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RESPONSE OF PEANUT TO FOLIAR SPRAYING WITH COPPER AND CALCIUM UNDER DIFFERENT LEVELS OF POTASSIUM FERTILIZATION IN SANDY SOILS

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ABSTRACT

Two field experiments were conducted during 2001 and 2002 seasons in the Agricultural Farm of Suez Canal University at Ismailia to study the effect of three levels of potassium fertilizer i.e. 35, 55 and 75 kg K_2O/ fad, three concentrations of chelated calcium (12 % Ca-EDTA) i.e. water (control), 850 and 1700 ppm and two concentrations of sequestreted copper (13 % Cu) namely water (control) and 500 ppm on yield, its components and yield quality of peanut Giza 6 variety in sandy soils of Ismailia Governorate.

Application of potassium fertilizer up to 75 kg K_2O/fad significantly increased plant height, number of branches, pods and seeds/ plant, weight of pods and seeds/ plant, 100-seed weight, seed oil content (%) and pod, seed, straw, biological and oil yields/fad.

Spraying peanut plants with chelated calcium up to 1700 ppm resulted in significant increases in plant height, seed oil content (%) and pod, seed, straw, biological and oil yields/ fad as well as all yield attributes except number of seeds/ pod.

Supplementary application of 500 ppm aqueous solution of sequestreted copper as foliar spraying significantly increased all the studied traits except number of seeds/ pod compared to the check treatment.

There were significant interactions between potassium fertilization x spraying with copper as well as Ca x Cu on number of pods/ plant and weight of pods and seeds/ plant. Also, K x Ca x Cu affected pod and seed yields/ fad significantly.

There was a positive and highly significant correlation between seed yield/ fad of peanut and each of number of branches, pods and seeds/ plant, weight of pods and seeds/ plant, number of seeds/ pod, 100-seed weight and pod yield/ fad.

INTRODUCTION

Peanut (*Arachis hypogaea* L.) is considered to be one of the most important edible oil crops in Egypt in addition to green leafy hay for livestock and it's ability for improving the physical structure of newly reclaimed sandy soils.

Many problems face the production of peanut in newly cultivated sandy soils such as poverty of sandy soils, high loss of nutrients by leaching and its low field capacity as well as the unfilled pods in the yield.

Potassium is the most important cation in plant because of its important role in physiological and biochemical functions such as activation of various enzymatic systems, stimulating synthesis of protein and many other compounds such as sugar, cellulose and cell wall (Marschner, 1986).

So, many researchers reported beneficial effects of potassium on yield, its components and yield quality of peanut.

Abdel-Halem *et. al.* (1988) recorded that increasing potassium fertilizer from 25 to 50 kg K_2O / fad significantly increased plant height, number of branches and pods/ plant, shelling percentage and seed yield per fad. While, seed yield / plant and weight of 100-seed were not affected.

Anton and Bassiem (1998) indicated that 100-seed weight and pod and seed yields/ fad of peanut responded positively to applying potassium fertilizer up to 48 Kg K_2O / fad.

Gabr (1998) added 0, 24 and 48 kg K_2O / fad to peanut plants and found that increasing K fertilization up to 48 kg K_2O / fad increased plant height, number of branches and pods/ plant, weight of pods/ plant, 100-seed weight, pod yield/ fad and seed oil content (%).

Nasr-Alla *et. al.*(1998) applied 24, 48 and 72 kg K_2O/ fad to peanut plants and mentioned that potassium fertilization significantly increased plant height, number of branches/ plant, pod and seed weight/ plant, pod, seed and biological yields/ fad and seed oil percentage. Whereas 100-seed weight was not affected.

Dahdouh (1999) revealed that increasing potassium fertilization from 0 to 24 and 48 Kg K_2O/ fad significantly increased pod and straw yields per fad, shelling percentage and seed oil percentage of peanut.

Ali (2001) studied the effect of four rates of potassium fertilizer i.e 0, 24, 32 and 40 kg K_2O/ fad and stated that number of pods and seeds/ plant, weight of pods/ plant, 100-seed weight, seed oil percentage and yields of pods and oil per fad were significantly increased by increasing K level up to 40 kg K_2O/ fad while shelling percentage was not affected.

Ali and Mowafy (2003) studied the influence of three potassium levels i.e 24, 48 and 72 kg K_2O/ fad on peanut and found that adding potassium fertilizer up to 72 kg K_2O/ fad significantly increased plant height, number of branches and pods/ plant, weight of pods and seeds/ plant, 100-seed weight, shelling percentage and pod, seed, straw and oil yields/ fad.

Saleh *et. al.* (2003) stated that application of 50 kg K2O/ fad at planting significantly increased 100-seed weight, pod, seed and straw yields/ fad and shelling percentage of peanut compared with applying 25 kg K2O/ fad or untreated plants.

