form (C)	P source (B)			
		OSP	TSP	MAP	Mean
		P concentration of straw %			
Clay Soil	Powdered	0.090	0.093	0.138	**0.107**
	granular	0.97	0.092	0.93	**0.094**
	mean	**0.094**	**0.093**	**0.116**	**0.101**
Sandy Loam Soil	Powdered	0.093	0.122	0.123	**0.112**
	granular	0.092	0.118	0.080	**0.097**
	mean	**0.093**	**0.120**	**0.102**	**0.106**
Calcareous Soil	Powdered	0.130	0.116	0.102	**0.116**
	granular	0.132	0.117	0.088	**0.115**
	mean	**0.131**	**0.117**	**0.095**	**0.114**
G.mean		**0.106**	**0.110**	**0.104**	
Mean of P form					
	powdered	0.104	0.110	0.121	**0.112**
	granular	0.107	0.109	0.088	**0.101**

LSD : 0.05 A:NS B:NS C:0.005 AB:0.011
AC:NS BC:NS ABC:0.015

No P treatments :
Clay : 0.086
Sandy loam : 0.087
Calcareous : 0.115
Mean : 0.096

Notes: **OSP :Ordinary Ca-superphosphate 6.8%P:TSP : triple Ca-superphosphate 15.9%P :MAP : mono-ammonium phosphate 25.5%P , 11% N .**
(each of TSP and OSP treatments received N equal to the amount involved in MAP treatment.)

Figure (16):Main effect of applying P fertilizers on P concentration % of bean straw of different soils
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)

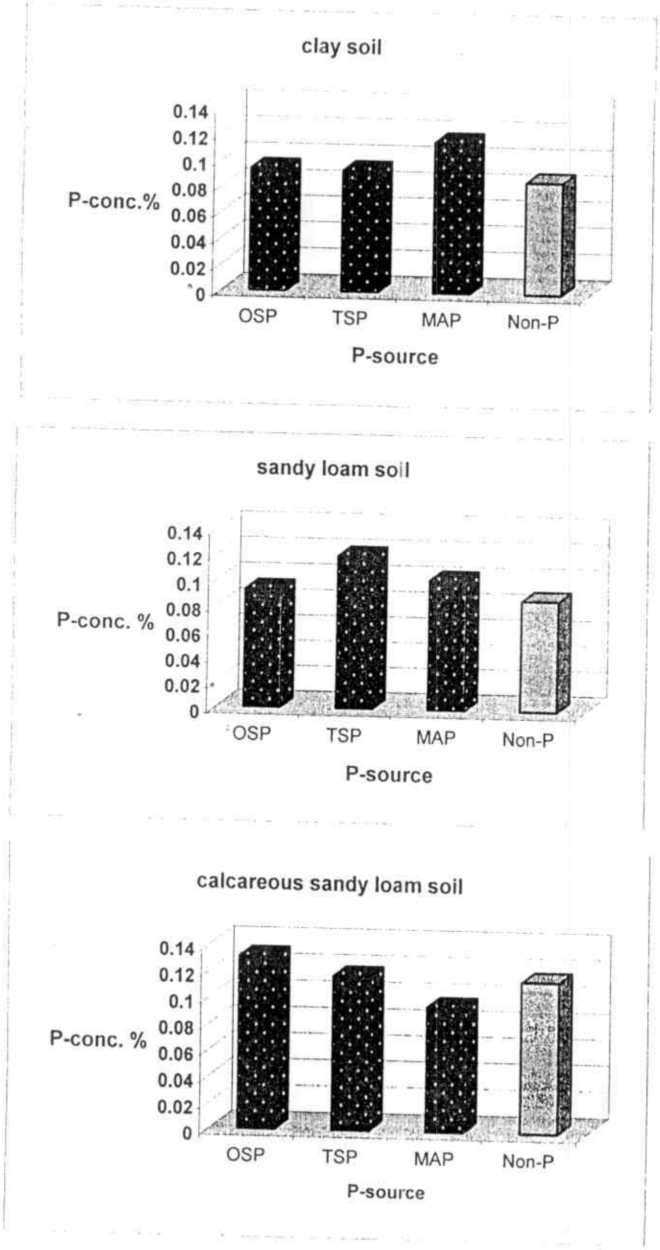
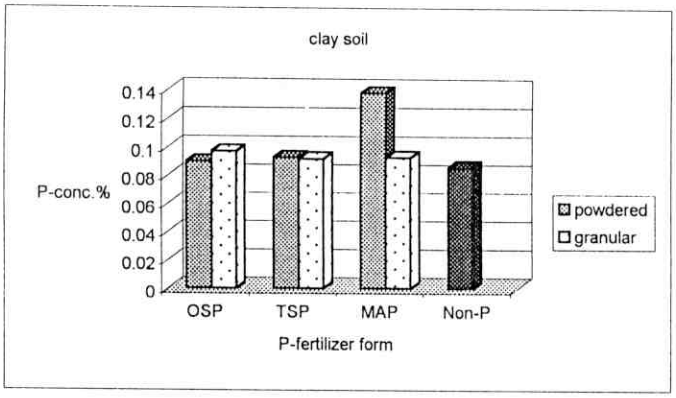
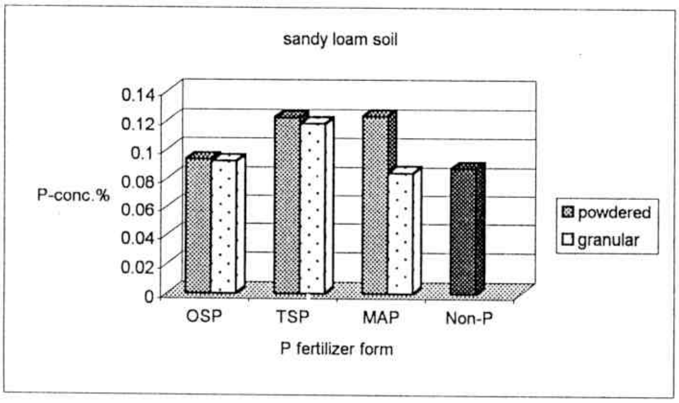


Figure (17) : Effect of applying P fertilizers (powdered and granular on P concentration in bean strraw of different soils
(P rate 50 mg /kg soil; OSP: ordinary superphosphate, TSP:triple superphosphate, MAP:monoammonium phosphate)





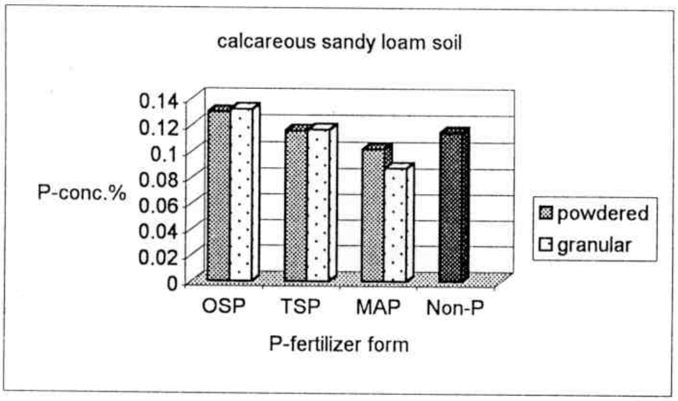
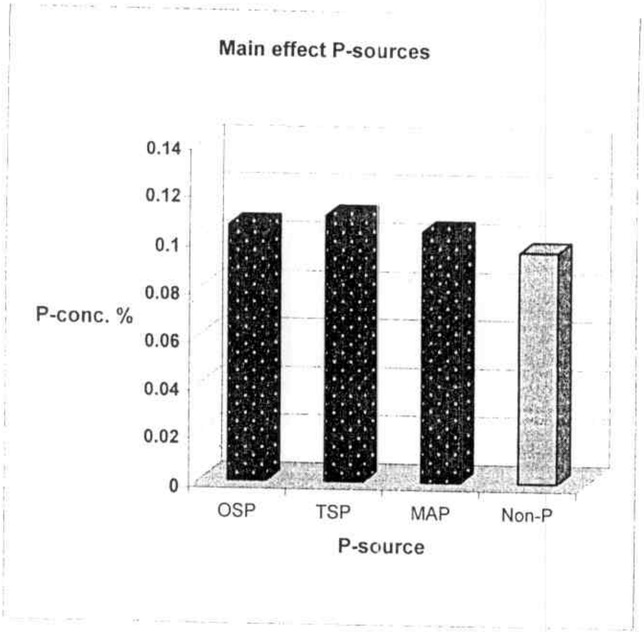
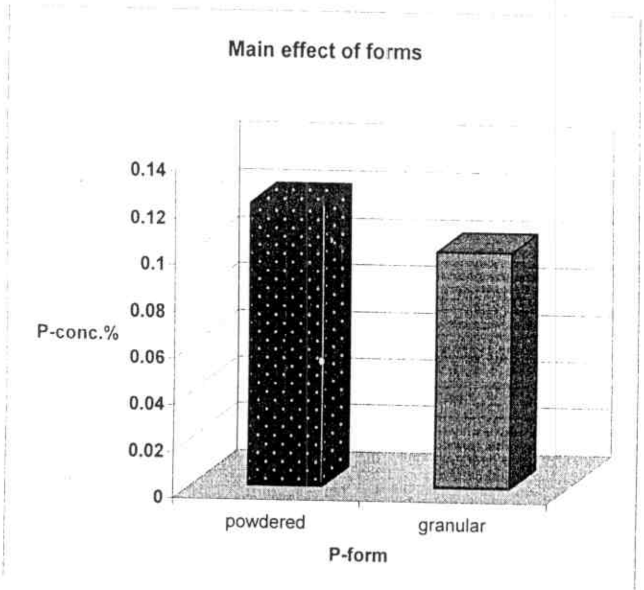


Figure (18): Main effect of applying P fertilizers and forms (average of 3 soils) on P concentration % of bean straw
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)





4.2.3. P concentration in pods (Table 8 and fig 19,20,and 21)

All fertilizers in all soils resulted in increases in P - concentration in pods. The mean values for P- concentration in pods of plants receiving no P were 0.086 %, 0.090 %, and0.075% for the clay, sandy loam, calcareous sandy loam soils respectively. The mean values for treatments receiving P were 0.119,0.124 and 0.109 % for the aforementioned soils respectively.

This represents a magnitude of increase in P concentration amounting to between one third to two thirds due to P-fertilization.

The main effect of fertilizer source showed that OSP gave slightly P contents over TSP; and OSP and TSP both, gave significantly greater contents over MAP. In this regard, there was an interaction with the soil OSP gave pods with greater P-concentration over TSP only in the sandy loam soil; TSP gave greater P concentration over OSP only in the calcareous sandy loam soil; MAP gave pods with the highest P concentration only in the clay soil. Such patterns were observed in most cases, resembling patterns of yield response (see table 4)

The main effect of forms showed that granulated fertilizers gave great P concentration over powdered fertilizers. However there was an interaction caused by fertilizer source; granular form gave P concentration more than given by the powdered form when the fertilizer source was OSP or MAP.

Table (8): Effect of applying P fertilizers (in different sources and forms) to broad beans on P concentration % of bean pods (P rate =50 mg/kg soil)

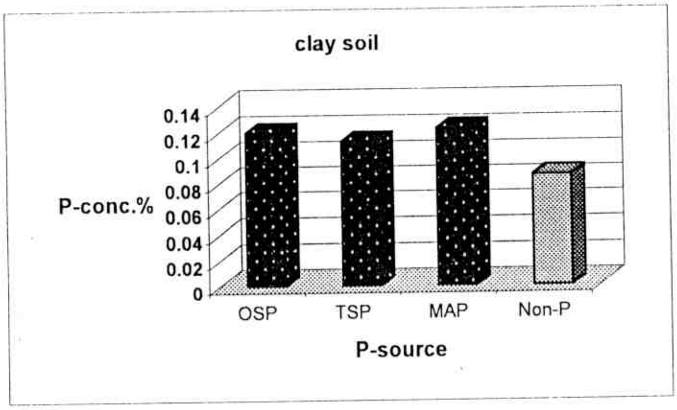
Soil (A)	P form (C)	P source (B)			
		OSP	TSP	MAP	Mean
		P concentration of pods %			
Clay Soil	Powdered	0.095	0.134	0.086	**0.105**
	granular	0.144	0.092	0.160	**0.132**
	mean	**0.120**	**0.113**	**0.123**	**0.118**
Sandy Loam Soil	Powdered	0.135	0.149	0.115	**0.133**
	granular	o.151	0.111	0.082	**0.115**
	mean	**0.143**	**0.130**	**0.099**	**0.124**
Calcareous Soil	Powdered	0.098	0.106	0.097	**0.100**
	granular	0.116	0.119	0.116	**0.117**
	mean	**0.107**	**0.113**	**0.106**	**0.108**
G.mean		**0.123**	**0.118**	**0.109**	
Mean of P-form					
	powdered	0.109	0.130	0.099	**0.113**
	granular	0.137	0.107	0.119	**0.121**

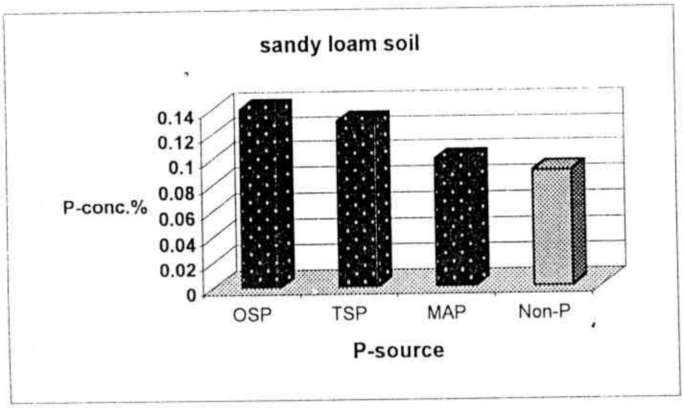
LSD : 0.05 A:0.007 B:0.007 C: 0.005
AB: 0.011 AC:0.009 BC:0.009 ABC:0.016

No P treatments :
Clay : 0.086
Sandy loam : 0.090
Calcareous : 0.075
Mean : 0.084

Notes: **OSP :Ordinary Ca-superphosphate 6.8%P. TSP : triple Ca-superphosphate 15.9%P. MAP : mono-ammonium phosphate 25.5%P , 11% N .**
(each of TSP and OSP treatments received N equal to the amount involved in MAP treatment.)

