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Potassium Phosphate Fertilization under Sunflower and Maize Intercropping System in A Calcareous Soil

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A FIELD experiment was conducted in Noubaria Research Station Farm on a normal calcareous soil planted with sunflower only (24000 plants/fed) or sunflower and maize (16000 plant of each crop/fed) soil application of K_2HPO_4 (17.8% P and 44.9% K) in a rate of 100 kg K_2HPO_4/fed, spraying with 10 or 20 kg K_2HPO_4 /fed was run in addition to O PK fertilization as a control treatment. Yields and yield components were recorded for each crop and plant content of NPK were determined.

Obtained results could be summarized in the followings:

Intercropping system of sunflower and maize reduced significantly sunflower seed yield, oil content, dry matter of stover, whole plant, K and stover N recovery of N, P and K. In the same time, that system could gain about 13 ardab maize grains/feddan associated with sunflower. To count the input and output of that 1:1 sunflower-maize intercropping system, it was found according to 2004 market prices that the pure grain was about 155% of that planted with sunflower only with about 630 Egyptian pounded (LE).

Each of sunflower and maize responded significantly to K_2HPO_4 applications to such soil. Soil application method was the most effective in increasing oil N and K contents in sunflower seeds, maize grain yield, 100 grain weight maize stover dry matter, contents of N and K in maize stover and whole plant. In other parameters K_2HPO_4 spraying was the most effective.

The interaction effect of the factors intercropping and K_2HPO_4 application gave significant response in some cases where one or both factors gave insignificant effects indicating that correct of intercropping negative sides might be due to P and /or K fertilization for those crops under the studied soil conditions.

The used soil application rate of 100 kg K_2HPO_4/fed resulted in somewhat low efficiency especially for K. Using the half rate in the form of KH_2PO_4 may be more beneficial. In most cases the 1st or low spraying rate was statistically as the same or more as the 2nd or doubled spraying one. Thus, spraying with 10 kg K_2HPO_4 may be satisfactory under the experiment conditions.

Keywords: Calcareous soil, Intercropping, Sunflower, Maize, K_2HPO_4.

Intercropping is a cultivation system in which more than one crop are planted in the same area. It is a useful program for intensive production has advantage and also disadvantages aspects. It is widely common to associate a legume crop with another unlegume one.

Sunflower and maize have approximately the same sowing time and cultivation practices in addition to the ability of sunflower to absorb some soluble salts reducing, in low limits, the moderate soil salinity. Many investigators studied sunflower – maize intercropping system such as El-Doubi (1992); Khalil (1994); Fagbayide *et al.* (1997); Lopez *et al.* (2001) and Latha (2003). They performed different trials to obtain satisfactory yields of the both crops but all of them found that maize had the higher values of the studied competitive ratios than sunflower. Some others intercropped maize or sorghum with sunflower to obtain more rich silage such as Banys *et al.* (1999 a, b) and Pintic *et al.* (2000). Intercropping of sunflower and maize may increase the resistance to yellow mosaic disease induced by mung bean which incidence of Vigna mungo (Thakur & Agrawal, 1998).

Nevertheless, maize could be intercropped with sorghum (Vergara & Pitra, 2000), rice (Ral *et al.*, 2002) upland rice (Usman *et al.*, 2002) or botato, (Sharaiha & Battikhi, 2002). Sunflower also could be intercropped with sesame, (Sarkar, 2001). They obtained economically good yields in spite of unlegumineous nature of all these crops.

From other side, whenever intensive yield production requires more fertilization, intercropping systems as forms of intensive cultivation need enough fertilizers to give their maximum yields. In this connection potassium phosphate was suggested to cover plant needs of phosphorus and potassium. Mono potassium-dihydrogen phosphate was suggested by Vei & Paianisami (2002) for spraying sunflower, Ronaghi *et al.* (2002) for sparaying maize and Tamboli & Daftardar (2004) for legumes. Di potassium-monohydrogen phosphate was suggested by Abou-Zeid *et al.* (2005) for clover, Khalifa *et al.* (2005) and El-Meneasy *et al.* (2005) for four consequent vegetable crops planted in calcareous soil.