Abd-Alla (2004) fertilized peanut with three levels of potassium fertilizer i.e. 24, 48 and 72 kg K_2O/fad and indicated that increasing potassium up to 72 kg K_2O/ fad significantly increased plant height, number of branches, pods and seeds/ plant, weight of pods and seeds/ plant, 100-seed weight, shelling percentage and pod, seed and biological yields/ fad.

Concerning calcium, it promotes root and leaf development and is important for the formation and functioning of root nodules bacteria in legumes. It is a constituent of the cell walls and necessary for cell elongation, protein synthesis and normal cell division. Calcium regulates the translocation of carbohydrates, cell acidity and permeability. It improves general plant vigor and increases stiffness of straw and encourages seed production (Follett *et. al.*, 1981). So, several investigators announced that application of calcium had favorable effect on peanut.

Shabassy *et. al.* (1971) noticed that pod and seed yields/ fad of peanut were increased by applying gypsum up to 800 kg/ fad.

El-Ahmer *et. al.* (1987) reported that shelling percentage and pod yield/ fad were increased by adding 500 kg gypsum/ fad to peanut plants.

Omar (1988) studied the effect of four gypsum rates i.e. 0, 250, 500 and 750 kg/ fad on peanut and found that number of pods/ plant, weight of pods and seeds/ plant and pod and straw yields/ fad were increased by applying gypsum.

Saad *et. al.* (1989) demonstrated that applying 500 kg gypsum/ fad significantly increased number and weight of pods per plant and seed yield/ plant of peanut. Whereas, seed oil percentage, 100-seed weight and shelling percentage were not affected.

Abdul-Galil *et. al.* (1995) fertilized peanut plants with 0, 500 and 1000 kg gypsum/ fad and stated that increasing gypsum up to 1000 kg/ fad significantly increased 100-seed weight, seed weight/ plant and pod and seed yields/ fad. While, shelling percentage was not affected.

Ali *et. al.* (1995a) studied the effect of three gypsum levels i.e. 0, 500 and 1000 kg/ fad on peanut and showed that applying 500 kg / fad significantly increased number of pods/ plant, weight of pods and seeds/ plant and pod, seed and straw yields/ fad.

Also, Ali *et. al.* (1995b) reported that adding 500 kg gypsum/ fad significantly increased number of seeds/ pod, weight of 100-seed, shelling percentage, seed oil percentage and oil yield per fad of peanut compared to unfertilized control.

Dahdouh (1999) concluded that foliar spraying with 5 gram calcium chelate significantly increased shelling percentage, pod and straw yields per fad and seed oil percentage of peanut compared with untreated plants.

Hussein *et. al.* (2000) recorded that application of 500 kg gypsum/ fad significantly increased number of branches and pods/ plant, pod weight/ plant, 100-seed weight, shelling percentage and pod yield/ fad whereas plant height and seed oil percentage of peanut were not affected.

Regarding copper, it plays a significant role in several physiological processes namely photosynthesis, respiration, carbohydrate distribution, nitrogen reduction and fixation, protein metabolism and it controls the production of DNA and RNA. Copper occurs in enzymes having vital function in plant metabolism as well as it influences water permeability of xylem vessels and thus controls water relationships. In addition its deficiency greatly inhibits the reproduction of plants i.e. reduces seed production and increases pollen sterility (Kabata-Pendias and Pendias, 1984).

Farrag (1978) stated that plant height and dry matter per plant were significantly increased by spraying faba bean plants with Cu.

Yakout *et. al.* (1980) stated that foliar spraying of maize plants with 400 ppm copper sulphate significantly increased plant height, shelling percentage, 100-seed weight and seed yield/ fad.

Yakout *et. al.* (1981) mentioned that foliar nutrition of soybean plants with 500 ppm copper sulphate significantly increased plant height, number of pods/ plant, weight of pods and seeds/ plant and 100-seed weight as well as photosynthetic pigments and stability of chlorophyll.

Ashour *et. al.* (1982) revealed that spraying wheat plants with 200 ppm copper sulphate increased plant height, number of branches/ plant and grain and straw yields.

Yakout *et. al.* (1982) found that plant height, number of pods/ plant, weight of pods and seeds/ plant and 100-seed weight of soybean were increased by foliar application of 500 ppm copper sulphate.

Farrag *et. al.* (1983) revealed that spraying faba bean plants with 100 ppm copper sulphate increased number of pods and seeds/ plant as well as weight of pods and seeds/ plant.

Salem (1984) demonstrated that spraying wheat plants with 50 ppm copper sulphate resulted in significant increase in 1000-grain weight and grain yield/fad, while plant height and straw yield/fad increased insignificantly.

Yakout *et. al.* (1985) mentioned that foliar nutrition of peanut plants with 200 ppm copper sulphate significantly increased number and weight of pods/ plant, 100-seed weight, shelling percentage, pod yield/ fad and seed oil content (%) compared to unsprayed plants. While number of seeds per pod and straw yield/ fad were not affected.