Figure (19):Main effect of applying P fertilizers on P concentration % of bean pods of different soils
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)





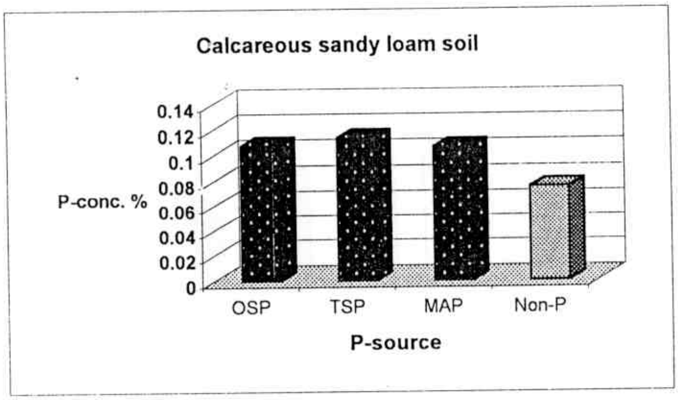


Figure (20) : Effect of applying P fertilizers (powdered and granular on P concentration in bean pods of different soils
(P rate 50 mg /kg soil; OSP: ordinary superphosphate, TSP:triple superphosphate, MAP:monoammonium phosphate)

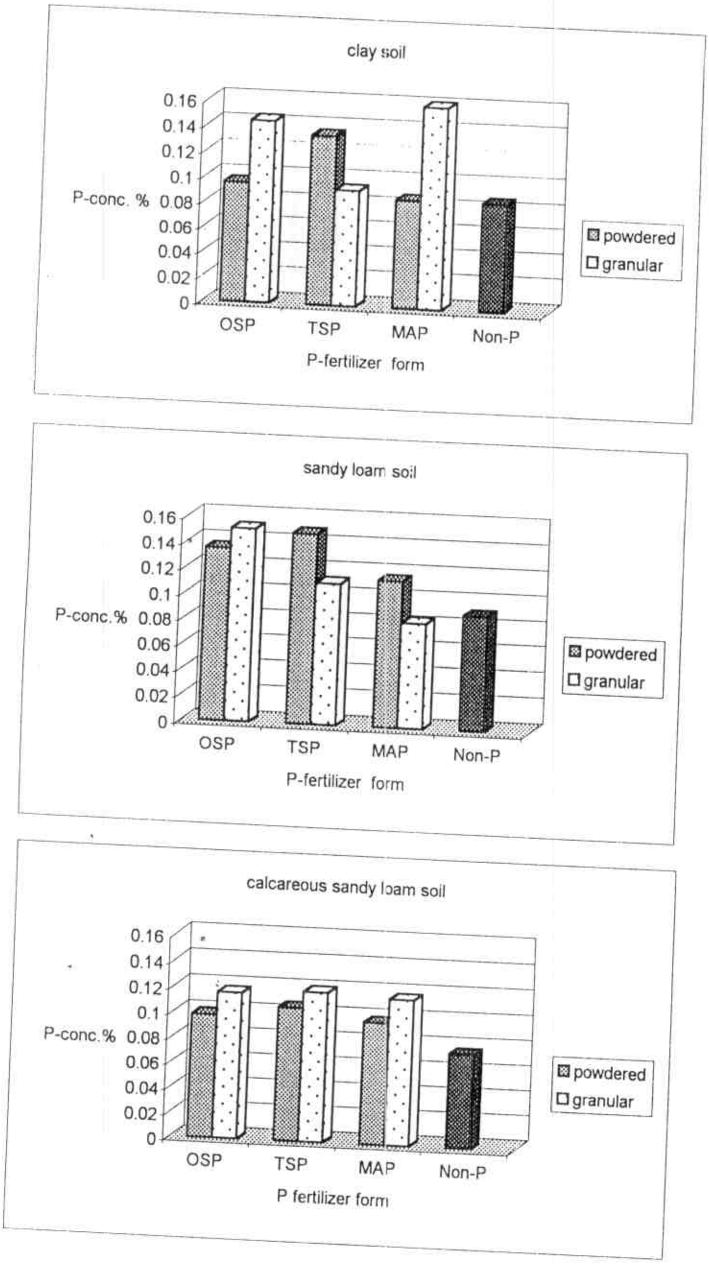
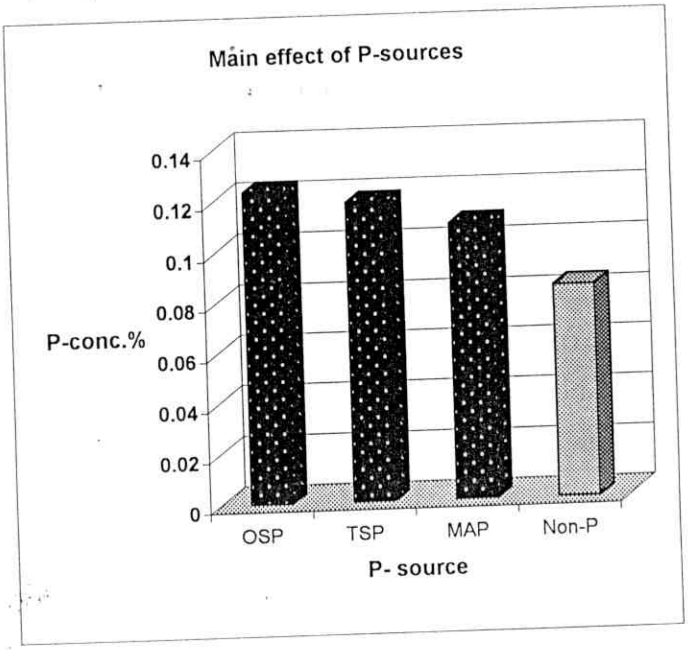
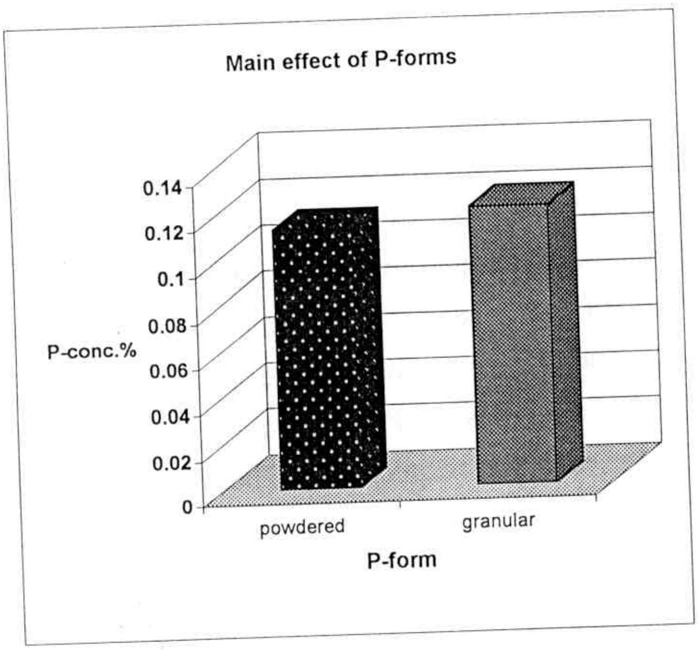


Figure (21): Main effect of applying P fertilizers and forms (average of 3 soils) on P concentration % of bean pods
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)





With TSP, the powdered form gave greater P concentration. There was anther interaction effecting the response to fertilizer form, an interaction caused by the soil; granular form gave higher P concentration than powdered, particularly in the clay and the calcareous sandy loam soils. In some cases increased P concentration was an outcome of a decreased pod yield, and *vice-versa*. In others, higher P-concentration, occurred parallel to increased yield ,such as higher P concentration as well as yield of pods caused by granular OSP and MAP over powdered OSP and MAP in the clay soil.

4.3.P- uptake by plants

Application of P resulted in increased uptake of P by the broad bean plants. Plants receiving OSP or TSP gave greater P-uptake than those receiving MAP.

4.3.1. P-uptake in bean seeds) Table 9 and Figs 22, 23, and 24)

All fertilizers in all soils resulted in increasing the uptake of P in seeds in plants. Mean values of P-uptake for treatments not receiving P were 35.24, 32.14, and 34.92 mg/pot for the clay, sandy loam and calcareous sandy loam soils respectively. Mean values for treatments receiving P (mean for all P-sources) were 49.54, 46.06, and 45.36 mg/pot for the same soils respectively. This represents an increase in P uptake averaging 40.6 %, 43.3% and 29.9 % for each soil respectively. The highest response was in the sandy loam soil.

Table (9): Effect of applying P fertilizers (in different sources and forms) to broad beans on P-uptake of bean seeds mg/pot (P rate =50mg/kg soil)

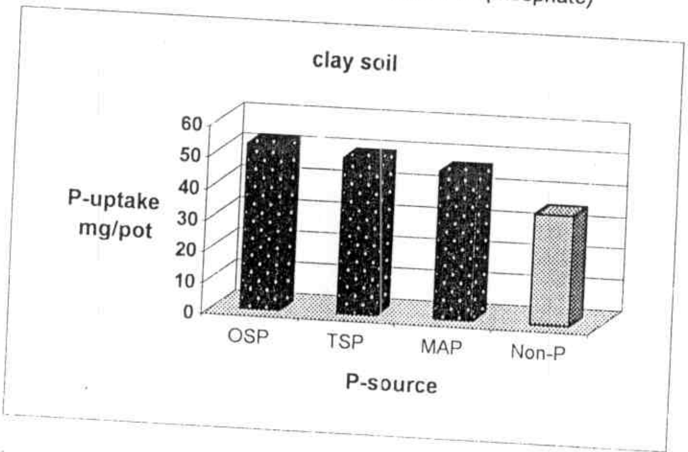
Soil (A)	P form (C)	P source (B)			
		OSP	TSP	MAP	Mean
		P uptake of seeds mg / pot			
Clay Soil	powdered	52.00	46.44	45.74	**48.06**
	granular	52.75	52.3	48.03	**51.03**
	Mean	**52.38**	**49.37**	**46.89**	**49.54**
Sandy Loam Soil	powdered	47.78	41.75	40.37	**43.30**
	granular	54.37	46.28	45.82	**48.82**
	Mean	**51.08**	**44.02**	**43.10**	**46.06**
Calcareous Soil	powdered	42.98	44.34	40.06	**42.46**
	granular	52.21	46.26	46.27	**48/25**
	Mean	**47.60**	**45.30**	**43.17**	**45.36**
G.mean		**50.35**	**46.23**	**44.38**	
Mean of P form					
	powdered	47.59	44.18	42.06	**44.61**
	granular	53.11	48.28	46.71	**49.37**

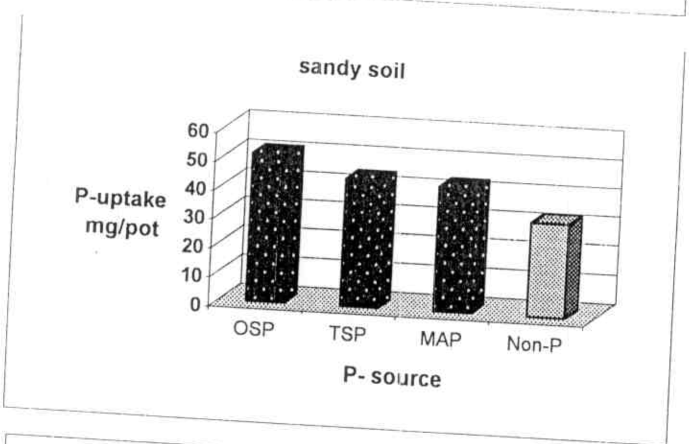
LSD : 0.05 A:1.31 B:1.31 C:1.07 AB :2.27
BC:NS AC:NS ABC:3.22

No P treatments :
Clay :35.24
Sandy loam :32.14
Calcareous: :34.92
Mean :34.10

Notes: **OSP :Ordinary Ca-superphosphate 6.8%P.TSP : triple Ca-superphosphate 15.9%P. MAP : mono-ammonium phosphate 25.5%P , 11% N . (each of TSP and OSP treatments received N equal to the amount involved in MAP treatment.)**

Figure (22):Main effect of applying P fertilizers on P uptake by bean seed of different soils
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)





