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Influence of Different Phosphorus Fertilization Levels and Sowing Date on Yield and Phosphorus Uptake by Corn

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ABSTRACT. This research studied the influence of different phosphorus fertilization rates (0, 50, 100, 150, 200, 250, 300 and 350 kg P_2O_5/ha) and different sowing dates (S_1 = 21-9-1993 and S_2 = 21-2-1994) on the total dry matter yield and its components (grain, ear and stover), grain protein contents, weight of 1000 grains, harvest index, shelling percentage and ear characters and components of corn plant (Giza 2 cultivar). The accumulation of phosphorus in soil was also investigated. Total dry matter yield and its components, 1000 grains weight, harvest index, shelling percentage, ear dry matter and volume, weight of grains/ear and phosphorus uptake were higher in sowing data S_1 than sowing date S_2. However, weight of cob/ear and number of rows/ear were higher in S_1 and S_2. The rest of characters and components were not affected by sowing date. Total dry matter yield and its components such as grains ears and stovers were significantly increased by the addition of 100 kg P_2O_5/ha. On the other hand phosphorus uptake by corn plant was significantly increased by the addition of 150 kg P_2O_5/ha. However, protein content of grain, the weight of 1000 grains, harvest index and shelling percentage were not affected by phosphorus application rates. Total phosphorus content of soil increased with increasing phosphorus application rates.

Introduction

Phosphorus is one of the most important nutrient on plant vegetative growth and on total dry matter yield and its components. Thus, the effect of phosphorus fertilizer on corn productivity was studied by many scientists. Barreto and Serpa (1986) studied the performance of corn and beans (*Phaseolus vulgaris* L.) under the influence of phosphate fertilization up to 300 kg P_2O_5/ha, and obtained the same amount of plant tissue phosphorus content by both species. Jiang *et al.* (1986), studied the response of corn yield to the application rate of phosphate fertilizers on calcareous soils. They found that phosphate application 60-90 kg P_2O_5/ha rates gave a yield increase of 29-36% in corn. Borges and Mello (1987), studied the effect of phosphorus application on corn (*Zea mays* L.) on soils originally covered by cerrado vegetation which was given 0,150,300,600 or

1200 kg P_2O_5/ha as rock phosphate and in the following year 0,50,100 or 200 kg P_2O_5/ha as triple superphosphate was banded. There was no significant response in grain yield to rock phosphate in the 1st year but in the 2nd year there was significant response. Triple superphosphate gave a significant effect where yields increased from 1.47 t/ha with no triple superphosphate to 4.77 t/ha with the highest rate (200 kg P_2O_5/ha).

Singh *et al.* (1987) found a significant effects of the applying 0-75 kg P_2O_5/ha on grain yield of four corn genotypes grown for two successive seasons. The application of 50 kg P_2O_5/ha to "Suwan" (growth period 105-110 days) and 25 kg P_2O_5/ha to "Diara Composite" gave the highest yield of 5.01 and 2.61 t/ha respectively as compared with respective yields of 4.25 and 2.18 t/ha without P. In the winter season, hybrid "H-starch" and "Lakshmi" cultivar gave almost similar yields of 4.46-4.47 t/ha without P and 5.91-6.21 t/ha with 50 kg P_2O_5/ha. Hi-starch and Lakshmi gave yields of 7.18 and 6.37 t/ha respectively with 75 kg P_2O_5/ha. Drover and Williams (1986) studied the response of annual crops of P-hungry soils to rock phosphate, they found that rock phosphate and superphosphate effects were additive and yield of annual crops ranged from 1.83 t/ha with no added P to 8.22 t/ha with 30 kg superphosphate - P /ha. Phosphorus (on dry matter basis) in ear leaves ranged from 0.16% without P fertilizer to 0.38% with 30 kg superphosphate - P/ha. On the other hand, Nader and Faught (1984), Neamtu and Ichim (1982), Mohammed *et al.* (1988) and Khakhar (1980), obtained an increase in corn grain yield when phosphorus and nitrogen were applied at rates 20 kg P/ha with 52 kg N/ha and 128 kg P/ha with 128 kg N/ha and 100 kg P/ha with 150 N/ha, 60 kg P/ha with 160 kg/N. On the other hand Khakar (1980), found an increase in the weight of 1000 grains with increase in phosphorus fertilization from 0 to 60 kg P_2O_5/ha. However, Getmanets *et al.* (1981), Hera *et al.* (1986), Mate and Ciobanu (1985), and Nagrila *et al.* (1987) found an increase in grain yield of corn with application of phosphorus added with nitrogen at the rates 90 kg P_2O_5/ha, 160 kg P_2O_5/ha, 150 kg P_2O_5/ha and 120 kg P_2O_5/ha respectively.