Rizk and Abd El-Salam (1992) reported that spraying faba bean plants with 0.15 gram of copper sulphate/ Liter resulted in significant increase in number and weight of pods/ plant, 100-seed weight and seed yield/ fad while the increases in plant height and straw yield/ fad were insignificant.

MATERIALS AND METHODS

Two field experiments were conducted during 2001 and 2002 seasons at the Experimental Farm, Faculty of Agriculture, Suez Canal University at Ismailia to study the effect of potassium fertilization and foliar nutrition of chelated calcium and sequestreted copper on yield, its components and yield quality of peanut.

The soil of the experiments was sandy with pH values of 7.88 and 7.79 and contained 3.38 and 3.65 ppm available N, 1.59 and 1.78 ppm available P, 8.66 and 9.53 ppm available K and 0.05 % and 0.06 % organic matter in the two seasons, respectively.

Every experiment included 18 treatments which were the combinations of three levels of potassium fertilizer 35, 55 and 75 kg K_2O/ fad, three concentrations of chelated calcium (12 % Ca-EDTA) i.e. water (control), 850 and 1700 ppm and two concentrations of sequestreted copper (13 % Cu) namely water (control) and 500 ppm.

Potassium in the form of potassium sulphate (48 % K_2O) at the previous levels was applied at two equal doses. The first dose was added after thinning and the second dose at complete flowering.

Foliar spraying with Cu and Ca treatments was done twice after 30 and 45 days from sowing for sequestreted copper and after 50 and 65 days from sowing for chelated calcium with volume spray of 400 Liter/ fad.

The experimental design was split-split plots with four replications. Three potassium levels were allocated randomly in the main plots, while the three treatments of foliar nutrition of calcium were arranged randomly in the sub plots and the two treatments of spraying of copper were distributed randomly in the sub-sub plots. Each experimental sub-sub plot consisted of 5 ridges, 4 meter in length and 60 cm in width (plot area = 12 m^2).

All seeds of peanut Giza 6 variety were coated by Arab gum and inoculated with the specific Rhizobium strain. Seeds were sown on one side of the ridge in hills 10 cm apart on May 20 and 14 in 2001 and 2002 seasons, respectively.

Calcium superphosphate fertilizer (16 % P_2O_5) was applied at the rate of 200 kg/ fad during preparing experimental soil. A starter dose of 30 kg N/ fad of ammonium sulphate (21 % N) was added to the soil after thinning.

After 18 days from sowing, peanut plants were thinned to one plant per hill. The normal cultural practices for growing peanut crop at Ismailia Governorate were followed.

At harvest, after 120 days from sowing, samples of 10 guarded plants were randomly taken from the inner ridges in each sub-sub plot to estimate plant height (cm), number of branches, pods and seeds/ plant, weight of pods and seeds/ plant (g), number of seeds/ pod and 100-seed weight (g). While pod yield (ardab/ fad), seed, straw and biological yields (ton/ fad) were determined from the plants of the two middle ridges (the 3rd and 4th ridges) in each plot and the yields per fad were calculated.

Seed oil content (%) was determined by using the Soxhelt continuous extraction apparatus with petroleum ether as an organic solvent according to A.O.A.C. (1975) and seed oil yield (ton/ fad) was calculated by multiplying oil percentage and seed yield per fad.

The analysis of variance of split-split plots design was used according to Snedecor and Cochran (1982). The combined analysis of variance was performed for the data of the two seasons.

Means followed by the same alphabetical letters are not statistically different according to Duncan's Multiple Range Test at the 5 % level of significance (Duncan, 1955).

RESULTS AND DISCUSSION

A- Effect of potassium fertilization:-

Data in Tables (1 and 2) show that increasing potassium fertilizer rate from 35 to 75 kg K_2O/ fad significantly increased plant height as well as number of branches, pods and seeds/ plant of peanut in both seasons and their combined averages. These results were expected since potassium plays a major role in cell extension and osmoregulation, also it enhances metabolic processes and various enzymes (Marschner, 1986). These results are in accordance with those reported by Abdel-Halem *et. al.* (1988), Gabr (1998) and Ali (2001).

Potassium fertilizer levels did not affect significantly number of seeds/pod in both seasons and over them (Table 3).

Fertilizing peanut plants with K fertilizer up to 75 kg K_2O/ fad gave significantly heaviest pods and seeds weight/ plant as well as 100-seed weight (Tables 2 and 3). That was true in the two seasons and over them. These results might be attributed to the important role of potassium in activation synthesis of protein and many other compounds including starch, sugar, cellulose, cell wall and vitamins. Also, K encourages various enzymes and photosynthesis as well as plant root development (Follett *et al.*, 1981) in turn resulted higher dry matter accumulation in leaves. Moreover, K enhances translocation of metabolites synthesized from leaves (the source) to pods and seeds (the sink), consequently

increases weight of pods and seeds/plant as well as 100-seed weight. Confirming results were obtained by Anton and Bassiem (1998), Gabr (1998), Nasr-Alla *et. al.* (1998), Dahdouh (1999), Ali and Mowafy (2003) and Abd-Alla (2004).

