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POTASSIUM FERTILIZATION FOR SOME INTERCROPPING PATTERNS IN EGYPTIAN NORTHERN DELTA SOILS

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Abstract

Two factorial field expeeriments were conducted during 1991/ 1992 season, the first on sugar beet/faba bean and the second on maize/soybean intercropping patterns to evaluate the relative efficiencies and economic optimum rates of k- sulfate fertilizer.

The soil experimental sites were clayey in texture and the average values of chemical characteristics were as follows : Ec_o -2.20 dSm^{-1}, pH -8.26, O.M. -1.36% and the available N-, P- and k- were 51, 9 and 347 $mg.kg^{-1}$, respectively.

The results showed that potassium fertilization as k- sulfate was beneficial for sugar beet, faba bean, maize and soybean whether grown in monocropped or intercropped patterns. The relative k- fertilizer efficiencies were reduced in intercropped patterns compared to monocropping systems. The economic optimum k- fertilizer rates inceased in intercropped patterns relative to monocropped patterns. The values of (E.O. k- rate)/(E.O. crop yield) ratio were lower under monocropped patterns relative to intercropped ones.

INTRODUCTION

Intercropping, the practice of growing two or more crops simutaneously in the

same field, Is a potentially beneficial system of crop prouduction that is practiced in many areas of the world , especially-in in the tropics, where crops are grown with a minimum amount of mechanization. In Egypt, Zahran (1970)found that the highest yields of maize and soybean were obtained when both crops occupied 2/3 of the cultivated area, although the yield of maize or soybean decreased when grown together.The combined yield produced exceeded their individual yields by about 25%. Ibrahim *et al* . (1977) found that maize and soybean yields obtained from a unit area of land were higher in 2:2 system than 2:1 system . Hosney (1983) found that intercropping maize with soybean decreased seed yield of soybean as compared to monocropping. In USA, Gardiner and Craker (1981) revealed that soybean and maize are commonly suggested as desirable intercrop species because different growth rates of these species should allow full utilization of the environment with minimum competition for light.Mohamed and Nigm (1988) found that the land equivalent ratio of maize (LER_m) in maize/soybean intercrop was significantly increased with increasing N-fertilizer level up to 166.6 kg N/ha. Other researches found good responses to k-fertilization for some field crops with comon rates of 170, 100, 60 and 70 kg k_2o/ha for sugar beet, faba bean, maize and soybean, respectively (Abd El-Hadi 1989; Genaidy 1988; Genaidy and Hegazy,1991; and Hegazy *et al.* (1990). It is not known whether the same type of response can be expected when sugar beet is intercropped with faba bean and maize with soybean.

The objective of this work was to evaluate potassium sulfate fertilization of sugar beet/faba bean and maize/soybean intercropping systems compared to monocropping systems.

MATERIALS AND METHODS

Two intercropping experiments involving k-rates of 0, 57 and 114 kg k_2O/ha were conducted on an alluvial soil at Sakha Agriculure Research Station, located at the Northern part of the Delta, Egypt. Soil data for the two sites of experimentation are shown in Table 1. Soils analysis were done according to Black, 1965. The first experiment (site 1) with monocropped and intercropped sugar beet (*Beta vulgaris, L.*) and faba bean (*Vicia faba, L.*) was planted on October 28, 1991. The second experiment (site 2) with monocropped and intercropped maize (*Zea mays, L.*) and soybean (*Glycin max* (1) Merill) was planted on May 15, 1992. Both crops in the

two experiments were planted on the same date. The intercropped treatments were planted in 2:1 system. The plot area was 6 x 7m = $42m^2$, rows spaced 60 cm and distance between hills were 20, 10, 30 and 20 cm for sugar beet, faba bean, maize and soybean, respectively. Treatments were replicated four times in a randonized complete block design. All the comon agronomic practices were done as usual under this area and k-sulfate fertilizer (K_2SO_4. 48% K_2O) was added to planting for all crops. Nitrogen and Phosphorus fertilizers (at the recommended rates) were applied to all treatments. Harvests were manually done on April, 26-1992, May, 16-1992, November, 15 and November, 25-1992 for faba bean, sugar beet, maize and soybean, respectively. All the obtained data were stastically analized according to Sendecor and Cochran (1971) . The mathematical approach reported by Capurro and Voss (1981), Balba (1987, 1988) and Genaidy and Hegazy (1991) was followed to determine the relative efficiences and the economic optimum rates of k-sulfate fertilizer under crop pattern as follows :