Many questions arise that need answers about the optimum rate of phosphorus fertilizer and sowing date on corn yield and quality. Since fertilizers are highly economic agricultural inputs, it is necessary to determine the optimum economical rate for sensible productivity. Due to the lack of information concerning this field crop in the western region of the Kingdom of Saudi Arabia and due to the importance of this crop in the area, this research was purposed to study the influence of phosphorus fertilizer and sowing date on corn productivity, yield components and phosphorus uptake.

Materials and Methods

This research studied the production of corn plant (Giza 2 cultivar), under the influence of different phosphorus rates. A two field experiment was conducted at the agricultural research station of King Abdulaziz University at Hada-Alsham area during two sowing dates (S_1 = 21-9-1993 and S_2 = 21-2-1994) to study the effect of different phosphorus rates application (0, 50, 100, 150, 200, 250, 300 and 350 kg P_2O_5/ha) on yield characteristic and phosphorus uptake of corn plant. The two experiment were grown on the same site. The accumulation of phosphorus in soil was also investigated. Table (1) illustrates the climatic conditions recorded by the Faculty of Meteorology of King Abdulaziz University. These data included mean temperature degrees (minimum, maximum and average) and mean relative humidity for each sowing date.

TABLE 1. Monthly recorded temperature and humidity of the study area during the two sowing dates of the corn experiment.

Month	First sowing date (21.9.1993)						Month	Second sowing date (21.2.1994)					
	Temperature (c)			Humidity (%)				Temperature (c)			Humidity (%)		
	Min.	Max.	Mean	Min.	Max.	Mean		Min.	Max.	Mean	Min.	Max.	Mean
August	21	47	34	22	87	54.5	February	10.8	34	22.4	22	99	60.5
September	22	46.2	34.1	21	99	60	March	10	35	22.5	22	99	90.5
October	16.7	42	29.35	23	99	61	April	8	38.2	23.1	20	99	59.5
November	14.2	36.5	25.35	27	99	63	May	14.8	42.8	28.8	23	99	61

Four random samples of surface soil (0-30 cm) were collected from the open field of the experiment. The samples were mixed together to make one representative sample, it was air dried, passed through a 20-mesh sieve, placed in tied plastic bag. From this sample, small portion of soil was used for some physical and chemical analysis. The soil texture was determined by the hydrometer procedure as described by Day (1956) at 25ºC using pyrophosphate as a dispersing agent. The result of soil texture analysis is presented in Table (2). Soil pH and EC were determined in soil to water ratio of 1:1 (w:v) using a glass electrode. Total organic matter (OM %) in the soil was determined by Jakson's (1973) method.

TABLE 2. Soil texture of Hada-Al Sham experimental site.

Particle size distribution %			Soil texture
Sand	Silt	Clay	
78	12	10	Sandy loam

Total nitrogen was determined according to Bremner (1965). Nitrogen content was measured using a KJELTEC AUTO 1030 analyzer. Total phosphorus and potassium was determined after being extracted using the perchloric-nitric digestion procedure of Shelton and Harper (1941). Phosphorus content was quantified at 640 nm wavelength using a Turner spectro-photometer (Model 2000). The concentration of total potassium in the extract was measured by flame photometer (Corning 400). The result of the soil analysis are shown in Table (3).

Each of the two sowing date was conducted in randomized complete block design with three replication. In conducting the experiments the site was ploughed, leveled and then divided into 24 plots (6 × 10 m), and each plot was divided into 12 rows, 75 cm a part. Planting pits within each row were spaced 30 cm a part, and 3 seeds were sown in each pip. The emerging seedlings were later thinned to one plant per hole. The different experimental doses of P-fertilizer (Triple super phosphate 46% P_2O_5) under study and potassium sulfate (50% K_2O at a rate of 400 kg K_2O/ha were mixed with the soil.