Table (1): Effect of potassium fertilization and foliar spraying with calcium and copper on plant height, number of branches/plant and number of pods/plant of peanut.

Treat-ments	Plant height (cm)			No. of branches/ plant			No. of pods/ plant		
	2001	2002	Comb.	2001	2002	Comb.	2001	2002	Comb.
Potassium fertilization (K)									
35 Kg K_2O/fad	34.16c	36.51c	35.34c	12.98c	14.89c	13.94c	19.07c	21.91c	20.49c
55 Kg K_2O/fad	39.25b	43.47b	41.36b	15.38b	17.84b	16.60b	22.77b	26.60b	24.68b
75 Kg K_2O/fad	44.31a	50.44a	47.37a	17.82a	20.94a	19.38a	26.69a	31.43a	29.06a
F.test	*	*	*	*	*	*	*	*	*
Spraying with calcium (Ca)									
Water	35.16c	38.01c	36.58c	13.70c	15.68c	14.69c	19.91c	23.00c	21.45c
850 ppm	39.37b	43.59b	41.48b	15.45b	17.96b	16.70b	22.80b	26.65b	24.72b
1700 ppm	43.19a	48.82a	46.00a	17.03a	20.03a	18.53a	25.82a	30.29a	28.05a
F.test	*	*	*	*	*	*	*	*	*
Spraying with copper (Cu)									
Water	37.85 b	41.73b	39.79b	14.81b	17.11b	15.95b	21.77b	25.36b	23.57b
500 ppm	40.63a	45.22a	42.92a	15.98a	18.67a	17.32a	23.91a	27.93a	25.92a
F.test	*	*	*	*	*	*	*	*	*
K x Ca	NS	*	NS	*	NS	NS	*	NS	NS
K x Cu	NS	NS	NS	NS	NS	NS	*	NS	*
Ca x Cu	NS	*	NS	NS	*	NS	NS	*	*
KxCaxCu	NS	NS	NS	NS	NS	NS	NS	NS	NS

It is clearly evident from Tables (3 and 4) that there were significant and consistent increases in pod, seed, straw and biological yields/ fad of peanut by increasing rate of potassium fertilizer from 35 to 55 and 75 kg K_2O/ fad and that held true in both seasons and their combined data. Fertilizing peanut plants with 75 kg K_2O/ fad outyielded those received 55 kg and 35 kg K_2O/fad in pod yield/ fad by 17.67% and 45.31% in the first season, 20.09% and 51.67% in the second one and 18.95% and 48.60% in the combined data, respectively. The relative increases for seed yield/ fad were 18.70% and 47.50 % in the first season, 21.79% and 54.93% in the second one and 20.34% and 51.41% in over them, respectively, for straw yield/ fad the increases reached 15.31% and 36.64% in the first season, 16.14% and 37.65% in the second one and 15.61 % and 37.01% in the combined data, respectively and for biological yield/ fad were 16.16% and 39.22% in the first season, 17.24% and 41.66% in the second season and 16.63% and 40.55% over them, respectively. The beneficial effect of potassium fertilization on seed yield/fad of peanut might be due to that K encouraged

vegetative growth of peanut plants as expressed by plant height and number of branches/plant which in turn increased number of pods and seeds/plant. Also, potassium increases the amount of metabolites synthesized because it enhances metabolism of carbohydrate and synthesis of protein and much compounds such as sugar, cellulose, starch, cell wall and vitamins (Marschner, 1986). Moreover, K favors translocation of metabolites from the leaves (the source) to the reproductive organs i.e. pods and seeds (the sink), which increased weight of pods and seeds/plant as well as 100-seed weight and finally seed yield per fad of peanut. These results are in conformity with those obtained by Abdel-Halem *et. al.* (1988), Anton and Bassiem (1998), Nasr-Alla *et. al.* (1998), Dahdouh (1999), Ali and Mowafy (2003), Saleh *et. al.*(2003) and Abd-Alla (2004).

Table (2): Effect of potassium fertilization and foliar spraying with calcium and copper on number of seeds/plant, weight of pods/plant and weight of seeds/plant of peanut.