Generally, it is well known that maize requires high nitrogen application rates to meet the N requirement of sunflower where Angel (2001) reported that N fertilizer rates from 60% 120 kg/ha had no effect on sunflower productivity in a calcareous black soil. The increase in yield was not more than 5.8% by using the rate 120 kg N/ha over that received 60 kg N/ha. He recommended also under his work condition that 100 kg P and 80 kg K/ha may act as optimum sunflower requirements.

So, this work aims to study the possibility of intercropping sunflower and maize to obtain high and good productivity without sharp consumption of soil fertility. Potassium mono hydrogen phosphate was suggested in different methods and rates of application as a compound P-K fertilizer.

Material and Methods

A field experiment was conducted in the farm of Noubaria Research Station at the summer agricultural season of 2004 on a normal calcareous soil. The main characteristics of the soil (Table 1) were carried out using the methods described by Black *el al.* (1965 a & b). A statistical split plot design was followed with four replicates. The main treatments were no intercropping system where sunflower (*Helianthus annus*) was planted only with intensive of 24000 plants/fed and intercropping of sunflower and maize (*zea mays* L.) at intensity of 1600 plants of each crop/fed on a system of one hole for sunflower and another for maize reciprocally on the row. Sunflower was planted in all plots on the 4th of May, 2004 and maize in the intercropping plots on the 11th of May, 2004.

The sub main treatments (A) without PK fertilization as a control, B) 100 kg K_2HPO_4 /fed were added as topdressing on two doses, *i.e.*, one third and two thirds, respectively on the 8th and 29th of June 2004, C) and D) 10 and 20 kg K_2PO_4 /fed added as foliar application on three equal doses on the 8th, 22nd of June and 6th of July, 2004. The soil application rates were 17.8 and 44.9 kg P and K/fed or in another word 40.76 and 54.06 kg P_2O_5 and K_2O, respectively. Foliar applications were of concentration of 16.67 and 33.33 g K_2HPO_4/L for each plot 3.5x6m^2 (0.005 of one feddan) of C and D treatments corresponding 200L/fed, respectively in each spraying time.

Plants were fertilized with 150 or 200 kg calcium ammonium nitrate (33.5% N)/fed in plots of pure sunflower or intercropping sunflower and maize, respectively, on two doses, one third and two thirds on the 8th and 29th of June, 2004. Flooded irrigation was given every 15 days following the recommended practices till maturity. Plants were harvested on the 22th of September, 2004. The air dry weights of heads, ears and stover were recorded. Air dry sunflower seeds and maize grains were obtained. Yield and yield components of each crop were estimated.

On the day before harvesting, plants samples from each crop and every plot were taken, divided into seeds (or grains) and stover, weighed, oven dried on 70° C and prepared for chemical analysis. Wet digestion was run using was sulphuric perochloric acid mixture for plant materials (Sommers & Nelson, 1972), N, P and K contents were determined according to Chapman & Pratt (1961).

Obtained data were statistically analyzed according to the methods described by Petersen (1976).

TABLE 1. Physical and chemical analysis of the experiment soil.

Layer depth	% without $CaCO_3$ removal				Texture class	$CaCO_3$ fractions (g/100 g soil)			
	C sand	F. sand	Silt	Clay		C sand	F. sand	Silt+clay	Total
0-20	9.71	23.22	44.76	22.21	S. clay loam	4.69	8.12	11.34	24.15
20-40	8.49	24.14	45.45	21.92	S. clay loam	4.22	8.2	11.3	23.72

Layer depth	T.S.S %	Cations (me/100 g soil)*				anions (me/100 g soil)*			
		Ca^{2+}	Mg^{2+}	Na^+	K^+	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$
0-20	0.13	1.30	0.69	2.70	0.25	-	0.55	2.50	1.85
20-40	0.13	1.25	0.60	2.95	0.20	-	0.75	2.50	1.75

Layer depth	W.H.C (%)	F.C (%)	CEC me/100 g soil	pH 1:2.5 susp.	O.M (%)	Total N %	C/N ratio	Available (ppm) P	Available (ppm) K
0-20	33.25	22.81	11.75	8.20	1.08	0.018	34.80	4.15	3.11
20-40	33.33	23.43	11.75	8.11	0.99	0.018	31.90	3.84	2.92

* soil paste extract

Results and Discussion

Yields and yield components

Table 2 shows the data of yields and some yield components of sunflower and maize crops as well as oil content in sunflower.