TABLE 3. Initial analysis for experimentalsite at Hada-Al Sham.

Soil pH	Soil EC (m.mos cm^{-1})	Organic matter %	Total amount of		
			N	P	K
			g kg^{-1}		
8.2	0.69	0.49	0.4	0.113	2.3

The urea (46% N) at a rate of 400 kg/ha were applied side dressed at four equal intervals of 2 weeks each during the growth period. In this respect the first dose was given 15 days after planting whereas the last dose was applied 60 days after planting. After that the experimental land received the sowing irrigation. The irrigation were carried out according to the crop water requirement.

At the end of the experiment, the whole crop was harvested, and total weight of 100 residual stover and weight of grains in 100 ears were measured for each plot. In addition total dry matter yield and its components (kg/ha), harvest index and shelling percentage were also estimated. Five ears from each plot were harvested and their mean length, diameter, and volume, number of grains/row, number of grains/ear, number of rows/ear, the mean weight of ear and its components (grains and cob), weight of 1000 grains and protein content of grains were also recorded. Statistical analysis was performed using the M-state program.

Results and Discussion

Ear Character and Components

The ear diameter and volume, weight of grain/ear (P = 0.01), number of rows/ear and weight of cob/ear (P = 0.05), were significantly affected by sowing date. The weight of cob/ear was affected by the interactions of sowing date with phosphorus treatment (Table 4).

TABLE 4. Summary of analysis of variance for ear characters and components of the two successive yields of corn plant.

Source	D.F.	Ear characters and components							
		Ear length (cm)	Ear diameter (cm)	Ear volume (cm3)	Number of rows / ear	Number of grains / ear	Number of grains / row	Weight of grains / ear	Weight of cob / ear
S	1	0.209	0.000**	0.000**	0.024*	0.273	–	0.000**	0.019*
P	7	0.175	0.432	–	–	–	–	0.113	0.306
S.P.	7	0.261	0.421	–	0.232	–	–	0.158	0.040*
E.M.S.	30	0.704	0.045	2151.848	0.816	3446.983	11.525	176.538	19.58

S = Sowing date
P = Phosphorus treatments
E.M.S. = Error mean square
D.F. = Degree of freedom
*Significance at 0.05 level
**Significance at 0.01 level

Ear diameter and volume, weight of grains/ear were higher in sowing date S_1 than sowing date S_2. Number of rows/ear, and weight of cob/ear were higher in S_2 and S_1. Ear length, number of grains/ear and number of rows/ear were not affected by sowing date (Table 5). On the other hand, ear characters and components were not affected by phosphorus treatments (Table 5). This in contrast to the finding of Getmanets *et al.* (1981), Hera *et al.* (1986), Mate and Ciobanu (1985) and Cieko *et al.* (1982). Temchenko *et al.* (1986) found an increase in grain protein content with increase in phosphorus fertilizers rates.

TABLE 5. Means of ear characters and components and their significance test for corn plant experiment.

		Ear character and components							
		Ear length (cm)	Ear diameter (cm)	Ear volume (cm3)	Number of rows / ear	Number of grains / ear	Number of grains / row	Weight of grains / ear	Weight of cob / ear
	S1	15.492 A	5.324 A	343.77 A	13.30 B	406.75 A	30.87 A	139.15 A	26.95 B
	S2	15.008 A	4.935 B	288.15 B	13.91 A	425.65 A	30.85 A	97.91 B	30.12 A
L.S.D.		0.53	8.63	18.93	0.36	23.96	1.38	5.42	1.8
	PO	15.34 A	5.17 A	324.05 A	13.97 A	373.67 A	30.07 A	117.60 A	31.70 A
	P1	15.13 A	5.01 A	302.13 A	13.17 A	402.00 A	30.70 A	118.37 A	30.03 A
	P2	14.17 A	5.22 A	315.88 A	13.87 A	433.73 A	30.40 A	125.17 A	29.17 A
P	P3	15.20 A	5.13 A	329.27 A	13.23 A	418.57 A	32.50 A	123.43 A	27.83 A
	P4	16.50 A	5.09 A	328.52 A	13.90	435.80 A	31.10 A	122.47 A	28.63 A
	P5	15.80 A	5.25 A	332.25 A	14.00 A	448.50 A	32.80 A	125.93 A	29.33 A
	P6	14.87 A	5.02 A	295.58 A	13.40 A	412.30 A	30.93 A	105.97 A	25.93 A
	P7	14.33 A	5.15 A	300.03 A	13.33 A	405.07 A	28.43 A	109.33 A	25.70 A
L.S.D.		2.398479	0.250126	54.69642	1.065119	69.2265	4.002889	15.66651	5.21746