Treat-ments	Number of seeds/plant			Weight of pods/plant (g)			Weight of seeds/plant (g)		
	2001	2002	Comb.	2001	2002	Comb.	2001	2002	Comb.
Potassium fertilization (K)									
35 Kg K_2O/fad	25.02c	28.55c	26.79c	25.97c	29.19c	27.58c	19.98c	23.03c	21.50c
55 Kg K_2O/fad	30.08b	34.84b	32.46b	31.01b	35.27b	33.13b	24.02b	27.78b	25.90b
75 Kg K_2O/fad	35.44a	41.48a	38.45a	36.27a	41.55a	38.91a	28.30a	32.77a	30.53a
F.test	*	*	*	*	*	*	*	*	*
Spraying with calcium (Ca)									
Water	26.14c	30.03c	28.08c	27.15c	30.61c	28.88c	20.89c	24.08c	22.48c
850 ppm	30.13b	34.87b	32.50b	31.04b	35.27b	33.15b	24.07b	27.78b	25.92b
1700 ppm	34.27a	39.97a	37.12a	35.05a	40.13a	37.59a	27.35a	31.72a	29.53a
F.test	*	*	*	*	*	*	*	*	*
Spraying with copper (Cu)									
Water	28.77b	33.20b	30.98b	29.69b	33.63b	31.66b	22.97b	26.60b	24.78b
500 ppm	31.59a	36.71a	34.15a	32.47a	37.05a	34.76a	25.24a	29.12a	27.18a
F.test	*	*	*	*	*	*	*	*	*
K x Ca	NS	*	NS	NS	*	NS	NS	*	NS
K x Cu	*	NS	NS	*	NS	*	*	*	*
Ca x Cu	*	NS	NS	NS	*	*	NS	*	*
K x Ca x Cu	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table (3): Effect of potassium fertilization and foliar spraying with calcium and copper on number of seeds/pod, 100-seed weight and pod yield/fad of peanut.

Treat-ments	Number of seeds/pod			100-seed weight (g)			Pod yield (ardab/fad)		
	2001	2002	Comb.	2001	2002	Comb.	2001	2002	Comb.
Potassium fertilization (K)									
35 Kg K_2O/fad	1.310	1.301	1.306	64.60c	70.70c	67.65c	16.13c	17.65c	16.89c
55 Kg K_2O/fad	1.319	1.308	1.314	69.17b	75.13b	72.15b	19.92b	22.29b	21.10b
75 Kg K_2O/fad	1.327	1.318	1.322	73.75a	79.51a	76.63a	23.44a	26.77a	25.10a
F.test	NS	NS	NS	*	*	*	*	*	*
Spraying with calcium (Ca)									
Water	1.311	1.304	1.307	64.96c	70.90c	67.93c	16.78c	18.40c	17.59c
850 ppm	1.320	1.306	1.313	69.11b	75.11b	72.11b	19.98b	22.39b	21.19b
1700 ppm	1.326	1.317	1.321	73.45a	79.32a	76.39a	22.72a	25.92a	24.32a
F.test	NS	NS	NS	*	*	*	*	*	*
Spraying with copper (Cu)									
Water	1.319	1.306	1.312	67.15b	73.11b	70.12b	18.78b	20.90b	19.84b
500 ppm	1.319	1.312	1.315	71.21a	77.12a	74.16a	20.87a	23.57a	22.22a
F.test	NS	NS	NS	*	*	*	*	*	*
K x Ca	NS	NS	NS	NS	NS	NS	*	NS	NS
K x Cu	NS	NS	NS	*	NS	NS	*	NS	NS
Ca x Cu	NS	NS	NS	*	NS	NS	NS	*	NS
K x Ca x Cu	NS	NS	NS	NS	NS	NS	NS	*	*

The results in Table (5) reveal that seed oil content (%) and seed oil yield/ fad of peanut were significantly increased as potassium fertilizer increased up to 75 kg K_2O/ fad in both seasons and over them. The increase in seed oil yield/fad of peanut by increasing potassium fertilizer rate might be due to the increase in seed oil content (%) and seed yield/fad. Similar results were found by Gabr (1998), Nasr-Alla *et. al.* (1998), Dahdouh (1999) and Ali and Mowafy (2003).

B- Effect of foliar spraying with chelated calcium:-

Results in Tables (1 and 2) illustrate that increasing the rate of chelated calcium concentration from zero to 850 and 1700 ppm as foliar spraying induced significant increases in peanut plant height and number of branches, pods and seeds/ plant. That held true in both seasons and over them. These results are in harmony with those found by Omar (1988), Saad *et. al.* (1989), Ali *et. al.* (1995a) and Hussein *et. al* (2000).

Table (4): Effect of potassium fertilization and foliar spraying with calcium and copper on seed yield/fad, straw yield/fad and biological yield/fad of peanut.