Seed yield of sunflower was significantly reduced by association of maize in the cropping system compared to that produced from sunflower mono system of cultivation. That reduction was, at least in one face, due to reducing of plants number/fed from 24000 at cultivating sunflower individually to 16000 plant because the resultant yield from 16000 plant when be referred to one plant seed weight in each system, the obtained value will be of insignificant difference than that of cropping sunflower alone. In spite of that significant reduction, there were, beside it, about 13 ardabe in average of maize grains per feddan resulted from that intercropping system. In this connection, sunflower seed yield was reduced when it was intercropped with maize in a ratio 50/50% as obtained by El-Doubi (1992); Khalil (1994); Fagbayide *et al.* (1997) and Lopez *et al.* (2001).

Neither PK application nor the intercropping PK interaction could not show significant effect on sunflower yield (Table 2). Vei & Paianisami (2002) found also low sunflower response to spraying with K_2HPO_4 where seed yield increased with about 4%. In case of maize grain yield, soil application of K_2HPO_4 treatment was the only higher significantly over the control which spraying with any of the used rates of K_2HPO_4 was insignificant. Ronaghi *et al.* (2002) was confirmed with these results.

Weight of 500 seeds of sunflower was not affected neither with cropping system nor K_2HPO_4 applications while the interaction of these two factors resulted in significant differences between the highest two values of foliation with the doubled K_2HPO_4 rate under sunflower cropping alone and K_2HPO_4 soil application under the intercropping system and the lowest three values of K_2HPO_4 soil application in sunflower alone system, the control and the 1^{st} K_2HPO_4 applying rate in the intercropping system. The 100 grain weight of maize was raised significantly by soil application of K_2HPO_4 over either the control or spraying with the 2^{nd} K_2HPO_4 rate treatments.

Regarding harvest index the another important agronomical yield component, any of cropping system or K_2HPO_4 treatment did not significantly affect that ratio in sunflower or maize indicating that the studied treatments could not make any considerable changes in vegetative and fruit part accumulation ratios.

According to 2004 market prices, the input costs of one feddan planted with 2400 sunflower plants was 948 LE and its output cost due to the actual produced seed yield (1.163 to x 1800 LE) was 2094.5 LE. The gain was (2094.5-948) 1146.5 LE. The input costs of one feddan planted with 1600 sunflower plants intercropped with 1600 maize plants was 1567 LE and its output costs due to the actual produced sunflower seed yield (0.66 ton x 1800 LE), maize grain yield

(12.84 x 145 LE) and maize stover (4.10 ton x 18 LE) was 3344.13 LE. The grain was (3344.10-1567) 1777.13. Under the current experiment, one feddan planted with sunflower-maize intercropping caused 155% of that planted with sunflower only as pure grain. The difference between each was (+) 630.63 LE.

TABLE 2. Yield parameters of sunflower and maize crops and oil content in sunflower as affected by potassium phosphate applications under an intercropping system.