Sowing date S1 = (21.9.1993)
S2 = (21.2.1994)
L.S.D. = Least significant difference at 0.05

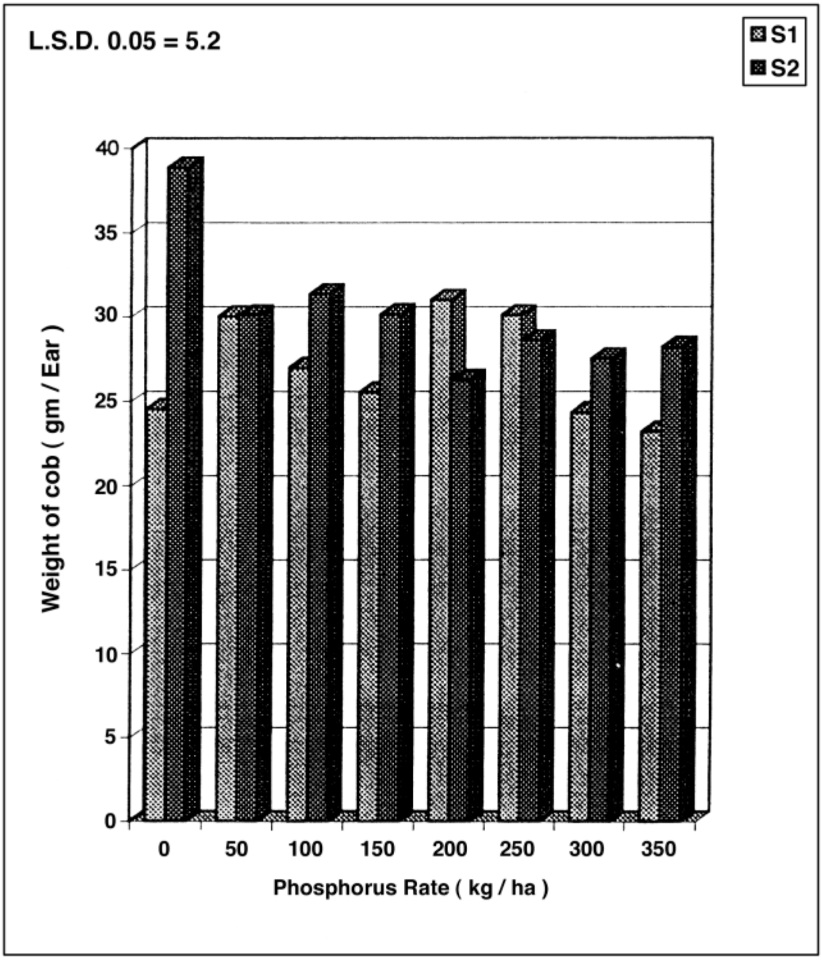
Phosphorus treatments (kg/ha)
PO = 0 kg P_2O_5 / ha
P1 = 50 kg P_2O_5 / ha
P2 = 100 kg P_2O_5 / ha
P3 = 150 kg P_2O_5 / ha
P4 = 200 kg P_2O_5 / ha
P5 = 250 kg P_2O_5 / ha
P6 = 300 kg P_2O_5 / ha
P7 = 350 kg P_2O_5 / ha

Means within a column for each character followed by the same letter are not significantly different at the 5% level using LSD test.

The weight of cob was decreased with increasing phosphorus rates with S_2 dominating S_1 (Fig. 1).

Total Dry Matter Yield and its Characters

The total dry matter yield and its components (grain, ear and stover), weight of 1000 grains, harvest index and shelling percentage were significantly affected by sowing date, while phosphorus application significantly affected grain, ear and total dry matter (P = 0.01) (Table 6).