Treat-ments	Seed yield (ton/fad)			Straw yield (ton/fad)			Biological yield (ton/fad)		
	2001	2002	Comb.	2001	2002	Comb.	2001	2002	Comb.
Potassium fertilization (K)									
35 Kg K_2O/fad	0.882c	0.963c	0.922c	2.92c	3.24c	3.08c	4.13c	4.56c	4.34c
55 Kg K_2O/fad	1.096b	1.225b	1.160b	3.46b	3.84b	3.65b	4.95b	5.51b	5.23b
75 Kg K_2O/fad	1.301a	1.492a	1.396a	3.99a	4.46a	4.22a	5.75a	6.46a	6.10a
F.test	*	*	*	*	*	*	*	*	*
Spraying with calcium (Ca)									
Water	0.917c	1.007c	0.962c	3.04c	3.36c	3.20c	4.29c	4.74c	4.51c
850 ppm	1.101b	1.232b	1.166b	3.47b	3.86b	3.66b	4.97b	5.54b	5.25b
1700 ppm	1.261a	1.442a	1.351a	3.86a	4.32a	4.09a	5.57a	6.25a	5.91a
F.test	*	*	*	*	*	*	*	*	*
Spraying with copper (Cu)									
Water	1.032b	1.151b	1.091b	3.33b	3.70b	3.51b	4.74b	5.26b	5.00b
500 ppm	1.153a	1.302a	1.227a	3.59a	3.99a	3.79a	5.15a	5.76a	5.45a
F.test	*	*	*	*	*	*	*	*	*
K x Ca	NS	*	NS	NS	NS	NS	NS	*	NS
K x Cu	NS	NS	NS	NS	*	NS	*	NS	NS
Ca x Cu	*	NS	NS	NS	NS	NS	NS	NS	NS
K x Ca x Cu	NS	*	*	NS	NS	NS	NS	NS	NS

It is obvious from Tables (2 and 3) that weight of pods and seeds/ plant and 100-seed weight of peanut were significantly increased when peanut plants were received aqueous solution of chelated calcium via foliage as compared to unsprayed plants. Spraying 1700 ppm Ca overcame significantly 850 ppm regarding the effect on the above characters. Similar results were reported by El-Ahmer *et. al.* (1987), Ali *et. al.* (1995a &b) and Hussein *et. al.* (2000).

Number of seeds/pod did not respond to foliar application of chelated calcium in the two seasons and over them (Table 3).

Data in Tables (3 and 4) show that pod, seed, straw and biological yields/ fad of peanut were significantly increased by increasing chelated calcium concentration as foliar spraying up to 1700 ppm and that was true in the two seasons and their combined averages. Foliar spraying peanut plants with 1700 ppm Ca surpassed those sprayed with 850 ppm and unsprayed plants in pod yield/ fad by 13.71% and 35.39% in the first season, 15.76% and 40.86% in the second one and 14.77% and 38.26% in the combined data, respectively. The relative increases for seed yield/ fad were 14.53% and 37.51% in the first season, 17.04%

and 43.19% in the second season and 15.86% and 40.43% over them, respectively, for straw yield/ fad increases were 11.23% and 26.97% in the first season, 11.91% and 28.57% in the second season and 11.74% and 27.81% in the combined data, respectively and for biological yield/ fad were 12.07% and 29.83% in the first season, 12.81% and 31.85% in the second season and 12.57% and 31.04% over them, respectively. The favorable effect of spraying with calcium on seed yield/fad of peanut was expected since calcium enhanced vegetative plant growth such as plant height and number of branches/plant because it promotes root and leaf development and it is important for the formation and functioning of root nodules bacteria. Also, calcium increases dry matter accumulation since it is a constituent of the cell walls and it is necessary for cell elongation, protein synthesis and normall cell division. Moreover, calcium regulates the translocation of carbohydrates, cell acidity and permeability (Follett *et al.*, 1981) which in turn might increase yield components such as number and weight of pods and seeds /plant as well as 100-seed weight, and consequently increased seed yield/fad. These results are in conformity with those recorded by Shabassy *et. al.* (1971), El-Ahmer *et. al.* (1987), Omar (1988), Abdul-Galil *et. al.* (1995), Ali *et. al.* (1995 a), Dahdouh (1999) and Hussein *et. al.* (2000).

Foliar nutrition of peanut plants with 1700 ppm chelated calcium significantly increased seed oil content (%) and seed oil yield/ fad as compared to 850 ppm Ca which in turn surpassed significantly unsprayed plants in this respect in both seasons and over them (Table 5). The increase in oil yield/fad by foliar spraying with chelated calcium could be due to the increase in seed oil content (%) and seed yield/fad. These results are in agreement with those reported by Ali *et. al.* (1995b) and Dahdouh (1999).

C- Effect of foliar application with sequestreted copper:-

Data in Tables (1 and 2) reveal that supplementary spraying peanut plants with 500 ppm sequestreted copper significantly increased plant height and number of branches, pods and seeds/ plant compared to unsprayed plants in both seasons and over them. Confirming results were obtained by Farrag (1978), Yakout *et. al.* (1981), Ashour *et. al.* (1982), Farrag *et. al.* (1983) and Rizk and Abd El-Salam (1992).

Tables (2 and 3) illustrate that weight of pods and seeds/ plant and 100-seed weight were significantly increased when peanut plants received 500 ppm aqueous solution of sequestreted copper via foliage compared to unsprayed plants. That was true in both seasons and their combined averages. These results are in same trend with those reported by Yakout *et. al.* (1980), (1982) and (1985) and Rizk and Abd El-Salam (1992).

The data presented in Table (3) reveal that no significant effect was detected on number of seeds/pod due to copper spraying and that held true in both seasons and their combined data.