1. $Y_1 = B_o + B_1 X_1 + B_{11} X^2$

2. $Ym = B_o - \frac{B21}{4B_{11}}$

3. $Y_{Ri} = 100 \frac{Y_i}{Y_m}$

4. $E_x = \frac{1}{10}\sqrt{B_1^2 - 4B_o B_{11}}$

5. $P_r = P_n / P_c$

6. $Y_o = \frac{Ym\ (100 - P^2r/E_x^2)}{100}$

7. $F_n = E_x\sqrt{100 - Y_{Ri}}$

8. $X_o = X_a + \frac{Y_o - Y_a}{F_n}$

Where the term Y_i is the yield corresponding to the application rate of nutrient X , B_o is the intercept coefficient, B_1 is the linear coefficient and B_{11} is the quadratic coeficient, Y_m is the maximum yield, Y_{Ri} is the relative yield, E_x is the relative efficiency index (which can be defined generally as the nutrient efficiency at 99% of maximum yield and is independed of the nutrient ratre), P_r is equal to the nutrient/ crop price ratio, P_n is the price of fertilizer rate applied, P_c is the peice of one ton

of crop yield, Y_o is the economic optimum yield, X_o is the economic optimum fertilizer nutrient rate, F_n is the nutrient efficiency at the economic optimum yield and Y_a is the actual measured yield obtained by nutrient rate equal to x_a. From the measured yield data, the parameters B_o, B_1 and B_{11} are calculated as follows :

$$B_o = Y_o,\ B_1 = (4Y_1 - Y_2 - 3Y_o) / 2,\ B_{11} = (Y_2 + Y_o - 2Y_1)/2.$$

Where Y_o, Y_1 and Y_2 were the actual obtained yields at nutrient rate X = 0,1, 2 units, respectively.

RESULTS AND DISCUSSION

I- EFFECT OF MAIN VARIABLES :

A- Potassium fertilization

As shown in Table (2 and 3) the k-fertilizer effects on crop yields were found to be significant whether grown monocropped or intercropped. As for the first experiment, the increase due to k-fertilizer of 57 and 114 kg K_2O/ha. On yields of sugar beet and faba bean patterns were 46% and 74% over (K_o). Abd El-Hadi (1989), Genaidy (1988), Hegazy *et al.* (1990) and Genaidy and Hegazy (1991) found similar responses of K-fertilizer for different field crops.

B- Crop patterns

Tables (2 and 3) also indicate the effect of crop pattern on yield of single crops and intercropped patterns where the decrease due to intercropping relative to monocropped were 22%, 35% for sugar beet/faba bean pattern and 15%, 50% for maize/soybean patern, respetively. Zahran (1970), Ibrahim *et al.* (1977) and Mohamed and Nigm (1988) found that maize and soybean yields were decreased when intercropped.

Table 1. Soil characteristics at experimental sites.

Soil characteristics	Exp. 1 (Site 1)	Exp. 2 (Site 2)
Soil texture	<----------Clayey---------->	
Soil pit (1: 2.5 Susp.)	8.23	8.30
EC_e (Soil paste at 25°C)	2.14 $dS.m^{-1}$	2.27 $dS.m^{-1}$
Organic Matter	1.33%	1.39%
Available N (K-sulfate ext.)	45 $mg.kg^{-1}$	58 $mg.kg^{-1}$
Available P (Olsen ext. P.)	8 $mg.kg^{-1}$	10 $mg.kg^{-1}$
Available K (Amm. acetate ext.)	307 $mg.kg^{-1}$	397 $mg.kg^{-1}$

Table 2. Effects of potassium fertilization and sugar beet/faba bean intercropping patterns and interaction on monocropped and intercropped yields (ton/ha.)Exp. 1.