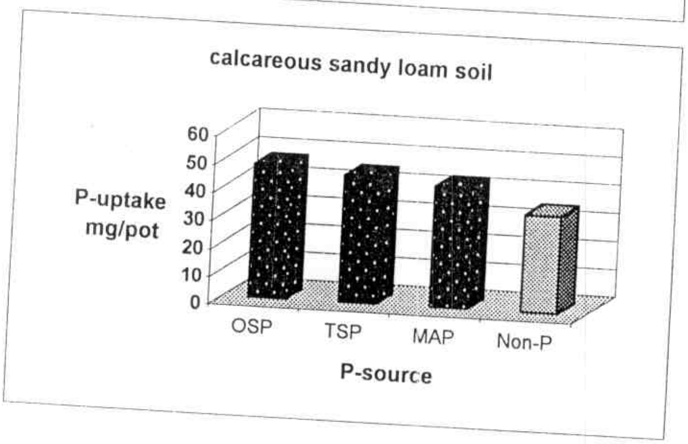
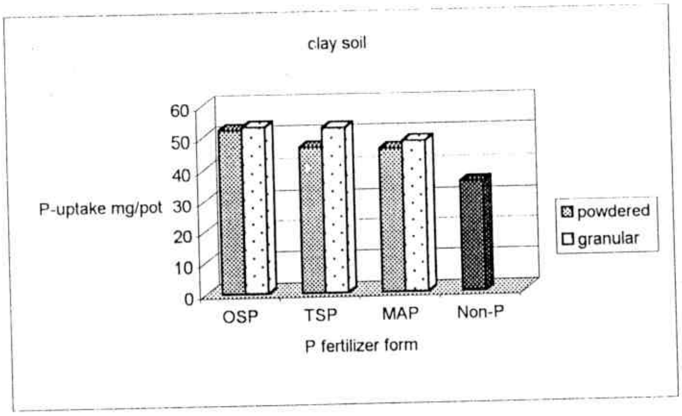
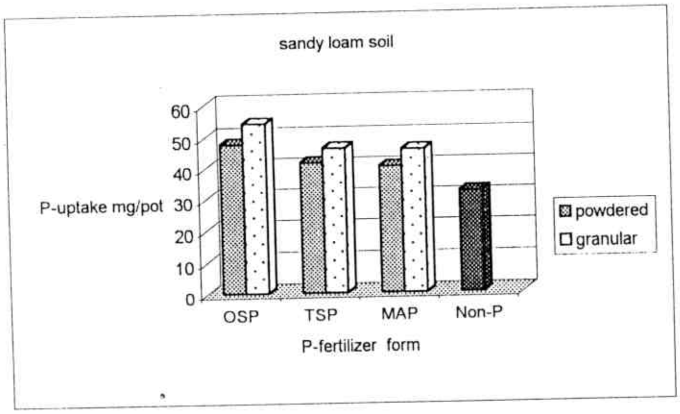


Figure (23) : Effect of applying P fertilizers (powdered and granular on P uptake by bean seeds of different soils
(P rate 50 mg /kg soil; OSP: ordinary superphosphate, TSP:triple superphosphate, MAP:monoammonium phosphate)





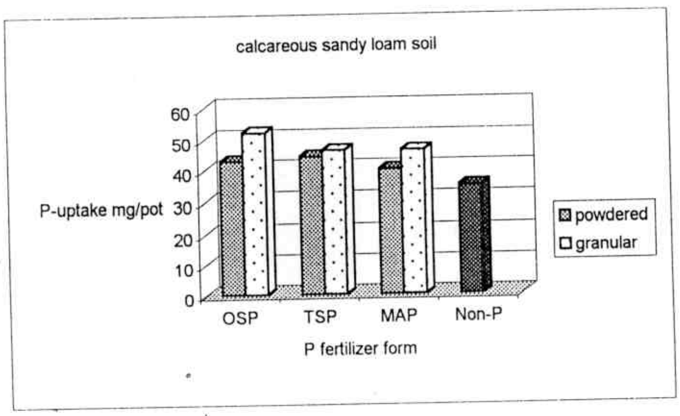
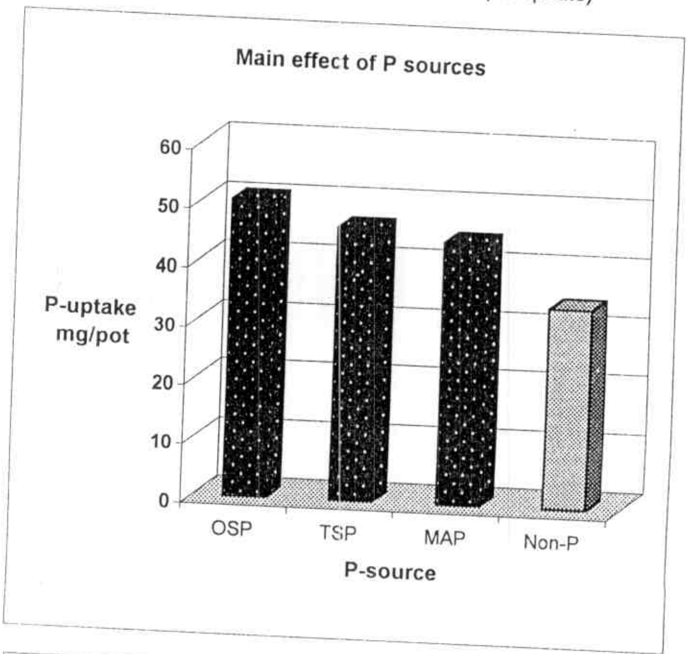
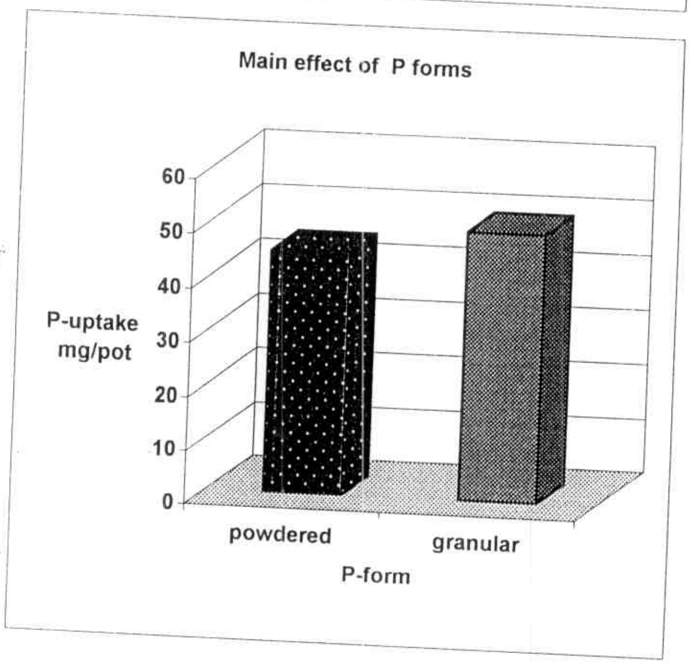


Figure (24): Main effect of applying P fertilizers and forms (average of 3 soils) on P uptake by bean seed
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)





The main effect of fertilizer source shows the following pattern: OSP gave the highest uptake followed by TSP then by MAP. Mean values of P uptake being 50.35, 46.23, and 44.38 mg/pot for the aforementioned sources respectively. Assessed as a percentage, the increases in the uptake of P were 47.7 %, 35.6 % and 30.2 % as result of applying OSP, TSP, and MAP respectively (average of all soils). Thus OSP was the most efficient and MAP was the least efficient. Superiorty of OSP over TSP; and superiorty of TSP over MAP were particularly considerable and significant in the clay soil. Therefore the ammonium phosphate (MAP) source was less effective than the both of the calcium phosphate forms as a source of P particularly in the clay soil. It seems that P of the MAP source in comparison with OSP or TSP was subject to greater fixation (or tighter retention) in this soil. Also, it may be that application of phosphate as calcium orthophosphate OSP or TSP is more benificial for plants than as ammonium phosphate since calcium phosphate introduces calcium, beside phosphorus as plant nutrient. Data of table (2) for yield of seeds may stress the second conclusion since the two calcium phosphate sources (OSP and TSP) gave greater yields of seeds over the ammonium phosphate source (MAP). The greater P uptake given by OSP over TSP, and by both sources over MAP occurred whether the fertilizers were powdered or granulated and in both the clay and the sand loam soils. In experiments under field conditions, **Salam and Hammam (1990)** on cotton grown on a clay soil, and **Ibrahim (1995)** on sorghum and barley grown on a sandy soil, reported greater efficiency of OSP over TSP in production , as well as P uptake by plants.

Granulation seems more effective for all sources in the calcareous sandy loam soil. Granulated superphosphate was reported to give more yields over powdered superphosphate fro many crops) **Chatterjee et al 1983, Sidorina et al 1985 and Sheng and Wang 1993)**

The main effect of granulation shows 10.7 % increase in P uptake as a result of using the granulated form over the powdered form. Granulation showed a clear superiorty in the calcareous soil in particular.

4.3.2. P uptake in plant straw) Table 10 and Figs 25,26, and 27)

As occurred with P-uptake in seeds, application of P-fertilizers resulted in increased uptake of P in straw of plants grown in all soils. Mean values of P uptake in straw for plants not fertilized with P were 8.03, 10.20, and 11.94 mg P/pot for the clay, sandy loam, and calcareous sandy loam soils respectively. The mean values of P uptake by straw of plants which had received P were 10.98,17.67, and 15.63 mg P/pot for plants grown in the clay, sandy loam, and calcareous sandy loam soils respectively. Therefore P application resulted in increases in P uptake amounting to 36.7 %, 73.2% and 30.9 % for each soil respectively. Highest effect was in the sandy loam soil, indicating a low fertility of this coarse–textured soil.

The main effect of fertilizer source showed that TSP gave greater P-uptake than OSP or MAP; and OSP gave greater uptake than

Table (10): Effect of applying P fertilizers (in different sources and forms) to broad beans on P-uptake of bean straw mg/pot
(P rate = 50 mg/kg soil)

Soil (A)	P form (C)	P source (B)			
		OSP	TSP	MAP	Mean
		P uptake of straw mg / pot			
Clay Soil	Powdered	9.43	8.71	14.06	**10.73**
	granular	11.59	10.19	11.92	**11.32**
	mean	**10.51**	**9.05**	**12.99**	**10.98**
Sandy Loam Soil	Powdered	18.15	22.92	21.54	**20.87**
	granular	15.15	16.98	11.26	**14.46**
	mean	**16.65**	**19.95**	**16.40**	**17.67**
Calcareous Soil	Powdered	16.86	16.97	13.51	**15.78**
	granular	17.74	16.92	11.76	**15.47**
	mean	**17.11**	**16.95**	**12.64**	**15.63**
G.mean		**14.76**	**15.45**	**13.95**	
Mean of P form					
	powdered	14.81	16.23	16.37	**15.79**
	granular	14.83	14.70	11.65	**13.73**

LSD : 0.05 A:0.632 B:0.632 C:0.516 AB:1.09
AC:0.894 BC:0.894 ABC:NS

No P treatments :
Clay: : 8.03
Sandy loam :10.20
Calcareous :11.94
Mean :10.06

Notes: **OSP :Ordinary Ca-superphosphate 6.8%P. TSP : triple Ca-superphosphate 15.9%P MAP : mono-ammonium phosphate 25.5%P , 11% N .**
(each of TSP and OSP treatments received N equal to the amount involved in MAP treatment.)

Figure (25):Main effect of applying P fertilizers on P uptake by bean straw of different soils
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)

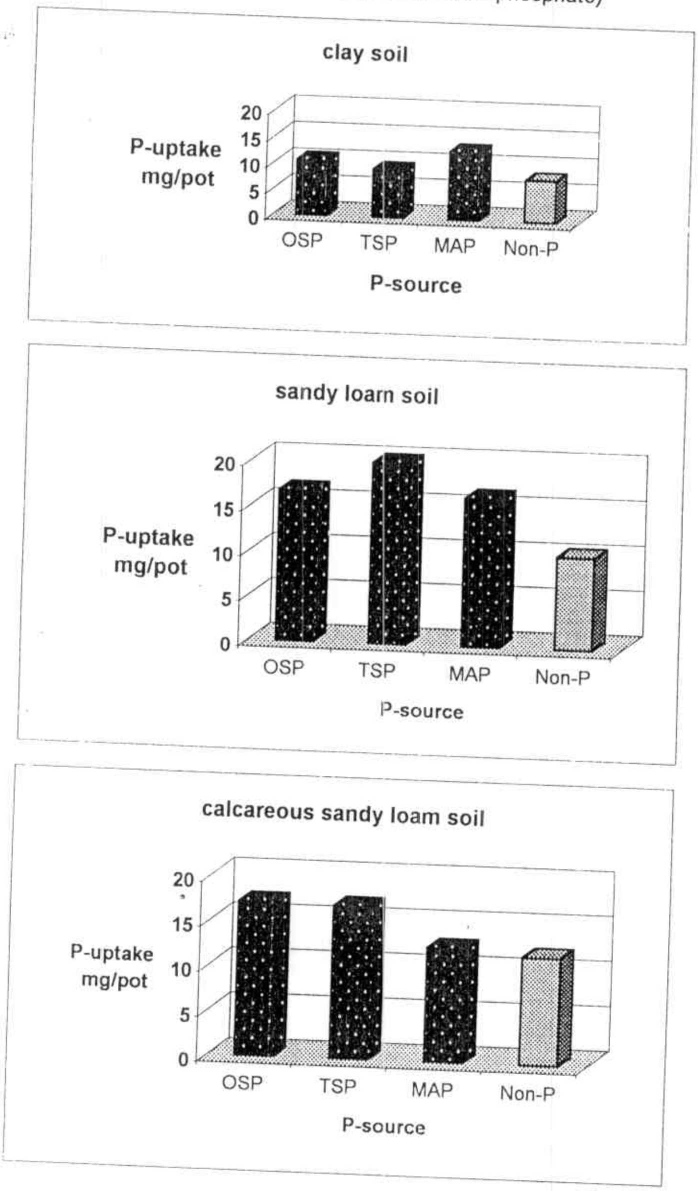
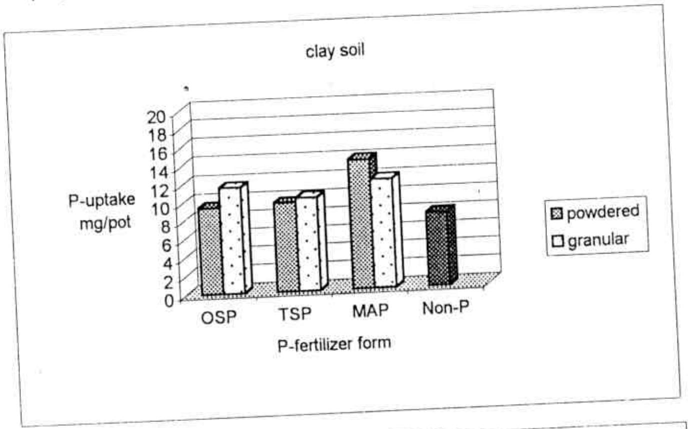
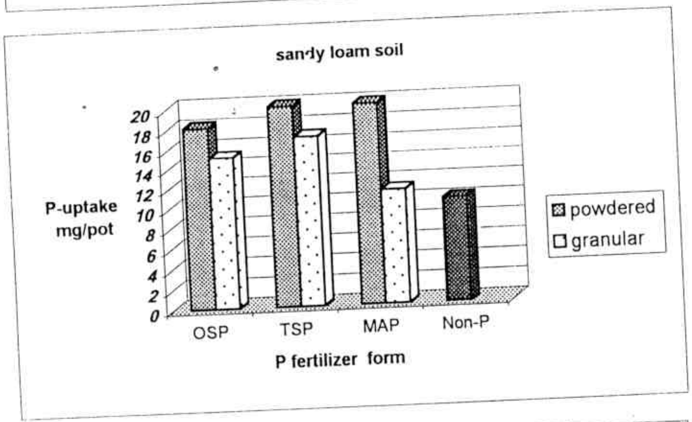