Item	Cropping system	PK treatments A	B	C	D	Inter-crop mean	L.S.D at 0.05 level
Sunflower							
Seed Y (kg/fed)	alone	1007.94	1067.16	1498.32	1081.02	1163.61	Intcrop. : 194.60
	Intcrop.	567.40	858.24	565.64	648.84	660.03	PK : n.s.
	PK mean	787.67	962.70	1031.98	864.93		Intcrop X PK : n.s.
500 seed W (g)	alone	23.94	21.27	24.60	27.01	24.20	Intcrop. : n.s.
	Intcrop.	22.14	27.54	22.96	23.85	24.12	PK : n.s.
	PK mean	23.04	24.41	23.78	25.43		Intcrop X PK : 3.50
Harv. Index (%)	alone	16.63	20.51	16.44	19.50	18.27	Intcrop. : n.s.
	Intcrop.	20.16	18.74	17.65	17.73	18.57	PK : n.s.
	PK mean	18.40	19.63	17.05	18.62		Intcrop X PK : n.s.
Oil content (%)	alone	29.21	28.77	30.33	23.77	28.02	Intcrop. : 1.28
	Intcrop.	18.15	32.35	27.06	28.10	26.42	PK : 1.81
	PK mean	23.68	30.56	28.70	25.94		Intcrop X PK : 2.56
Oil (g/plant)	alone	12.67	13.46	19.49	10.45	14.02	Intcrop. : 2.61
	Intcrop.	7.22	16.91	9.44	11.23	11.20	PK : 3.70
	PK mean	9.95	15.19	14.47	10.84		Intcrop X PK : 5.23
Oil (kg/fed)	alone	304.17	323.05	467.79	250.74	336.44	Intcrop. : 70.94
	Intcrop.	115.49	270.50	151.01	179.73	179.18	PK : n.s.
	PK mean	209.83	296.78	309.40	215.24		Intcrop X PK : 14.88
Maize							
Grain Y (ard)		10.70	15.10	12.36	13.18		3.06
100 gr.W. (g)		29.59	33.30	31.90	28.75		2.90
Harv. Ind. (%)		28.98	31.92	28.32	30.07		n.s.

Intcrop. : Intercropping.

Oil content in sunflower seeds

As Table 2 indicated, intercropping system of sunflower and maize was of significant of negative effect on oil content in sunflower seed per cent, in gram per plant or in kg per feddan. Lopez *et al.* (2001) considered that oil content in sunflower was affected mainly with intercropping ratio with maize 75-25, 50-50 or 25-75. Reading interaction effect of intercropping system and each of K_2HPO_4 soil and doubled rate foliar applications converted the oil content percentage of their treatments to be significantly higher by than the same K_2HPO_4 application in sunflower alone system. Thus, phosphorus and potassium fertilization could be modifying for the reduction of oil % in sunflower seeds intercropped with maize.

Regarding to K_2HPO_4 effect, data showed significant relative increases in the descending order B > C> D> A.

The same order was true in case of oil amount per plant but in the form of B = C > D = A. Although K_2HPO_4 treatments were statistically insignificant on oil amount per feddan, the increases in soil and 1st rate spraying application over the control were 41.4 and 47.5%, respectively Nevertheless, within sunflower alone system the 1st rate of spray (C) was of significant effect on oil productivity as well as soil application (B) under the tested intereropping system.

Dry matter production

Table 3 shows dry matter yield of sunflower and maize plant. Intercropping system caused significant reduction in seed, stover per fed and consequently the whole plant dry matter indicating that sunflower plant in intercropping system was significantly smaller than that in cropping sunflower alone system.

Application of K_2HPO_4 seemed to be of significant effect on stover in case of 1st rate of spraying compared with the control and 2nd or doubled rate spraying treatments. And compared with the control only on whole plant. Almost similar results were obtained by El-Meneasy *et al.* (2005) on garlic, cowpea, cauliflower and jews as well as Abou-Zeid *et al.* (2005) on Egyptian clover.

TABLE 3. Dry matter yield of sunflower and maize (g/plant) as affected with potassium phosphate applications under an intercropping system.

Item	Cropping system	PK treatments				Inter-crop mean	L.S.D at 0.05 level	
		A	B	C	D			
Sunflower								
Seeds	alone	51.34	43.13	60.95	43.96	49.85	Intercrop.	: n.s.
	Intercrop.	37.19	52.63	34.68	39.80	41.08	PK	: 7.15
	PK mean	44.27	47.88	47.82	41.88		Intercrop X PK	: 14.11
Stover	alone	120.86	113.34	157.60	107.12	124.73	Intercrop.	: 13.84
	Intercrop.	94.48	120.09	104.96	113.40	108.23	PK	: 19.57
	PK mean	107.67	116.72	131.28	110.26		Intercrop X PK	: 27.68
Whole	alone	172.20	157.23	218.55	151.08	174.77	Intercrop.	: 19.50
	Intercrop.	131.66	172.60	139.64	153.20	149.28	PK	: 27.58
	PK mean	151.93	164.92	179.10	152.14		Intercrop X PK	: 39.00
Maize								
Grains		80.08	112.55	162.52	171.98			34.03
Stover		122.39	180.44	163.87	148.78			27.33
Whole		202.47	292.99	326.39	320.75			71.27

The interaction effects of the both intercropping and PK fertilization factors were significantly positive on seed stover and whole plant dry matter within sunflower alone system by adding the 1st rate of spraying over the others.