Sowing Date S1 = 21.9.1993 Sowing Date S2 = 21.2.1944

Fig. 1. Effect of different rates of phosphorus on weight of cob of two successive crops of corn plant.

TABLE 6. Summary of analysis of variance for yield characters and components of the two succesive yields of corn plant.

Source	D.F.	Dry matter yield (kg / ha)				Phosphorus uptake (kg / ha)	Protein content of grains (%)	1000 Grains weight (grain index)	Harvest index	Shelling percentage
		Grain	Ear	Stover	Total					
S	1	0.000**	0.000**	0.001**	0.000**	0.021*	0.258	0.000**	0.000**	0.000***
P	7	0.000**	0.000**	0.171	0.002**	0.016*	0.209	–	–	0.226
S.P.	7	0.266	0.231	–	–	0.000*	–	0.275	–	0.396
E.M.S.	30	486402.7	913231.9	1373932.2	3182638.1	0.548	6.811	188.781	19.789	20.4

S = Sowing date
P = Phosphorus treatments D.F. = Degree of freedom
E.M.S. = Error mean square *Significance at 0.05 level
**Significance at 0.01 level

Total dry matter yield and its components such as grain, ear and stover, weight of 1000 grains, harvest index and shelling percentage were higher in sowing date S_1 than sowing date S_2 (Table 7). Differences in the environmental conditions of sowing date S_1 and S_2 in term of temperature (Table 1), (Mack *et al.* 1966) and light intensity (Leonard and Martin, 1963) might had contributed to the differences observed on total dry matter yield and its components. The total dry matter and its components such as grain, ear and stover were significantly increased by the addition of 100 kg P_2O_5/ha. There was no significant difference between (P_2-P_7) (P_2 100 - P_7 350 kg P_2O_5/ha) (Table 7). Similar results were obtained by the following authors: Jiang *et al.* (1986), Singh *et al.* (1987) and Drover and Williams (1986).

TABLE 7. Means of yield characters and components and their significance test for corn plant experiment.

		Dry matter yield (kg / ha)				Phosphorus uptake (kg / ha)	Protein content of grains (%)	100 Grain weight (grains index)	Harvest index	Shelling percentage
		Grain	Ear	Stover	Total					
	S1	5824.43 A	8403.45 A	5922.5 A	14325.96 A	2.581 A	7.29 A	350.81 A	43.71 A	75.02 A
	S2	2679.80 B	4792.05 B	4773.7 B	9565.74 B	2.348 B	8.16 A	241.91 B	33.07 B	66.83 B
L.S.D.		284.72	390.13	478.52	728.31	0.152	1.65	5.6	1.81	1.84
	PO	3275.77 B	5118.46 B	4233.06 C	9651.51 B	1.523 D	7.11 A	290.82 A	36.08 A	68.64 A
	P1	3134.27 B	5319.87 B	4385.4 C	9705.3 B	1.6 D	8.86 A	295.68 A	38.75 A	72.53 A
	P2	4743.37 A	6868.61 A	5877.2 B	12745.8 A	2.174 C	9.20 A	298.10 A	37.22 A	71.52 A
P	P3	4216.65 A	6597.75 A	5150.6 B	11748.4 AB	2.732 B	8.70 A	304.37 A	40.03 A	72.71 A
	P4	4504.00 A	6736.65 A	5533.8 B	12270.4 A	2.759 B	7.80 A	299.05 A	40.55 A	74.50 A
	P5	4567.80 A	7195.02 A	5829.3 B	13024.3 A	2.837 AB	7.46 A	295.22 A	38.27 A	69.46 A
	P6	4663.83 A	7264.47 A	5957.2 A	13221.6 A	2.953 AB	7.61 A	295.17 A	37.73 A	69.72 A

TABLE 7. Contd.