Figure (26) : Effect of applying P fertilizers (powdered and granular on P uptake by bean straw of different soils
(P rate 50 mg /kg soil; OSP: ordinary superphosphate, TSP:triple superphosphate, MAP:monoammonium phosphate)





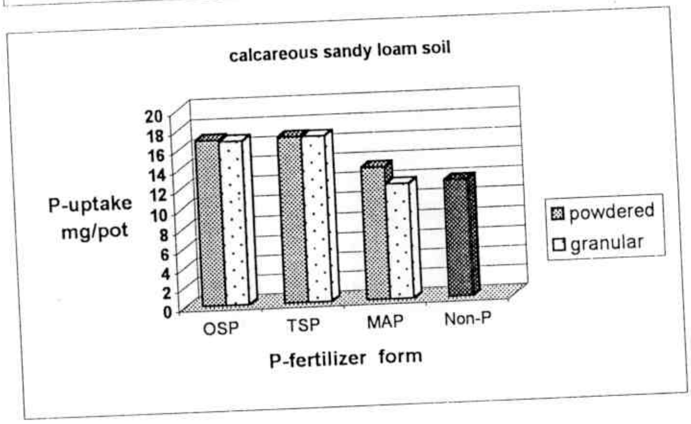
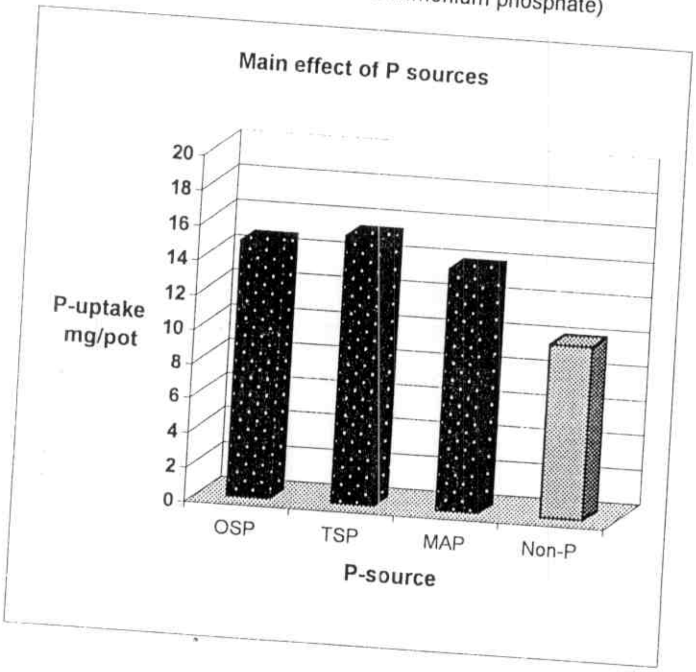
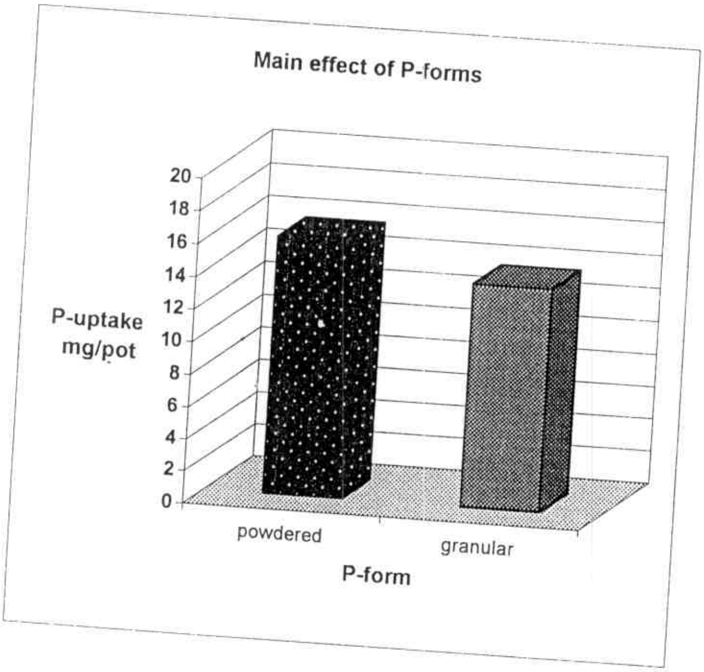


Figure (27): Main effect of applying P fertilizers and forms (average of 3 soils) on P uptake by bean straw
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: moncammonium phosphate)





MAP. Therefore the pattern was TSP > OSP > MAP. The mean values of P-uptake in straw of plants fertilized by TSP, OSP, and MAP were 15.45, 14.78 and 13.95 mg P /pot respectively. Increases in P- uptake caused by these sources were 46.7 %, 53.6 %, and 38.7 % for OSP, TSP, and MAP respectively. However there was an interaction with soil; the superiority of TSP over the other sources was particularly evident in the sandy loam soil; its superiorty in this soil occurred with both forms (powdered as well as granulated). The sandy loam soil is low in calcium carbonate, and thus it would be the lowest of the three soils in P-fixation **(Amer and Aboul Roos 1975)**. Greater uptake of P by the TSP over the OSP and MAP sources in the sandy loam soil amounted to 19.8 % and 21.8 % respectively. In the other two soils it was OSP which resulted in greater P-uptake as compared with TSP. This shows that in soils which retain fertilizer P more tightly (i.e. clay and calcareous soils), applying P as ordinary superphosphate "OSP" (which contains calcium sulphate) may be more benificial than applying it as either triple superphosphate "TSP" or ammonium phosphate "MAP" (neither of which contain calcium sulphate) . It may also indicate that the extent of P-fixation in these soils is greater from triple superphosphate or ammonium phosphate compared with ordinary superphosphate.

Application of OSP whether as powdered or granulated, was equally effective, i.e. no superiorty of one form over the other. For TSP or MAP, however, the powdered form resulted in greater P-uptake than the granulated form.

4.3.3 P-uptake in pods (Table 11 and Figs 28, 29, and 30)

All fertilizers resulted in increases in P uptake in pods. The mean values of P-uptake for treatments not receiving P fertilizer were 1.89, 2.57, and 1.90 mg P/pot for the clay, sandy loam, and calcareous sandy loam respectively. The mean values for the treatments receiving P (average of all P-sources and forms) were 3.40, 4.27, and 3.79 mg P/pot for the same mentioned soils respectively. Such increases amounted to 79.9%, 49.4% and 46.9 % for each of these respective soils.

The main effect of fertilizer source showed no significant difference between the sources. The mean values for P-uptake given by the P sources were 3.99, 3.78, and 3.69 mg P/pot for OSP, TSP, and MAP respectively. Increases due to fertilizer P application caused by these sources were 88.2 %, 78.3 %, and 74.1 % for each of the aforementioned sources respectively. There were significant interactions between three sources. For example, there was an interaction with soils when in the clay soil and in the calcareous soil MAP gave the highest uptakes, but in the sandy loam soil OSP gave the highest uptake. There was an increase of 15.4% and 15.3% caused by MAP over OSP in P-uptake in the clay soil and the calcareous soil respectively. In the sandy loam soil the OSP source gave 58.3 % increase over MAP. This may reflect a greater need for calcium and sulphate in the sandy loam soil as compared with the other soils.

Table (11): Effect applying P fertilizers (in different sources and forms) to broad beans on P-uptake of bean pods mg/pot
(P rate = 50 mg/kg soil)

Soil (A)	P form (C)	P source (B)			
		OSP	TSP	MAP	Mean
		P uptake of pods mg / pot			
Clay Soil	Powdered	2.29	3.33	2.50	**2.69**
	granular	4.25	3.04	5.01	**4.11**
	mean	**3.25**	**3.19**	**3.75**	**3.40**
Sandy Loam Soil	Powdered	5.30	5.05	3.86	**4.74**
	granular	5.18	3.48	2.76	**3.81**
	mean	**5.24**	**4.27**	**3.31**	**4.27**
Calcareous Soil	Powdered	4.18	3.34	3.62	**3.71**
	granular	2.77	4.47	4.37	**3.87**
	mean	**3.47**	**3.90**	**4.00**	**3.79**
G.mean		**3.99**	**3.78**	**3.69**	
Mean of P-form					
	powdered	3.91	3.90	3.33	**3.71**
	granular	4.07	3.66	4.04	**3.92**

LSD : 0.05 A:0.26 B:NS C:0.21 AB:0.45
AC:0.36 BC:0.36 ABC:0.61

No P treatments :
Clay : 1.89
Sandy loam : 2.57
Calcareous : 1.90
Mean : 2.12

Notes: **OSP :Ordinary Ca-superphosphate 6.8%P. TSP : triple Ca-superphosphate 15.9%P. MAP : mono-ammonium phosphate 25.5%P , 11% N .**
(each of TSP and OSP treatments received N equal to the amount involved in MAP treatment.)

Figure (28):Main effect of applying P fertilizers on P-uptake by bean pods of different soils
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)

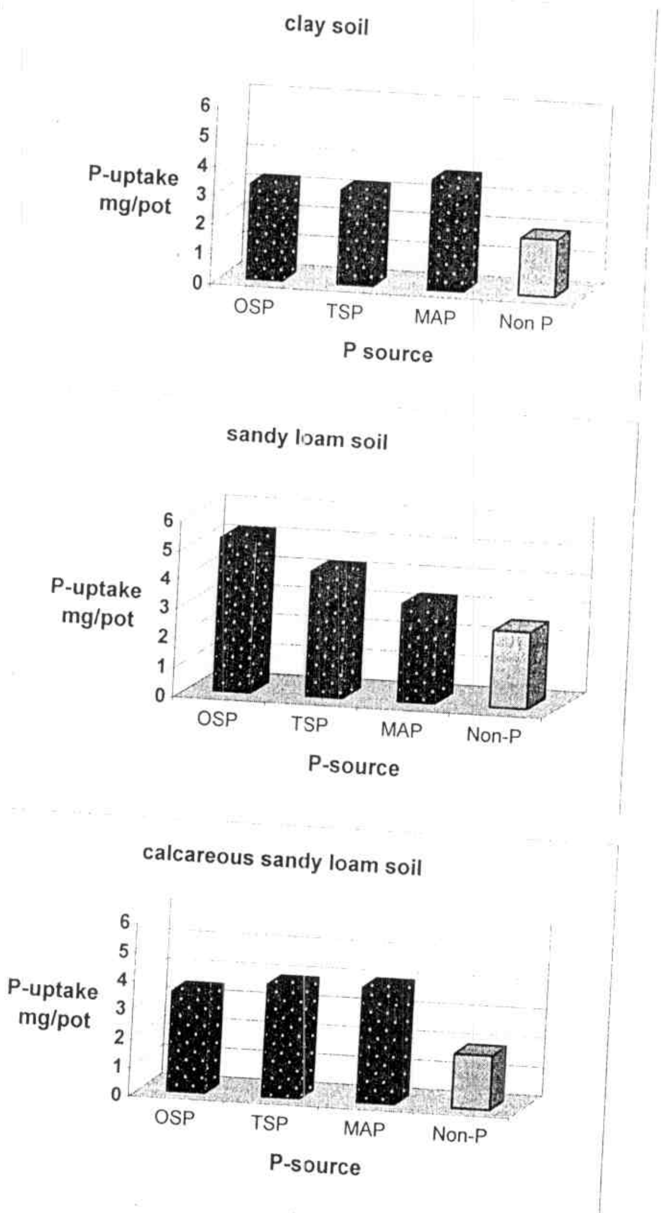


Figure (29) : Effect of applying P fertilizers (powdered and granular on P uptake by bean pods of different soils
(P rate 50 mg /kg soil; OSP: ordinary superphosphate, TSP:triple superphosphate, MAP:monoammonium phosphate)