Under intercropping system dry matter yield of sunflower seeds and whole plant increased significantly over the control and 1st rate of spraying by using soil application.

Maize dry matter also was affected with K_2HPO_4 applications. As for grains, sprayings were of significant effect over the control or soil application and for stover soil application over the 2nd rate of foliation and the control and 1st rate of foliation over the control. These effects were translated in whole plant dry matter to an observation that all K_2HPO_4 applications were of significant effect over the control without differences among them.

Nitrogen uptake and recovery

Table 4 shows nitrogen amounts (uptake) in seeds, grains and stover for one plant and its recovery in kg per feddan. Generally, plots under intercropping system were received more N fertilizer to give each plant the same quantity of N fertilizer under both cropping systems.

TABLE 4. Nitrogen uptake by sunflower and maize (mg/plant) and its recovery (kg/fed) as affected by potassium phosphate applications under an intercropping system.

Item	Cropping system	PK treatments				Inter-crop mean	L.S.D at 0.05 level	
		A	B	C	D			
Uptake by sunflower								
Seeds	alone	621.43	744.24	1027.18	717.72	777.64	Intercrop.	: n.s.
	Intercrop.	716.57	943.78	574.50	584.03	704.72	PK	: 169.89
	PK mean	669.00	844.01	800.84	650.88		Intercrop X PK	: 240.26
Stover	alone	1148.63	1178.57	1627.72	926.39	1220.33	Intercrop.	: 209.63
	Intercrop.	527.99	864.47	695.81	768.66	714.23	PK	: 296.47
	PK mean	838.31	1021.52	1161.77	847.53		Intercrop X PK:	
Total	alone	1770.10	1922.81	2654.90	1644.11	1997.98	Intercrop.	: 336.31
	Intercrop.	1247.06	1807.75	1271.15	1352.69	1419.66	PK	: 475.62
	PK mean	1508.58	1865.28	1963.03	1498.40		Intercrop X PK	: n.s.
Uptake by maize								
Grains		645.43	816.31	620.15	705.59		Intercrop.	168.28
Stover		339.61	888.50	852.01	630.21		PK	230.02
Total		1045.04	1704.81	1472.16	1335.80		Intercrop X PK	404.65
Recovery by sunflower								
alone		42.481	46.147	63.718	39.458		Intercrop.	: 8.590
with		19.953	28.932	20.337	21.643		PK	: n.s.
PK mean		31.217	37.540	42.028	30.551		Intercrop X PK	: n.s.
Recovery by maize								
		16.721	27.277	25.472	24.100			6.424
Total recovery								
alone		42.481	46.147	63.718	39.458	47.951	Intercrop.	: 6.265
the both		36.674	56.209	45.809	45.743	46.109	PK	: 9.709
PK mean		39.578	51.178	54.764	42.601		Intercrop X PK	: 13.730

Results of sunflower indicated that intercropping with maize did not reduce N uptake in seeds significantly. The N uptake in stover and by whole plant showed significant decreases under intercropping than sunflower alone system. That observation may be explained due to N mobility from shoot to seeds till received their requirements where the N storage appeared sharply in stover.

The N uptake by both sunflower and maize plants was increased by K_2HPO_4 applications, particularly in sunflower seeds and maize grains under K_2HPO_4 top dressing over the control. Spraying with the 1st rate of K_2HPO_4 raised N uptake in sunflower seeds under mono cropping system significantly over that in intercropping one. Concerning stover, the 1st rate of K_2HPO_4 spraying was significantly superior to the control and the 2nd spraying rate in increasing N amount in case of sunflower while in maize, any of K_2HPO_4 treatment gave significant superiority over the control. Total N uptake was only appeared to be significantly in case of maize when K_2HPO_4 was added as top dressing or at the 1st spraying rate. Nearly similar results were obtained by El-Meneasy *et al.* (2005) and Abou-Zeid *et al.* (2005).