		Dry matter yield (kg / ha)				Phosphorus uptake (kg / ha)	Protein content of grains (%)	100 Grain weight (grains index)	Harvest index	Shelling percentage
		Grain	Ear	Stover	Total					
	P7	4911.28 A	7681.17 A	5518.1 AB	13199.2 A	3.139 A	5.09 A	292.52 A	38.54 A	68.36 A
L.S.D.		822.3395	1126.792	1382	2103.52	0.3777	3.07722	16.20064	5.24523	5.325466

Sowing date S1 = (21.9.1993)
S2 = (21.2.1994)
L.S.D. = Least significant difference at 0.05

Phosphorus treatments (kg/ha)
PO = 0 kg P_2O_5 / ha
P1 = 50 kg P_2O_5 / ha
P2 = 100 kg P_2O_5 / ha
P3 = 150 kg P_2O_5 / ha
P4 = 200 kg P_2O_5 / ha
P5 = 250 kg P_2O_5 / ha
P6 = 300 kg P_2O_5 / ha
P7 = 350 kg P_2O_5 / ha

Means within a column for each character followed by the same letter are not significantly different at the 5% level using LSD test.

However, the weight of 1000 grains, harvest index, shelling percentage and protein content of grains were not affected by phosphorus rates (Table 7). Similar result was found by Ahmed *et al.* (1965) and Ibrahim *et al.* (1979). They did not observe any effect of phosphorus fertilizer rates on weight of 1000 grains. However, Khakar (1980), found an increase in the weight of 1000 grains with increasing in phosphorus fertilization from 0 to 60 kg P_2O_5/ha. Also, addition of phosphorus was found to increase protein content of leaves, stems and grain of corn as was found by Temchenko *et al.* (1986).

Plant-Phosphorus Uptake

Phosphorus uptake by corn plants was significantly affected by sowing date growth stage and phosphorus rate (P = 0.05). The phosphorus uptake was significantly affected by the interaction of sowing date × growth stage and sowing date × phosphorus rate (P = 0.01) (Table 6).

Phosphorus uptake was significantly higher in sowing date S_1 (2.581 kg/ha) than sowing date S_2 (2.348 kg/ha) (Table 7). The phosphorus uptake significantly increased by increasing phosphorus application rates. However, there were no significant differences between phosphorus rates P_3 to P_7 (150-350 kg/ha) which means that 150 kg/ha was adequate to produce the highest phosphorus uptake by corn plant (Table 7). This result was in agreement with Sedlarska (1985), who reported that increasing rates of superphosphorus application gave an increase in phosphorus uptake from fertilizer. He concluded that in low phosphorus soils the increase in P uptake was partially linear with P application rate but was curve linear in high phosphorus soils. The rate pattern of phosphorus uptake followed closely that for total dry matter yield and its components

Final Soil Analysis

Total phosphorus content of soil at the end of the harvest (sowing date S_2) was significantly increased with increasing rates of phosphorus fertilization (Fig. 2). The significant effect of phosphorus fertilizer on yield (kg/ha) and its components and phosphorus uptake (kg/ha) suggests that residual content of phosphorus in this soil was increased with increasing rates of phosphorus fertilization. Similar result was found by Brar *et al.* (1987), Patiram and Prasad (1991) and Webb *et al.* (1992).