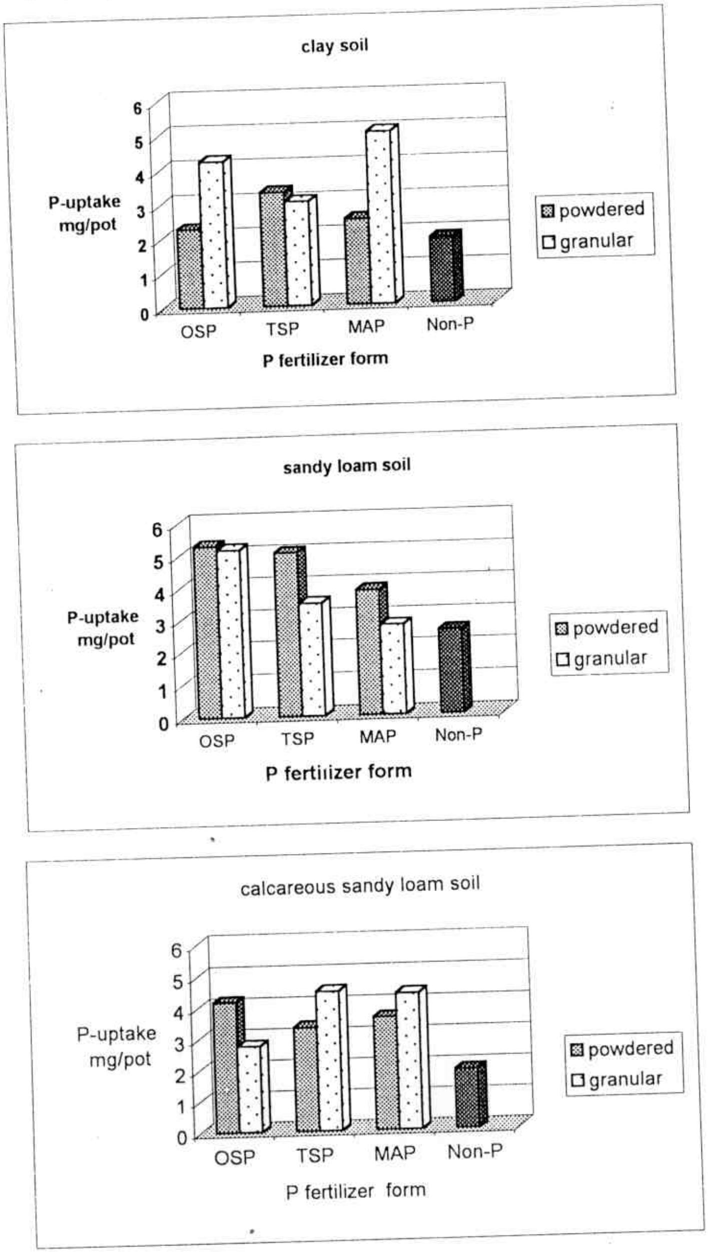
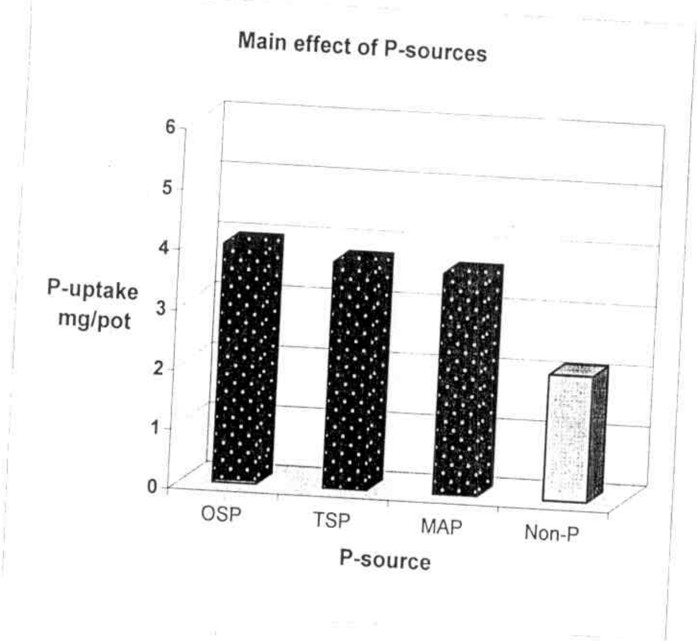
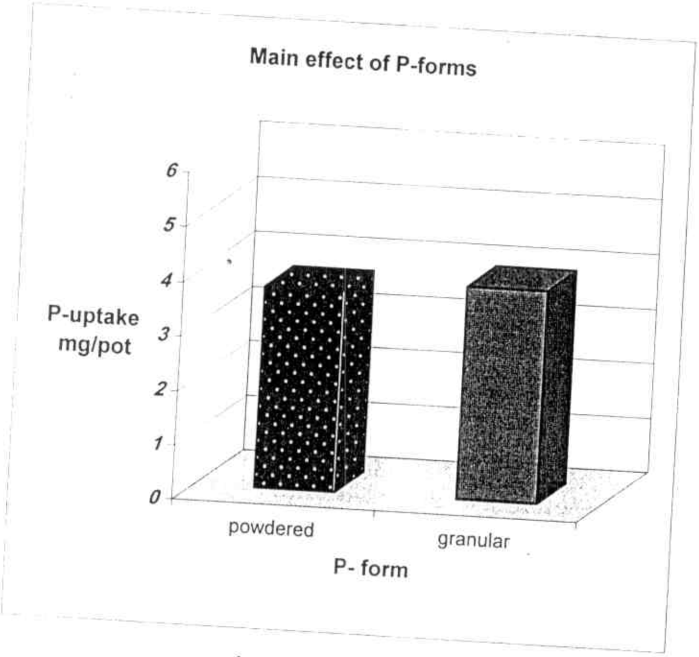


Figure (30): Main effect of applying P fertilizers and forms (average of 3 soils) on P uptake by bean pods
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)





The main effect of fertilizer forms shows that the granulated form resulted in greater uptake than the powdered form. However, soil as well as fertilizer source showed a significant interaction regarding the effect of form. The superiorty of the granulated form over the powdered form was most pronounced in the clay soil giving P- uptake which was greater by 52.8 % when granulated than when powdered; in the calcareous sandy loam soil there was a slightly greater uptake with granulated form. In the sandy loam soil, however, the powdered form was superior to the granulated form by 24.4 %.

Granulation was most effective when MAP was the source in the calcareous soil and the clay soil. In the sandy loam soil, pulverization (powdering) of fertilizers was more effective than granulation. The improvement effect of granulation in decreasing P fixation in clayey and calcareous soils is thus manifested in such results. Therefore in the two soils (i.e. the clay and calcareous soils) which would, most certainly, have greater capacity for tight retention (i.e. fixation) of phosphate, the positive effect of granulation in decreasing P-tight retention (or P-fixation) is apparent. In the sandy loam soil (which does not have high contents of calcium carbonate nor high contents of clay) it seems that pulverization helps in spreading fertilizer particles so as to allow the reach of as much root surface as possible, to the P source.

4.3.4. P uptake of above-soil plant parts (seeds + straw + pods):" Table 12 and Figs 31,32, and 33:"

Uptake of above-soil plants parts (i.e. seed +straw +pods) show that application of P fertilizers resulted in increases in P uptake in total plant parts. The mean values of P-uptake by plants not receiving P were 46.70, 42.40, and 48.20 mg/pot for plants grown in the clay, sandy loam, and calcareous sandy loam soils respectively. Treatment which had received P, gave uptake values (means over the 3 P-sources) of 63.53, 67.35 and 65.32 mg/pot for the same respective soils. Such values show increases of 36.1 %, 58.9 % and 35.5 % in P uptake in plants grown in each of these soils respectively. **Holford (1995)** stated that the highest uptake of P occurred in plants grown on soils with the lowest buffering capacity (sandy soils), and the lowest uptake occurred in soils with the highest buffering capacity (clay and calcareous sandy loam soils).

The main effect of fertilizer source showed the following pattern: OSP>TSP>MAP.This is the same pattern obtained with regard to yield (see Table 5 and Figs 10 to 11). The mean values of P-uptake given by P sources were 68.85, 66.12, and 61.23 mg/pot for OSP, TSP, and MAP respectively. Increases caused by these sources amounted to 50.4 %, 44.4 %, and 33.8 % for each of the aforementioned sources respectively.

The OSP source was superior to the TSP source in all three soils, and particularly in the sandy loam soil; which had low plant nutrient contents and less fixation factors. The OSP source was superior to the MAP source in all soils particularly in the sandy loam soil.

The TSP source was superior to the MAP source in all three soils, particularly in the calcareous soil, which has a high pH, and under such condition losses of nitrogen from MAP by ammonia volatilization **(Stumpe et al 1984)** may had occurred. The superiorty of OSP over TSP and MAP occurred whether the P fertilizer was powdered or granulated. This confirms the high efficiency of ordinary calcium superphosphate, which contains calcium sulphate along with calcium phosphate. Granulation gave the higher P-uptake over pulverization particularly when OSP was used in the calcareous soil. The granular form gave, greater uptake over the powdered form; the mean P-uptake for the former was 66.76 mg P/pot as compared with 64.04 mg P/ pot given by the pulverized (powdered) form.

Plants grown in the sandy loam soil gave the highest P-uptake and those of the clay soil gave the lowest. The mean values of P uptake given by plants grown in the fertilized soils were 63.53, 67.35 , and 65.32 mg P/pot for plants grown in the clay , sandy loam , and calcareous sandy loam soils, respectively.

Table (12): **Effect of applying P fertilizers (in different sources and forms) to broad beans on total P-uptake (seeds + straw + pods) mg/pot**

(P rate = 50 mg/kg soil)

Soil (A)	P form (C)	P source (B)			
		OSP	TSP	MAP	Mean
		P uptake of total plants mg / pot			
Clay Soil	powdered	63.70	59.90	58.58	**60.72**
	granular	66.86	67.08	65.10	**66.35**
	Mean	**65.27**	**63.49**	**61.84**	**63.53**
Sandy Loam Soil	powdered	71.04	68.39	65.39	**68.27**
	granular	74.69	65.69	58.89	**66.42**
	Mean	**72.67**	**67.04**	**62.14**	**67.35**
Calcareous Soil	powdered	64.11	68.04	57.20	**63.12**
	granular	72.73	67.61	62.23	**67.52**
	Mean	**68.42**	**67.83**	**59.71**	**65.32**
G.mean		**68.85**	**66.12**	**61.23**	
Mean of P-forms					
	powdered	66.27	65.44	60.39	**64.04**
	granular	71.43	66.79	62.07	**66.76**

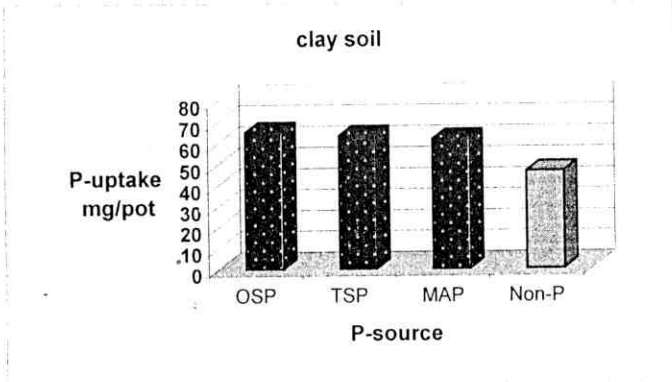
LSD : 0.05 A:1.6 B:1.6 C:1.3 AB:2.8 AC:2.3 BC:2.3 ABC:3.9

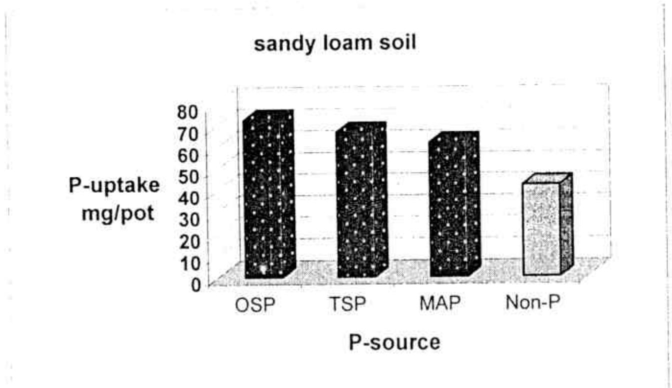
No P treatments :

Clay :46.70
Sandy loam :42.40
Calcareous :48.20
Mean :45.76

Notes: **OSP :Ordinary Ca-superphosphate 6.8%P. TSP : triple Ca-superphosphate 15.9%P. MAP : mono-ammonium phosphate 25.5%P , 11% N .**
(each of TSP and OSP treatments received N equal to the amount involved in MAP treatment.)