There were significant and remarkable increases in pod, seed, straw and biological yields/ fad by foliar nutrition of peanut plants with 500 ppm

sequestreted copper as compared to unsprayed plants and that held true in the two seasons and over them (Tables 3 and 4). Foliar nutrition of peanut plants with 500 ppm Cu increased pod yield/ fad by 11.12%, 12.77% and 11.99%, seed yield/ fad by 11.72%, 13.11% and 12.46%, straw yield/ fad by 7.80%, 7.83% and 7.97% and biological yield/ fad by 8.64%, 9.50% and 9.00% in the two seasons and over them, respectively. The increase in seed yield/fad of peanut by foliar spraying with copper might be attributed to that copper plays a significant role in several physiological processes namely photosynthesis, respiration, carbohydrate distribution, nitrogen reduction and fixation, protein metabolism as well as it controls the production of DNA and RNA (Kabata-Pendias and Pendias, 1984). Therefore, copper might enhance growth characters as expressed by plant height and number of branches/plant which in turn increased yield attributes such as number and weight of pods and seeds/plant as well as 100-seed weight, and consequently seed yield/fad. These results are in harmony with those recorded by Ashour *et. al.* (1982), Salem (1984), Yakout *et. al.* (1985) and Rizk and Abd El-Salam (1992).

It is clearly evident from Table (5) that spraying peanut plants with 500 ppm sequestreted copper gave significant increments in seed oil content (%) and seed oil yield/ fad compared to unsprayed control in both seasons and their combined data. Similar results were emphasized by Yakout *et. al.* (1985).

D-Interactions effects:-

The combined analysis of variance for the data of the two seasons indicated that the all possible interactions among the three studied factors were not significant regarding the effects on the studied characters except potassium fertilization x spraying with copper and foliar application of calcium x spraying with copper on number of pods/ plant and weight of pods and seeds/ plant and potassium fertilization x Ca x Cu on pod and seed yields/ fad (Tables 1-5).

Results in Table (6) show that the highest number of pods/ plant and weight of pods and seeds/ plant were obtained by applying 75 kg K_2O/ fad and foliar spraying with 500 ppm Cu, while the lowest values were resulted by adding 35 kg K_2O/ fad without Cu spraying. Foliar spraying with 1700 ppm Ca combined spraying with 500 ppm Cu gave the highest values of the aforementioned characters, meanwhile the lowest values were obtained from plants unsprayed with Ca and Cu.

Concerning the significant effect of the second order interaction on pod and seed yields/ fad, the highest values were achieved by application of 75 kg K_2O/ fad and spraying with 1700 ppm Ca and 500 ppm Cu, while the lowest values were obtained by adding 35 kg K_2O/ fad and without spraying of Ca and Cu.

Table (5): Effect of potassium fertilization and foliar spraying with calcium and copper on seed oil content (%) and seed oil yield/fad of peanut.

Treatments	Seed oil content (%)			Seed oil yield (ton / fad)		
	2001	2002	Comb.	2001	2002	Comb
Potassium fertilization (K)						
35 Kg K_2O/fad	44.07c	45.98c	45.02c	0.391c	0.446c	0.418c
55 Kg K_2O/fad	48.43b	50.81b	49.62b	0.534b	0.628b	0.581b
75 Kg K_2O/fad	52.99a	55.66a	54.32a	0.694a	0.838a	0.766a
F.test	*	*	*	*	*	*
Spraying with calcium (Ca)						
Water	44.89c	46.79c	45.83c	0.416c	0.477c	0.446c
850 ppm	48.53b	50.97b	49.75b	0.540b	0.636b	0.588b
1700 ppm	52.07a	54.70a	53.38a	0.663a	0.799a	0.731a
F.test	*	*	*	*	*	*
Spraying with copper (Cu)						
Water	46.98b	49.08b	48.03b	0.493b	0.576b	0.534b
500 ppm	50.01a	52.55a	51.28a	0.586a	0.698a	0.642a
F.test	*	*	*	*	*	*
K x Ca	NS	NS	NS	NS	NS	NS
K x Cu	*	NS	NS	*	NS	NS
Ca x Cu	NS	*	NS	NS	*	NS
K x Ca x Cu	NS	NS	NS	NS	NS	NS

Table (6): Yield and some components of peanut as significantly affected by the interaction between the studied factors (the combined data).