Nitrogen recovery by 16000 sunflower plants was significantly reduced than that by 24000 plant. When the recovery of N by other 16000 maize plants was added to that of 16000 of sunflowers, no significant difference was found between N recovery of 24000 sunflower plants alone and 32000 sunflower + maize plants put in consideration the higher N rate added to the latter cropping system. Thus increasing N rate of application can correct the effect of intercropping system on feeding the intensive cultivation with nitrogen.

Regarding to K_2HPO_4 applications, the amounts recovered of N by maize plants were significantly enhanced by any of these applications. Such increases were reflected of the total N recovery, with sunflower + maize under intensive cropping system in significant increases due to both soil and 1st spraying rate applications over the untreated plots.

Phosphorus uptake and recovery

Data of phosphorus uptake by sunflower and maize plants and its recovery in kg/fed are tabulated in Table 5.

There was no significant effect of intercropping system on P amounts in sunflower seeds, stover and consequently the whole plant.

On the other hand, K_2HPO_4 effected significantly on P amount in sunflower seeds when it was added top dressing or at the 2nd spraying rate. Nevertheless, that spraying rate was significantly superior to the lower one. In sunflower stover and whole plant any K_2HPO_4 application caused significant increase in P amount over the control without differences among these applications above significance limit. The interaction effects between cropping systems and K_2HPO_4 applications induced increases in absorbed P when soil application was arranged within 32000 plants than within 24000 plants. These increases were significant in case

of seeds and whole plant. The opposite was true when any rate of K_2HPO_4 was sprayed with significant differences for both rates in case of seeds and for the 1st rate only in case of stover and whole plant.

TABLE 5. Phosphorus uptake by sunflower and maize (mg/plant) and its recovery (kg/fed) as affected by potassium phosphate applications under and intercropping system.

Item	Cropping system	PK treatments				Inter-Crop mean	L.S.D at 0.05 level	
		A	B	C	D			
Uptake by sunflower								
Seeds	alone	170.90	130.53	206.46	248.61	189.13	Intcrop.	: n.s.
	Intcrop.	107.57	266.62	130.90	182.46	171.89	PK	: 46.27
	PK mean	139.24	198.58	168.68	215.54		Intcrop X PK	: 65.44
Stover	alone	212.57	327.27	348.30	290.68	294.70	Intcrop.	: n.s.
	Intcrop.	157.46	342.28	244.14	297.32	263.11	PK	: 63.11
	PK mean	185.02	334.77	296.22	294.00		Intcrop X PK	: 89.24
Total	alone	383.47	457.80	554.75	539.29	483.83	Intcrop.	: n.s.
	Intcrop.	265.03	608.90	375.04	479.78	432.19	PK	: 94.14
	PK mean	324.25	533.35	464.90	509.53		Intcrop X P	: 133.14
Uptake by maize								
Grains		332.88	332.52	303.76	407.35		Intcrop.	59.33
Stover		129.52	298.47	196.65	376.94		PK	137.38
Total		462.32	630.99	500.41	784.29		Intcrop X PK	129.50
Recovery by sunflower								
alone		9.204	10.627	11.762	12.943	11.134	Intcrop.	: 1.700
Intcrop.		4.241	9.742	6.001	7.676	6.915	PK	: 2.410
PK mean		6.723	10.185	8.882	10.310		Intcrop X PK	: n.s.
Recovery by maize								
		7.397	10.096	8.007	12.549			2.072
Total recovery								
alone		9.204	10.627	11.762	12.943	11.134	Intcrop.	: 1.021
the both		11.705	19.838	14.007	22.025	16.894	PK	: 1.444
PK mean		10.455	15.228	12.885	17.484		Intcrop X PK	: 2.042

Maize responded significantly to K_2HPO_4 either soil or high rate of foliar application in increasing P amount in stover and whole plant while the high rate spraying caused the significancy over all other treatments in grains. These results were in accordance with those of Ronaghi *et al.* on maize and Tamboli & Daftardar (2004) on legumes.

Regarding to P recovery, the more intensive sunflower plants (24000) recovered significantly more phosphorus than the recovery of 16000 ones. That

position converted when 16000 maize plants recovered about 9.5 kg P were associated with 16000 sunflower plants recovered about 7 kg P in average.