Figure (31) :Main effect of applying P fertilizers on P uptake by total plant patrs (seeds + straw + pods) of different soils (P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)





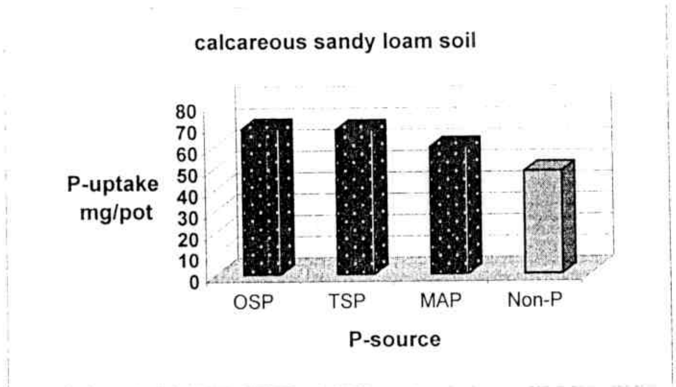


Figure (32): Effect of applying P fertilizers (powdered and granular) on total P uptake by (seeds + straw + pods) of different soils
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP:triple superphosphate, MAP: monoammonium phosphate)

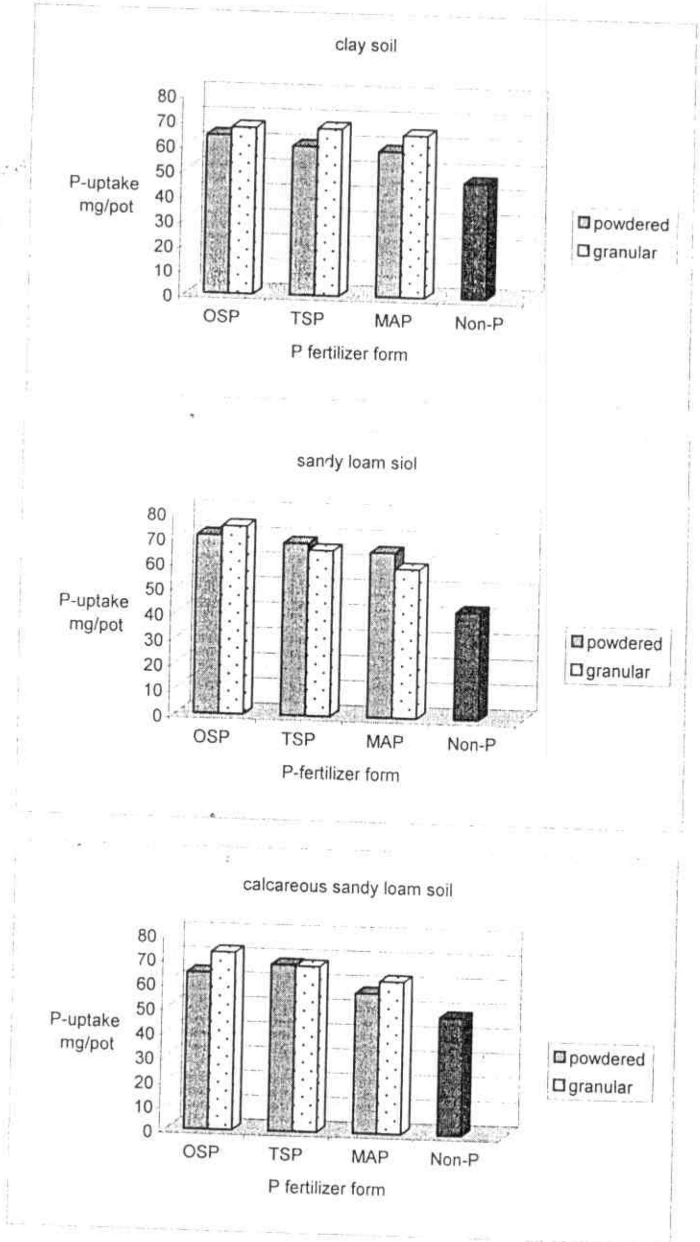
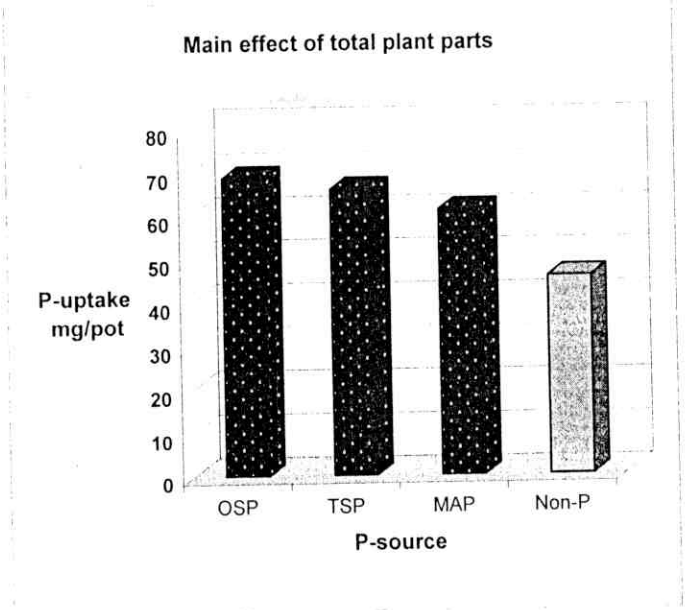
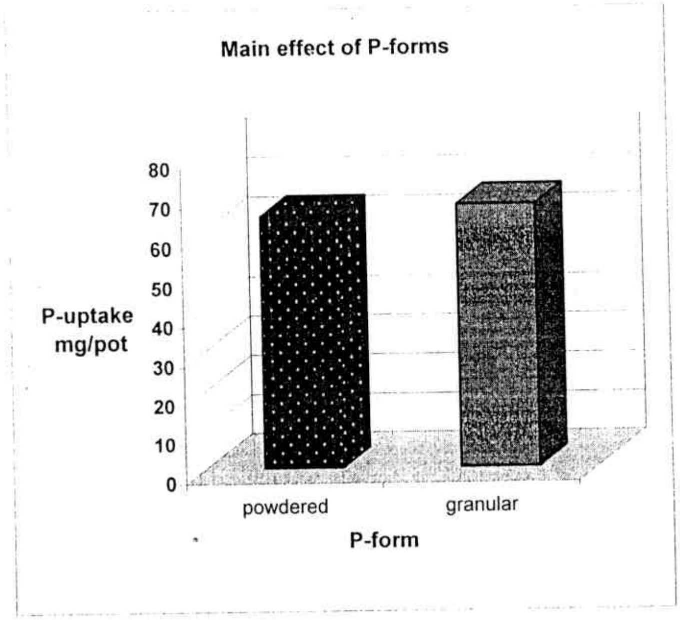


Figure (33): Main effect of applying P fertilizers and forms (average of 3 soils) on P uptake by total plant parts (seeds+ straw + pods) (P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)





4.4 Ca uptake by the plant

4.4.1. Ca uptake by broad bean seeds (Table 13 and Figs 34, 35, and 36)

The use of P fertilizers in all soils resulted in increases in Ca uptake by seed. The mean values for treatments not receiving P were 8.48, 10.19, and 8.08 mg Ca /pot for the clay, sandy loam, and calcareous sandy loam soils respectively. The mean values for treatments receiving P (mean for all P-sources) were 9.93, 11.18, and 13.19 mg Ca /pot in seeds of plants grown in the same respective soils; the percentage increase being 17.09 %, 9.7% and 63.2 % for each soil respectively.

The main effect of fertilizer source showed the following pattern: TSP>OSP>MAP. The mean yields given by P sources were 11.85, 11.50, and 10.95 mg Ca/pot for TSP, OSP, and MAP respectively. Increases caused by these sources amounted to 32.8 %, 28.9 %, and 22.8 % for each source respectively. Such a pattern resembles the patterns concerning plant yields and P uptake.

The OSP gave greater Ca-uptake over the TSP and MAP sources in the clay and the sandy loam soils in particular. In the calcareous soil the TSP source was superior to OSP and MAP; also the MAP source was superior to the OSP source in the calcareous soil. Both of OSP and TSP gave greater Ca –uptake in soils over the MAP source respectively when used the fertilizer as granulated. The granular form gave an average, greater Ca-uptake over the powdered form

Table (13): Effect of applying P fertilizers (in different sources and forms) to broad beans on Ca-uptake of bean seeds mg/pot (P rate =50 mg/kg soil)

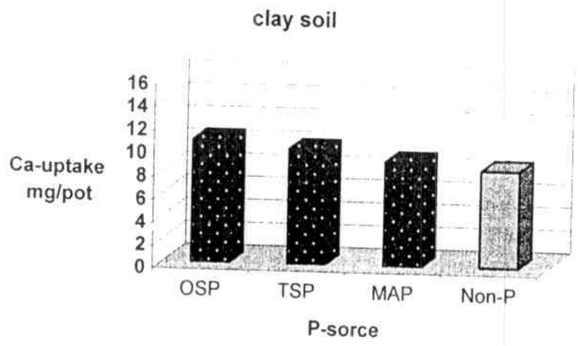
Soil (A)	P form (C)	P source (B)			
		OSP	TSP	MAP	Mean
		Ca uptake of seeds mg / pot			
Clay Soil	Powdered	10.25	9.74	8.58	**9.53**
	granular	11.08	10.32	9.61	**10.34**
	mean*	**10.67**	**10.03**	**9.10**	**9.93**
Sandy Loam Soil	Powdered	11.94	9.57	11.53	**11.02**
	granular	12.24	10.72	11.10	**11.35**
	mean	**12.10**	**10.15**	**11.31**	**11.18**
Calcareous Soil	Powdered	8.61	11.86	12.11	**10.86**
	granular	14.87	18.90	12.78	**15.52**
	mean	**11.74**	**15.38**	**12.44**	**13.19**
G.mean		**11.50**	**11.85**	**10.95**	
* Mean of P-form					
	powdered	10.27	10.39	10.74	**10.47**
	granular	12.73	13.31	11.16	**12.40**

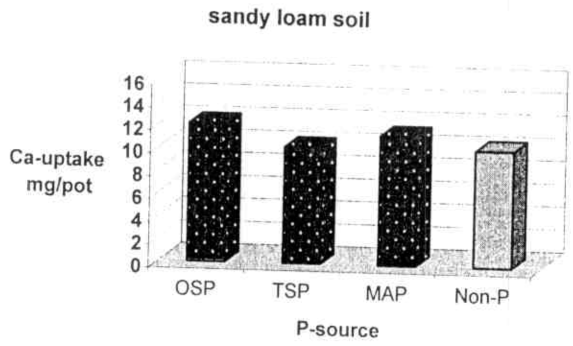
LSD : 0.05 A:0.30 B:0.30 C:0.25 AB:0.52 AC:0.43 BC:0.43 ABC:0.84

No P treatments :
Clay : 8.48
Sandy loam :10.19
Calcareous : 8.08
Mean : 8.92

Notes: **OSP :Ordinary Ca-superphosphate 6.8%P. TSP : triple Ca-superphosphate 15.9%P. MAP : mono-ammonium phosphate 25.5%P , 11% N .**
(each of TSP and OSP treatments received N equal to the amount involved in MAP treatment.)

Figure (34) :Main effect of applying P fertilizers on Ca- uptake by bean seeds of different soils
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)





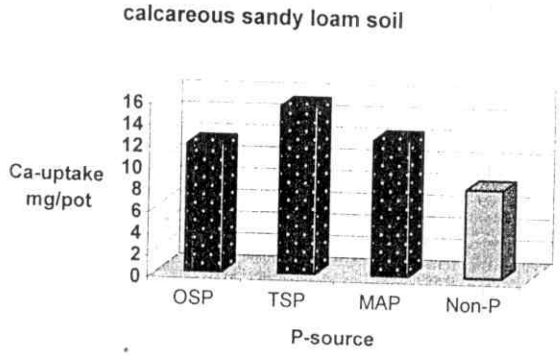


Figure (35): Effect of applying P fertilizers (powdered and granular) on Ca uptake by bean seeds of different soils
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP:triple superphosphate, MAP: monoammonium phosphate)