Character	Highest value	Treatment	Lowest value	Treatment
No. of pods/plant	30.44	75 Kg K_2O/fad x 500 ppm Cu	19.52	35 Kg K_2O/fad x unsprayed Cu
Weight of pods/plant (g)	40.72	75 Kg K_2O/fad x 500 ppm Cu	26.29	35 Kg K_2O/fad x unsprayed Cu
Weight of seeds/plant (g)	31.94	75 Kg K_2O/fad x 500 ppm Cu	20.51	35 Kg K_2O/fad x unsprayed Cu
No. of pods/plant	29.40	1700 ppm Ca x 500 ppm Cu	20.46	Unsprayed Ca x unsprayed Cu
Weight of pods/plant (g)	39.33	1700 ppm Ca x 500 ppm Cu	27.52	Unsprayed Ca x unsprayed Cu
Weight of seeds/plant (g)	30.90	1700 ppm Ca x 500 ppm Cu	21.44	Unsprayed Ca x unsprayed Cu
Pod yield (ardab/fad)	30.67	75 Kg K_2O/fad x 1700 ppm Ca x 500 ppm Cu	13.33	35 Kg K_2O/fad x unsprayed Ca x unsprayed Cu
Seed yield (ton/fad)	1.722	75 Kg K_2O/fad x 1700 ppm Ca x 500 ppm Cu	0.721	35 Kg K_2O/fad x unsprayed Ca x unsprayed Cu

E-Simple correlation analysis:-

The results in Table (7) show the simple correlation coefficients among seed yield/ fad and some studied characters of peanut (the combined data).

It is clearly evident from the same Table that seed yield/ fad was highly significant and positively correlated with each of number of branches, pods and seeds/ plant, weight of pods and seeds/ plant, number of seeds/ pod, 100-seed weight and pod yield/ fad. These results are in harmony with those reported by Ali and Mowafy (2003) and Abd-Alla (2004).

Table (7): Simple correlation coefficients between seed yield/ fad and yield components of peanut (the combined data).

Character	R
Number of branches / plant	0.983 **
Number of pods / plant	0.989 **
Number of seeds / plant	0.992 **
Weight of pods / plant	0.995 **
Weight of seeds / plant	0.991 **
Number of seeds / pod	0.667 **
100- seed weight	0.951 **
Pod yield / fad	0.999 **

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إستجابة الفول السودانى للرش الورقى بالنحاس والكالسيوم تحت مستويات مختلفة من التسميد البوتاسى فى الأراضى الرملية

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أجريت تجربتان حقليتان بمزرعة كلية الزراعة- جامعة قناة السويس بالاسماعيلية خلال موسمى ٢٠٠١ و ٢٠٠٢ بهدف دراسة تأثير ثلاثة معدلات من التسميد البوتاسى ٣٥و ٥٥ و٧٥ كجم بو٢أ/ الفدان وثلاثة تركيزات من الكالسيوم المخلبى وهي الرش بالماء (مقارنة) و٨٥٠ و١٧٠٠ جزء في المليون وتركيزين من النحاس المخلبى وهى الرش بالماء (مقارنة) و٥٠٠ جزء في المليون علي المحصول

ومكوناته وجودته في الفول السودانى صنف جيزة ٦ تحت ظروف الأراضى الرملية بمحافظة الإسماعيلية. ويمكن تلخيص النتائج كما يلي:-

١- أدت زيادة معدل التسميد البوتاسى حتى ٧٥ كجم بو٢أ/ فدان إلى زيادة معنوية في إرتفاع النبات وعدد الأفرع/ نبات وعدد القرون/ نبات وعدد البذور/ نبات ووزن القرون/ نبات ووزن البذور/ نبات ووزن المائة بذرة ونسبة الزيت بالبذور (%) ومحصول القرون/ فدان ومحصول البذور/ فدان ومحصول القش/ فدان والمحصول البيولوجي/ فدان ومحصول الزيت/ فدان.

٢- أدت زيادة تركيز الكالسيوم المخلبى في الرش الورقى حتى ١٧٠٠ جزء في المليون إلي زياده معنوية في إرتفاع النبات وجميع مكونات المحصول (ما عدا عدد بذور القرن) ونسبة الزيت بالبذور (%) ومحصول القرون/ فدان ومحصول البذور/ فدان ومحصول القش/ فدان والمحصول البيولوجى/ فدان ومحصول الزيت/ فدان.

٣- أدى الرش الورقى بتركيز ٥٠٠ جزء في المليون من النحاس المخلبى إلي زيادة معنوية فى جميع الصفات المدروسة (ما عدا عدد بذور القرن) وذلك بالمقارنة مع النباتات غير المعاملة.

٤- يوجد تأثير معنوى للتفاعل بين كل من (التسميد البوتاسى x الرش الورقى بالنحاس) و (الرش بالكالسيوم x الرش بالنحاس) على عدد القرون/ نبات ووزن القرون/ نبات ووزن البذور/ نبات. وكذلك بين (التسميد البوتاسي x الرش بالكالسيوم x الرش بالنحاس) على محصول القرون/ فدان ومحصول البذور/ فدان.

٥- يوجد إرتباط موجب وعالى المعنوية بين محصول البذور/ فدان وكل من: عدد الأفرع/ نبات وعدد القرون/ نبات وعدد البذور/ نبات ووزن القرون/ نبات ووزن البذور/ نبات وعدد بذور القرن ووزن المائة بذرة ومحصول القرون/ فدان.