Application of K_2HPO_4 enhanced P recovery by sunflower plants significantly when added top dressing or spraying with the higher rate. The same trend was found in case of maize. The final recovery either for 24000 sunflower plants or 32000 sunflower and maize plants showed the following descending order of significance: D = B > C > A. referring to the amounts of K_2HPO_4 added in these treatments, one feddan received 17.80, 1.78 or 3.56 kg P in the treatments B, C or D. thus the efficiency of these applications are 26.81, 136.52 or 197.44% respectively, indicating the low percentage of utilization of soil application and the elevation of spray treatments especially in the higher rate to the level in which plants were encouraged to recover more quantities of soil phosphorus.

Potassium uptake and recovery

In Table 6, data of potassium uptake by sunflower and maize plants and its recovery are presented. Sunflower of mono plant cropping system contained more amounts of K than that of intercropping system in seeds and stover. That increases were significant in case of stover and whole plants.

As for K_2HPO_4, any of the used applications caused significant difference more than the control in K amount in seeds while the 1st rate of foliar application only caused that effect in stover and whole plant. The interaction of these two factors produced significant increases by using the 1st rate of spraying in mono plant cropping system than that in intercropping system in case of seeds stover and consequiently whole plant. On the contrary soil application cases the same effect in intercropping system.

Maize was significantly affected with K_2HPO_4 soil application in increasing K amounts in grains, stover and whole plant over the other treatments without significant differences among them with exception of the 1st rate of spraying which was significantly superior to the control in the case of stover. These results were in agreement with those of El-Meneasy *et al.* (2005) and Abou-Zeid *et al.* (2005).

Potassium recovery by sunflower plants under the two cropping systems clarified the significant increase in case of mono plant system than in intercropping one. That increase declined when K recovered by maize was added. Recovery of K by sunflower plants was significantly higher by using the 1st rate of spraying while the same effect was produced by K_2HPO_4 soil application in case of maize. The total recovery followed recovery by sunflower trend.

Concerning the efficiency of these K fertilization treatment where the added K quantities were 44.92, 4.49 or 8.98 kg K/fed in treatment B, C or D, Respectively, the efficiency were 16.54, 254.83 and 36.01% of the added quantities in the same order of treatments B, C and D. It could be noticed that the 1st rate of K_2HPO_4 spraying encouraged the plants to consume about 7 kg of native soil K.

TABLE 6. Potassium uptake by sunflower and maize (mg/plant) and its recovery (kg/fed) as affected by potassium phosphate applications under an intercropping system.

Item	Cropping system	PK treatments				Inter-crop mean	L.S.D at 0.05 level	
		A	B	C	D			
Uptake by sunflower								
Seeds	alone	234.88	201.62	300.49	214.22	237.80	Intcrop	: n.s.
	Intcrop.	132.06	290.79	167.57	247.11	209.39	PK	: 43.06
	PK mean	183.47	246.21	234.03	230.66		Intcrop X PK	: 60.90
Stover	alone	1466.40	1343.63	2129.82	1427.93	1591.95	Intcrop.	: 209.51
	Intcrop.	1161.17	1658.68	1277.97	1396.10	1373.48	PK	: 296.30
	PK mean	1313.79	1501.15	1703.90	1412.02		Intcrop X PK	: 419.02
Total	alone	1701.28	1545.24	2430.31	1642.15	1829.75	Intcrop.	: 230.91
	Intcrop.	1293.47	1949.46	1445.54	1643.20	1582.92	PK	: 326.54
	PK mean	1497.38	1747.38	1937.93	1642.68		Intcrop X PK	: 461.82
Uptake by maize								
Grain		151.90	249.06	184.27	169.50	43.914	Intcrop.	42.74
Stover		765.38	1174.87	917.71	891.04	25.332	PK	150.42
Total		917.28	1423.93	1101.98	1060.54		Intcrop X PK	187.23
Recovery by sunflower								
alone		40.831	37.086	58.327	39.412	43.914	Intcrop.	: 6.110
Intcrop.		20.696	31.191	23.129	26.4291	43.340	PK	: 8.640
PK mean		30.764	34.139	40.728	32.852		Intcrop X PK	: 12.220
Recovery by maize								
		14.676	22.783	17.632	16.969			6.366
Total recovery								
alone		40.831	37.086	58.327	39.412	43.914	Intcrop.	: n.s.
the both		35.372	53.974	40.760	43.260	43.340	PK	: 8.930
PK mean		38.102	45.530	49.544	41.336		Intcrop X PK	: 12.640