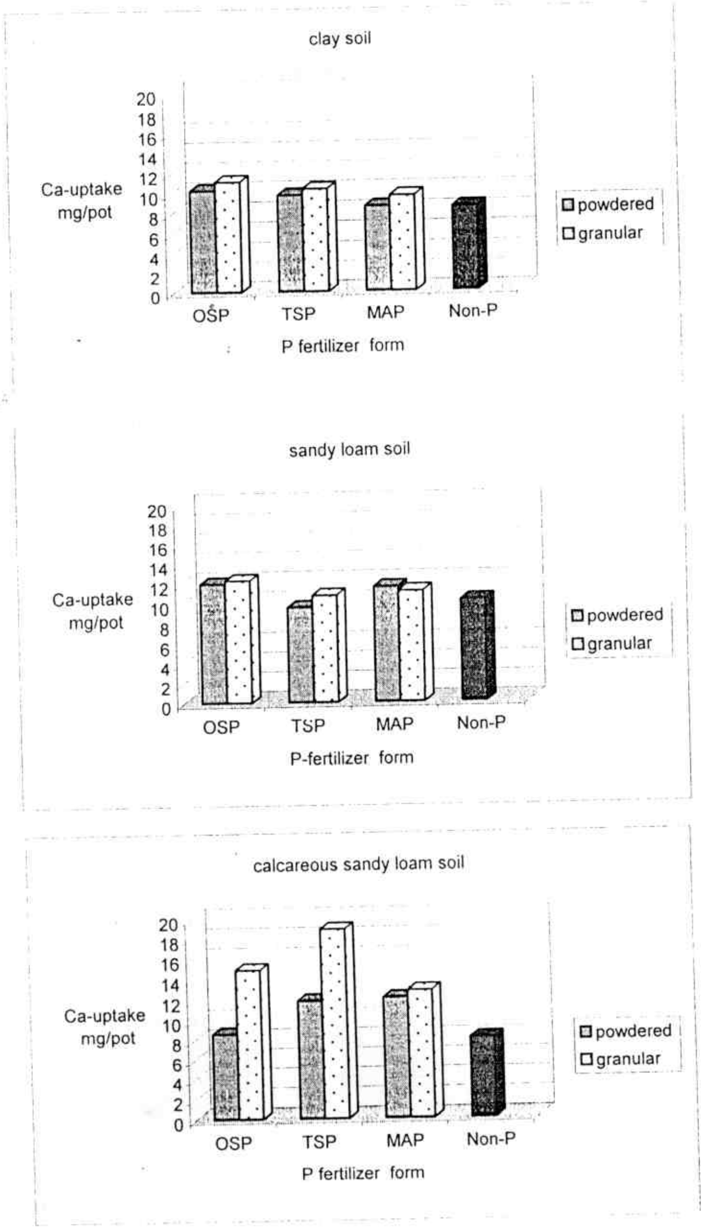
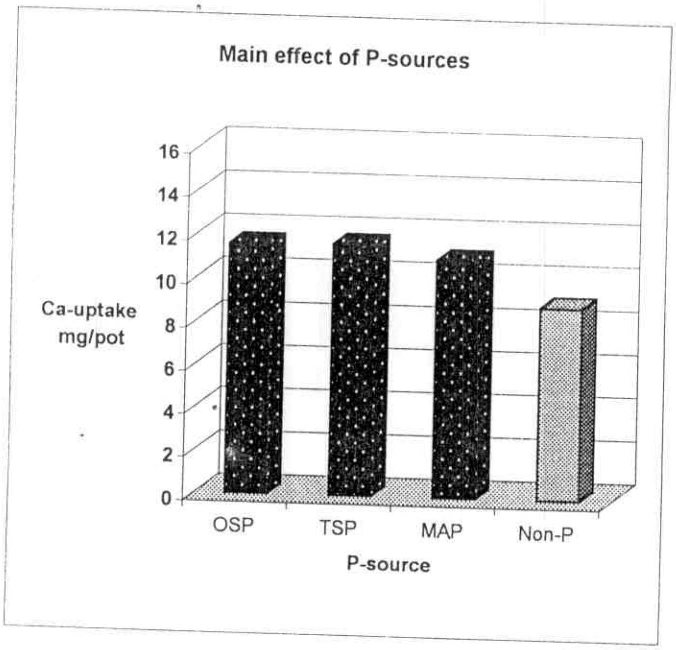
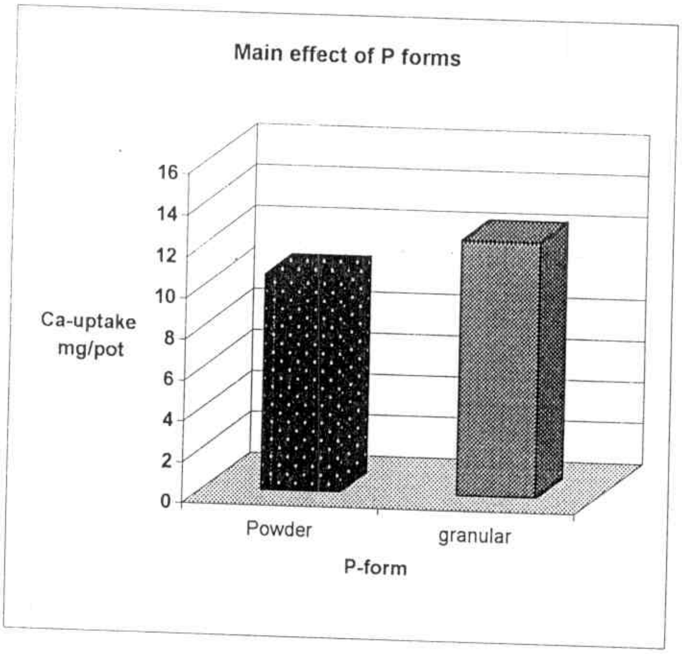


Figure (36): Main effect of applying P fertilizers and forms (average of 3 soils) on Ca-uptake by bean seeds
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)





The main Ca-uptake values for the granulated form was 12.40 mg P/pot as compared with10.47m g/ pot given by the powdered form; an increase of 18.4 % due to the use granulated fertilizers

Seeds of plants grown in the calcareous sandy loam soil gave the highest Ca-uptake reflecting the abundance of Ca in this particular soil and plants of clay soil gave the lowest. Mean values of Ca uptake given by seeds of plants grown in the fertilized soils were 9.93,11.18 and 13.19 mg Ca/pot for the clay, sandy loam, and sandy loam calcareous soils respectively.

4.5 Parameters in soil after harvesting

4.5.1 Soil pH (Table 14 and Figs 37,38, and 39)

All fertilizers in all soils resulted in very slight decreases in pH values. The mean value of treatments not receiving P was 8.06,7.83, and 8.28 for soils the clay, sandy loam, and calcareous sandy loam soils respectively.The mean values for treatments receiving P (mean for all P-sources) were 8.07, 7.58 and 8.25 mg for the same three soils respectively. Differences among sources or forms were not significant. **Yasmin et al (1994)** reported that OSP treatment lowered the pH value of the soil from being 8.64 to 6.41.

The calcareous sandy loam soil showed the highest pH value and the sandy loam soil gave the lowest. Mean values of pH of the fertilized soils were 8.07,7.58 and 8.25 for the aforementioned soils respectively.

Table (14): Effect of applying P fertilizers (in different sources and forms) to broad beans on Soil pH at harvest (P rate =50 mg/kg soil)

Soil (A)	P form (C)	P source (B)			
		OSP	TSP	MAP	Mean
		Soil pH at harvest			
Clay Soil	Powdered	8.10	8.07	8.10	**8.09**
	granular	8.07	8.03	8.07	**8.06**
	mean	**8.08**	**8.05**	**8.08**	**8.07**
Sandy Loam Soil	Powdered	7.70	7.53	7.53	**7.59**
	granular	7.57	7.57	7.60	**7 58**
	mean	**7.93**	**7.55**	**7.57**	**7.58**
Calcareous Soil	Powdered	8.30	8.27	8.33	**8.30**
	granular	8.13	8.23	8.23	**8.20**
	mean	**8.22**	**8.25**	**8.28**	**8.25**
G.mean		**7.98**	**7.95**	**7.98**	
Mean of P-form					
	powdered	8.03	7.96	7.99	7.99
	granule	7.92	7.94	7.97	7.94

LSD : 0.05 **A:0.08** **B:NS** **C:NS** **AB:NS**
AC:NS **BC:NS** **ABC:NS**

No P treatments :

Clay : 8.06
Sandy loam : 7.83
Calcareous : 8.28
Mean : 8.05

Notes: **OSP :Ordinary Ca-superphosphate 6.8%P. TSP : triple Ca-superphosphate 15.9%P. MAP : mono-ammonium phosphate 25.5%P , 11% N .**
(each of TSP and OSP treatments received N equal to the amount involved in MAP treatment.)

Figure (37) : Main effect of applying P fertilizers on pH at harvest of different soils
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)

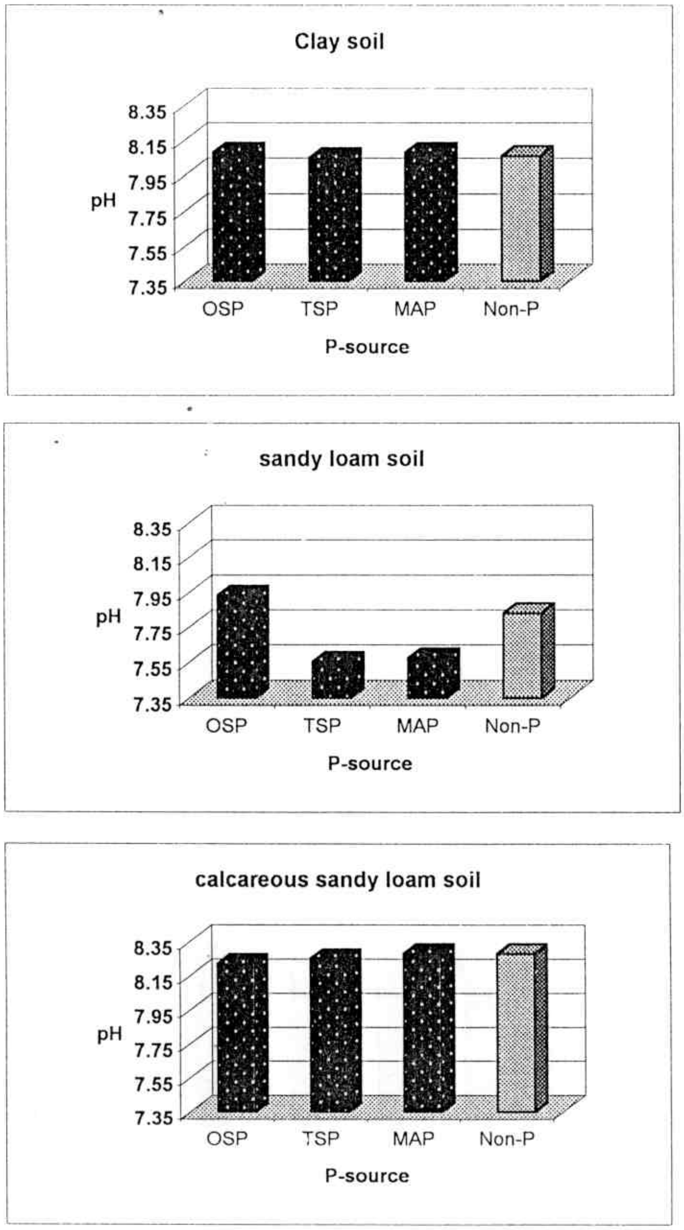


Figure (38): Effect of applying P fertilizers (powdered and granular) on pH at harvest of different soils
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP:triple superphosphate, MAP: monoammonium phosphate)

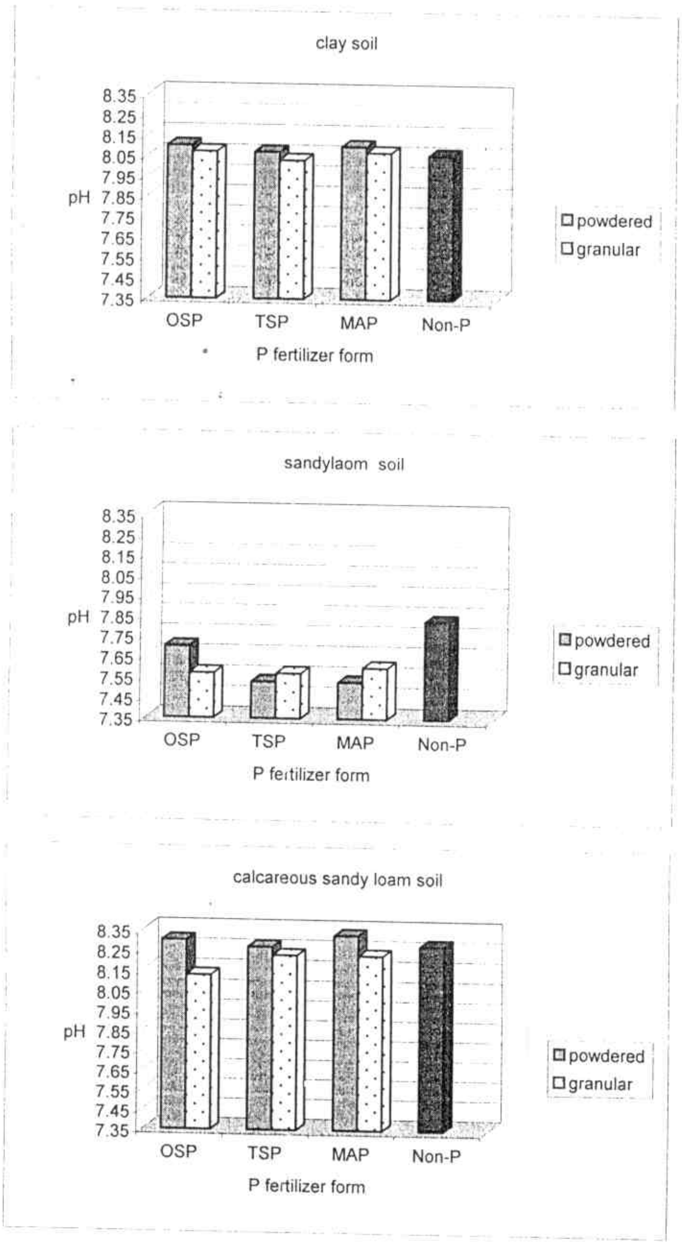
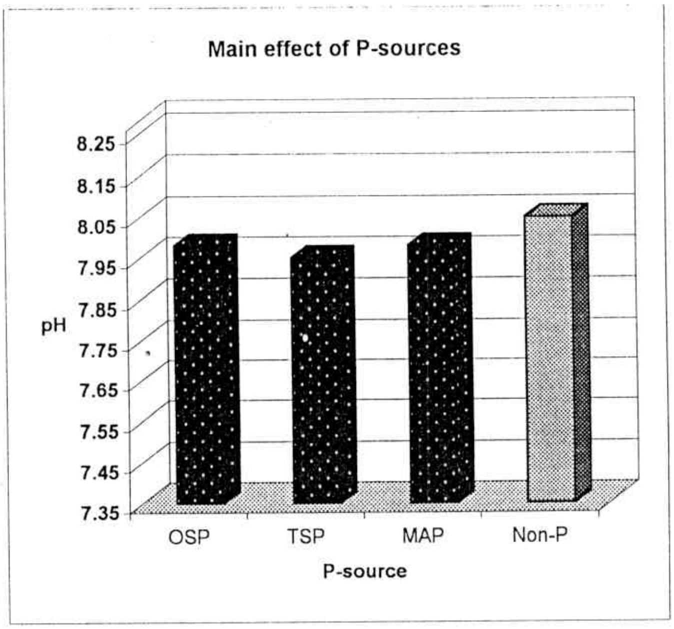
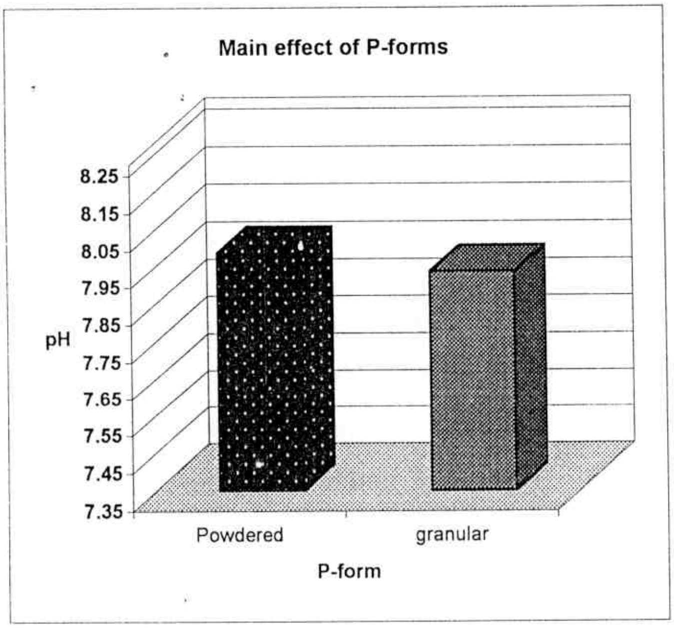


Figure (39): Main effect of applying P fertilizers and forms (average of 3 soils) on pH at harvest
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)





4.5.2Available P in soil (Table 15and Figs 40,41, and 42)

"Available" P and "P availability" are terms that are loosely used and poorly understood, and they do not mean the same thing. Available P is time-specific and crop-specific. It is the quantity of P that will come into solution and be taken up by the crop during its life cycle. It is therefore a quantitative (extensive) parameter. On the other hand P availability is a qualitative (intensive) parameter which does not define the quantity of available P, (**White and Beckett 1964**)

Soils which received P-fertilizers, showed increases in their available P at end of experiment. The mean values of treatments not receiving P were 2.75,3.16, and 2.92 mg P/kg soil for the clay, sandy loam, and calcareous sandy loam soils, respectively .The mean values for treatments receiving P (mean for all P-sources) were 5.19, 7.65, and 6.20 mg P/kg soil for the same three soils respectively; an increase of 88.7 %, 142 % and 115 % for each soil respectively. **Singh and Gupta (1995)** stated that application of P resulted in significant increases in available P in soil.