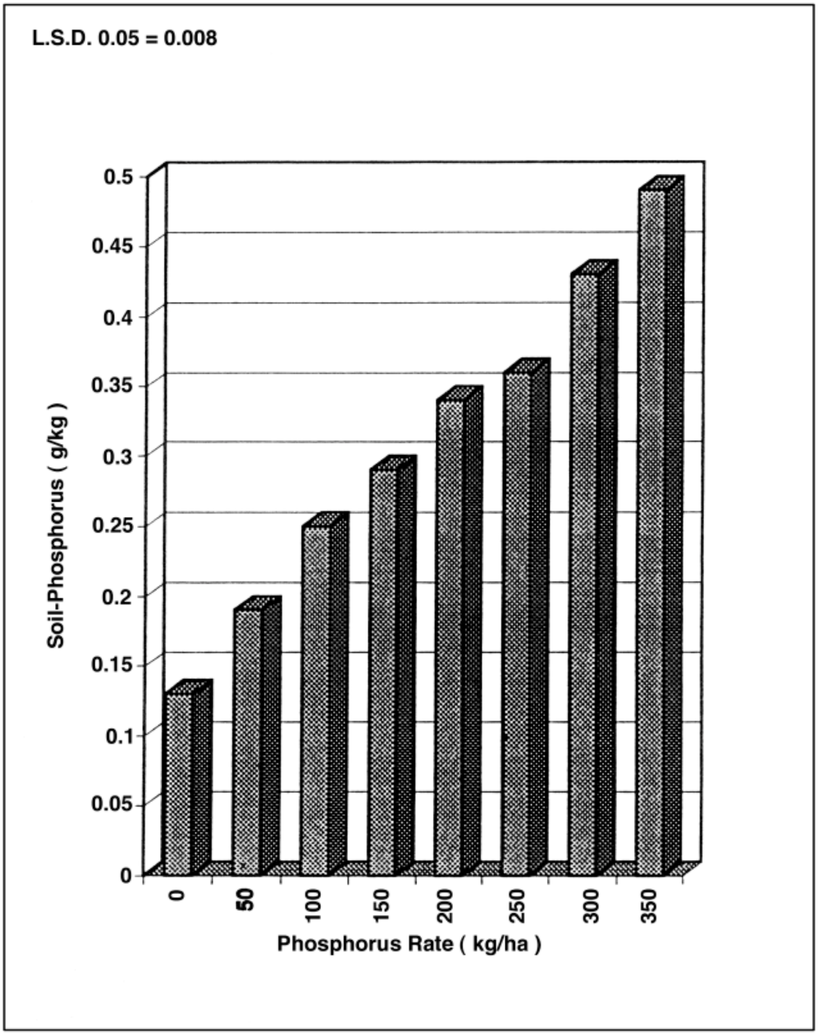


FIG. 2. Effect of different rates of phosphorus on the phosphorus content of soil under corn plant experiment.

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تأثير معدلات مختلفة من التسميد الفوسفوري وميعاد الزراعة على إنتاجية الذرة الشامية (*Zea mays* L.) وامتصاصه للفوسفور

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جـــــدة - المملكة العربية السعودية

المستخلص . أجري هذا البحث بغرض دراسة تأثير إضافة معدلات مختلفة من السماد الفوسفوري (صفر ، ٥٠ ، ١٠٠، ١٥٠، ٢٠٠، ٢٥٠، ٣٠٠، ٣٥٠ كجم فوسفور/ هكتار) وموعدين زراعيين مختلفين (موعد الزراعة الأول S_1 في ٢١/ ٩/ ١٩٩٣م وموعد الزراعة الثاني S_2 في ٢١/ ٢/ ١٩٩٤م) على وزن المحصول ومكوناته (وزن البذور والكيزان والقش) وكذلك وزن ألف بذرة ودليل الحصاد ونسبة التصافي في الكوز وكمية الفوسفور الممتص بواسطة النبات (كجم/ هكتار) . كما تم دراسة تراكم الفوسفور في التربة بعد انتهاء التجربة . الوزن الكلي لمحصول الذرة الشامية (كجم/ هكتار) ومكوناته (وزن البذور ، الكيزان والقش) ووزن ١٠٠٠ بذرة ، ودليل الحصاد وكذلك نسبة التصافي للكوز ومتوسط قطر وحجم الكوز ، والفوسفور الممتص بواسطة النبات ومتوسط قطر وحجم الكوز ، ووزن البذور لكل كوز ، تفوقت في موعد الزراعة الأول S_1 على موعد الزراعة الثاني S_2 . وفي المقابل تفوق موعد الزراعة الثاني S_2 على الأول S_1 في عدد الصفوف لكل كوز ووزن القولحة لكل كوز . كما وجد أن إضافة ١٠٠ كجم فوسفور/ هكتار كانت كافية لزيادة المحصول الجاف الكلي للذرة الشامية ومكوناته (وزن البذور ، الكيزان والقش) . بينما أدت إضافة ١٥٠ كجم فوسفور/ هكتار لزيادة الفوسفور الممتص بواسطة النبات بينما لم يتأثر المحتوى البروتيني للبذور ووزن ١٠٠٠ بذرة ونسبة التصافي في الكوز بالمعاملات المختلفة للفوسفور أما محتوى التربة الكلي للفوسفور فقد زاد زيادة معنوية بزيادة الفوسفور المضاف .