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التسميد بفوسفات البوتاسيوم تحت نظام تحميل دوار شمس وذرة بأرض جيرية

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أجريت تجربة حقلية بمزرعة محطة البحوث الزراعية بالنوبارية فى أرض جيرية عادية بدوار الشمس فقط (٢٤ ألف نبات/فدان) أو دوار الشمس مع الذرة الشامية (١٦ ألف نبات/فدان من كل من المحصولين) وقد أعطى التسميد الفوسفاتى البوتاسى فى صورة فوسفات ثنائى البوتاسيوم بو٢يد٥فو٤ (١٧,٨٪ فو٢ ٤٤,٩٪ بو) بمعدل ١٠٠ كجم/فدان إضافة أرضية أو رشا بمعدل ١٠ كجم أو ٢٠ كجم بو٢يد٥فو٤/فدان إلى جانب قطع لم يضف لها أى تسميد فوسفاتى بوتاسى كمقارنة، وقد تم تسجيل المحصول وبعض الثوابت لكل محصول كما قدر محتواها من النيتروجين والفوسفور والبوتاسيوم.

وقد أمكن تلخيص النتائج المتحصل عليها فيما لى:

- نتج عن نظام تحميل الذرة مع دوار الشمس عن نقص معنوى حاد فى محصول بذور دوار الشمس ومحتواها من الزيت والمادة الجافة لكل من الحطب وكامل النبات ومن ثم المسحوب الكلى من الأرض من النيتروجين والفوسفور والبوتاسيوم إلا أنه فى نفس الوقت تحصل فى ذات المساحة على نحو ١٣ أردبا من حبوب الذرة /فدان مشتركا مع دوار الشمس. ولحساب مدخلات وعوائد الانتاج حسب أسعار ٢٠٠٤ لنظام التحميل محل الدراسة وجد أن العائد الصافى ١٥٥٪ من العائد من زراعة دوار الشمس فقط بما يقدر بنحو ٦٣٠ جنيها تقريبا فرقا عن الأخير.

- وقد استجاب كل من دوار الشمس والذرة معنويا لإضافات فوسفات ثنائى البوتاسيوم لهذه الأرض وكانت الإضافة الأرضية تكبيشا هى الأكثر تأثيرا فى زيادة محتوى بذور دوار الشمس من الزيت والنيتروجين والبوتاسيوم وكذلك محصول حبوب الذرة ووزن مائة حبة منه والمادة الجافة لحطب الذرة ومحتوى الحطب والنبات الكامل للذرة بينما كانت لمعاملات الرش الأثر الأكبر فى بقية القياسات الأخرى.

- أما الأثر المتبادل لعاملى الدراسة نظام التحميل وإضافة فوسفات ثنائى البوتاسيوم فقد حقق إستجابة معنوية فى بعض الحالات حيث لم تظهر استجابة ما لأحد هذين العاملين أو كليهما مما يدل على إمكانية تصحيح الآثار السلبية لنظام التحميل محل الدراسة هذا بالتسميد بأى من الفوسفات أو البوتاسيوم أوكليها لهذين المحصولين تحت ظروف هذه الأرض.

- أيضا نتج أن إضافة ١٠٠ كجم بويد٢فو٤/فدان يحقق كفاءة منخفضة خاصة بالنسبة للبوتاسيوم ويحسن أن يضاف نصف هذا المعدل فى صورة بويد٢فو٤، وفى معظم الأحوال كان معدل الرش الأول أى الأقل له نفس الأثر إحصائيا للمعدل الأعلى (المضاعف) بـل ربما يفضله ومن ثم فإن معدل رش ١٠ كجم بويد٢ فو٤ قد يكون كافيا تحت ظروف التجربة.