The main effect of fertilizer source showed the following pattern TSP>OSP>MAP. The mean values given by P sources were 6.89, 6.20 and 5.95 mg P /kg soil for TSP, OSP, and MAP respectively. Increases caused by these sources amounted to 141.1 %, 114.3 %, and 102.3 % for each of the aforementioned sources respectively .

Table (15): **Effect of applying P fertilizers (in different sources and forms) to broad beans on available P at harvest mg/kg Soil (P rate =50 mg/kg soil)**

Soil (A)	P form (C)	P source (B)			
Clay Soil		OSP	TSP	MAP	Mean
		available P at harvest			
	Powdered	5.14	6.17	6.30	**5.87**
	granular	3.16	5.56	4.81	**4.51**
	mean	**3.15**	**5. 86**	**5.56**	**5.19**
Sandy Loam Soil	Powdered	7.89	8.78	7.28	**7.98**
	granular	6.31	8.52	7.15	**7.33**
	mean	**7.10**	**8.65**	**7.22**	**7.65**
Calcareous Soil	Powdered	7.42	7.07	5.14	**6.54**
	granular	7.28	5.25	5.02	**5.85**
	mean	**7.35**	**6.16**	**5.08**	**6.20**
G.mean		**6.20**	**6.89**	**5.95**	
Mean of P-form					
	powdered	6.82	7.34	6.24	**6.80**
	granular	5.58	6.44	5.66	**5.89**

LSD : 0.05 A:0.51 B: 0.51 C:0.42 AB:0.89

AC:NS BC:NS ABC:NS

No P treatments :

Clay :2.75

Sandy loam :3.16

Calcareous :2.92

Mean :2.94

Notes: **OSP :Ordinary Ca-superphosphate 6.8%P. TSP : triple Ca-superphosphate 15.9%P. MAP : mono-ammonium phosphate 25.5%P , 11% N .**

(each of TSP and OSP treatments received N equal to the amount involved in MAP treatment.)

Figure (40) : Main effect of applying P fertilizers on available P at harvest of different soils
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)

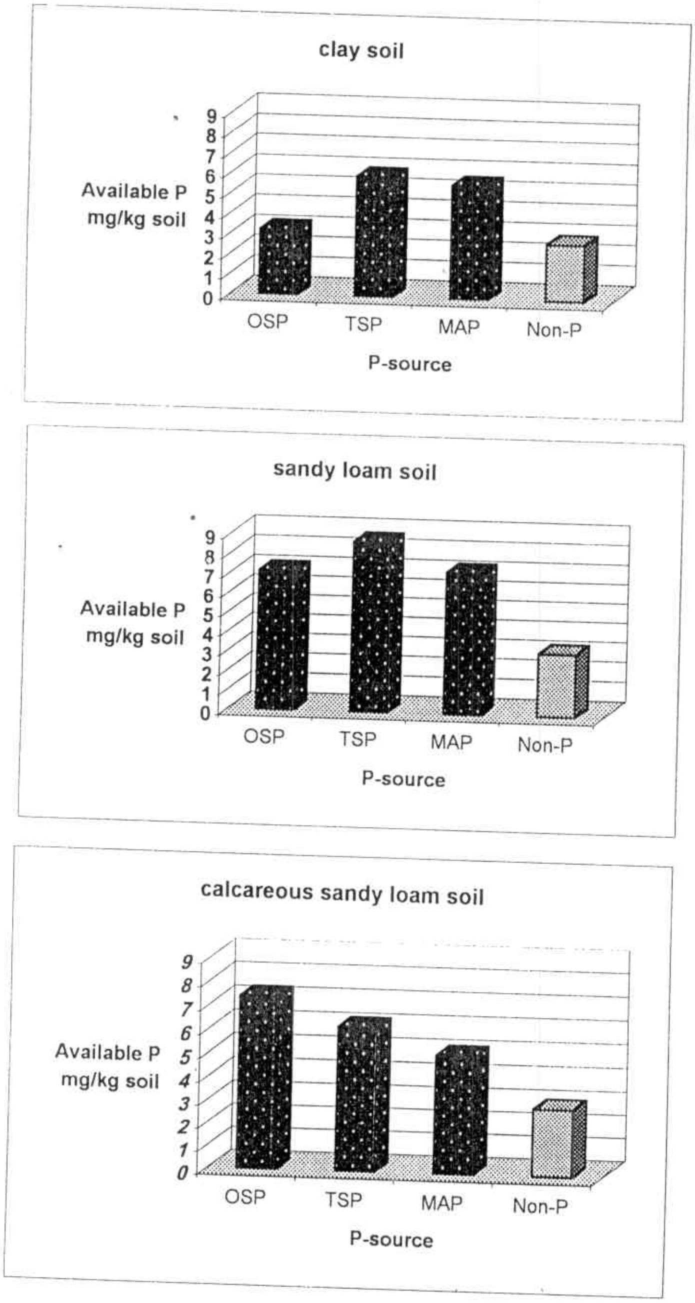


Figure (41): Effect of applying P fertilizers (powdered and granular) on available P at harvest of different soils
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP:triple superphosphate, MAP: monoammonium phosphate)

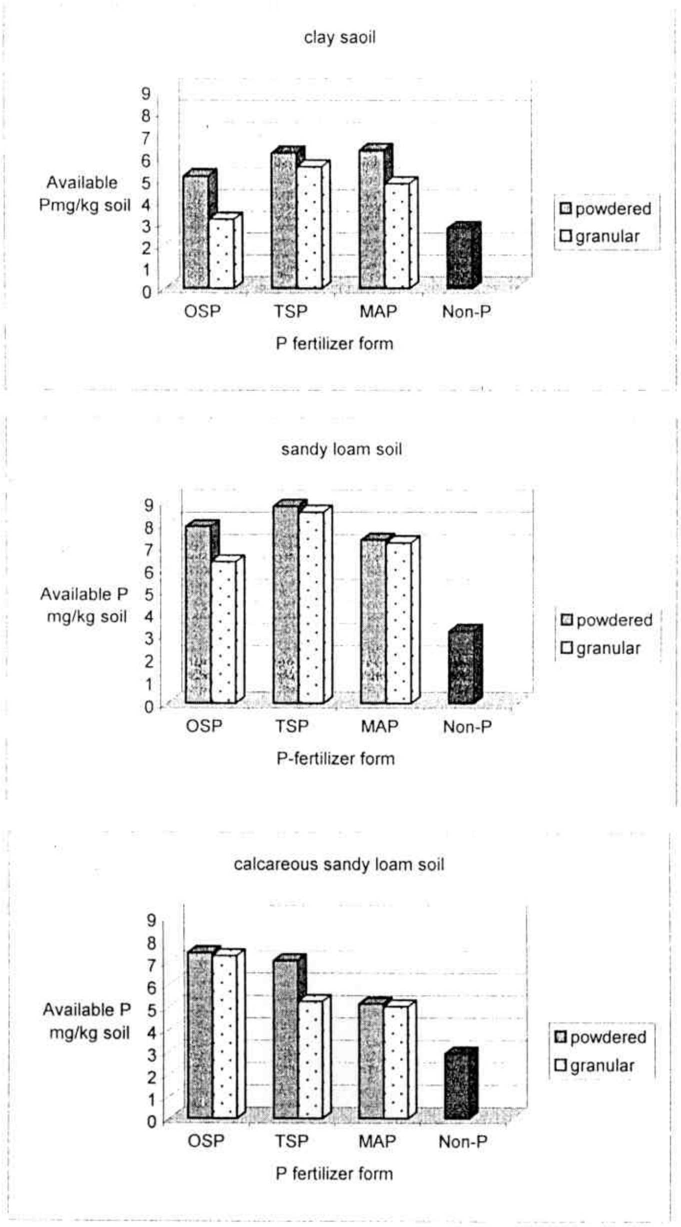
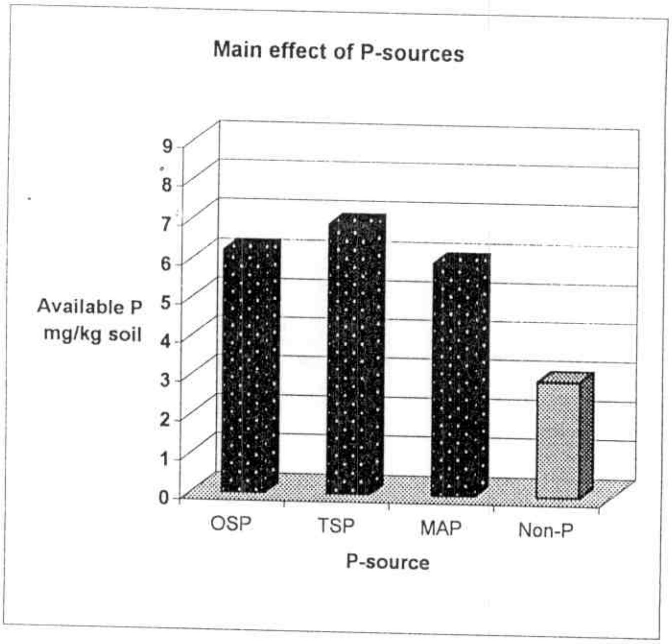
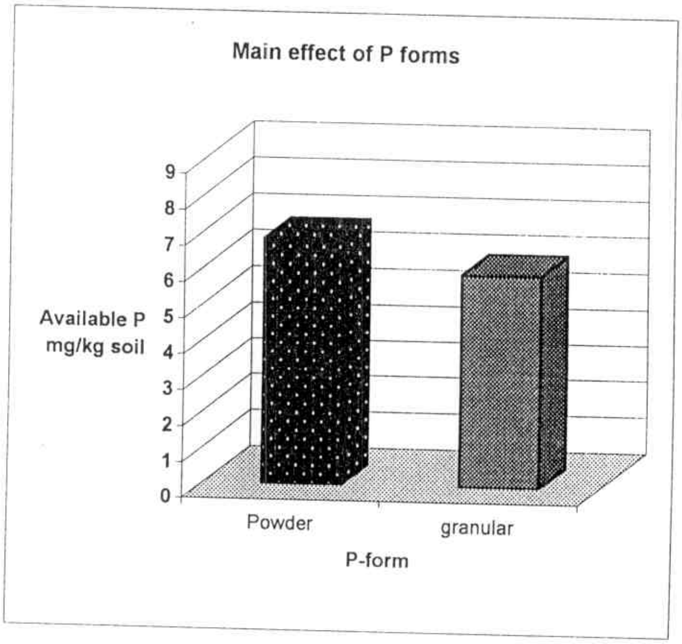


Figure (42): Main effect of applying P fertilizers and forms (average of 3 soils) on available P at harvest
(P rate 50 mg/kg soil; OSP: ordinary superphosphate, TSP: triple superphosphate, MAP: monoammonium phosphate)





TSP source was superior to OSP or MAP sources in the clay soil and the sandy loam soil, while OSP was superior to TSP in the calcareous sandy loam soil. MAP was superior to OSP only in the clay soil. The superiorty TSP over OSP and MAP occurred whether the fertilizer was powdered or granulated. The powdered form gave, (on average) greater available P over the granular form. The mean value for the former was 6.80 mg P/kg soil as compared with 5.89 mg P /kg soil given by the granular form, an increase of 15.4 %. **El-Maghraby (2000)** reported that TSP fertilizer (powdered) gave higher values of available P compared with OSP when both were used in a sandy clay loam soil.

The sandy loam soil gave the highest available P and the clay soil gave the lowest. Mean values of available P given by the fertilized soils were 5.19, 7.65,and 6.20 mg P/kg soil for the clay, sandy loam, and sandy loam calcareous soils respectively. **Grzywonwicz (1983)** reported that fertilization influenced the level of available P in light soils more than in heavy soils, and **Wassif et al (1986)** found that the unused phosphate remains in the soil and in varying contents depending upon soil type, climate, frequency and the level of fertilizers application.