Crop pattern	Monocropped		Intercropped		Mean
	Sugar beet	Faba bean	Sugar beet/Faba bean		K-fertilizer
K-fertilization Kg K2O/ha					
0	4.24	1.80	2.91	1.49	2.60
57	6.31	2.69	4.75	1.56	3.83
114	7.43	2.48	5.48	1.61	1.80
Mean crop Pattern	5.99	2.33	4.38	1.55	

L.S.D. $_{0.05}$ K-fertilizer = 0.23
Crop pattern = 0.22
Interaction = 0.46

Table 3. Effect of potassium fertilization and maize/soybean intercropping patterns and interaction on monocropped and intercropped yields (ton/ha.) Exp. 2.

Crop pattern	Monocropped		Intercropped		Mean
	Maize	Soybean	Maize	/ Soybean	K-fert.
K-fertilization Kg K2O/ha					
0	6.79	1.42	6.29	0.82	3.83
57	8.27	1.91	7.14	0.96	4.57
114	9.05	2.10	7.11	1.00	4.81
Mean Crop pattern	8.04	1.81	6.85	0.93	

L.S.D. $_{0.05}$ K-fertilizer = 0.34
Crop pattern = 0.40
Interaction = 0.69

C- Interaction effect :

The crop yields were affected by the interaction of (k-fertilization X crop pattern), Tables (2 and 3). As for the first experiment, the increments due to the addition of 57 and 114 kg K_2O/ha. over (K_o) for single sugar beet, single faba bean and intercropped were (48%, 19%), (49%, 37%), (63%, 88%) and (9%, 17%), respectively. While the second experiment revealed the parallel results to be (22%, 33%), (34%, 47%), (14%, 13%) and (17%, 22%) for single maize, single soybean and intercropped ones, respectively.

II- QUANTITATIVE CONCEPT :

Data of the calculated polynomial equations and their derivations are shown in Table 4 and indicate the following :

a. There were no significant differences between the calculated and determined yields for single or intercropped crops as for its response to K-fertilization.

b. The economic optimum yields for sugar beet crop were 7.69 and 5.48 ton sugar/ ha. for single and intercropped patterns, respectively. Those yelds were obtained by adding the economic optimum rates of 82.11 and 140.86 kg K_2O/ha. with relative nutrient efficiencies (F_n) of 0.264 and 0.043, respectively.

c. As for faba bean crop, the optimum yields of 2.74, 1.84 ton seeds/ha. for single and intercropped patterns were obtained by adding the economic optimum rates of 76.97 and 150.70 kg K_2O/ha. with relative efficiencies (F_n) of 0.317 and 0.040, respectively.

d. As regard to maize crop, the economic optimum yields of 9.16, 7.51 ton grains/ ha. for single and intercropped patterns were obtained by adding the economic optimum rates of 60.25 and 154.23 kg K_2O/ha. with relative efficincies (F_n) of 0.191 and 0.103, respectively.

e. As for soybean crop, the yields of 2.09 and 1.017 ton seed/ha. of single and intercropped patterns were found by adding the economic optimum rates of 58.79 and 106.25 kg K_2O/ha. with relative efficiencies (F_n) of 0.141 and 0.009 for the two patterns, respectively.

Table 4. Potassium fertilizer efficiencies and economic optimum additions for monocropped and / or intercropped patterns.

Field season	Winter Season												Summer Season											
Field Crop	Sugar beet						Faba bean						Maize						Soybean					
Crop Pattern	Monocropped			Intercropped			Monocropped			Intercropped			Monocropped			Intercropped			Monocropped			Intercropped		
Potassium fert. kg/ha	0	57	114	0	57	114	0	57	114	0	57	114	0	57	114	0	57	114	0	57	114	0	57	114
Variable :																								
A. Yield (ton/ha)																								
1- Actual yield	4.238	6.314	7.428	2.914	4.762	5.476	1.809	2.690	2.476	1.428	1.559	1.667	6.785	8.273	9.048	6.285	7.143	7.107	1.423	1.909	2.097	0.816	0.961	0.997
2- Calculated yield	4.238	6.314	7.428	2.919	4.738	5.328	1.809	2.690	2.476	1.428	1.559	1.667	6.785	8.273	9.048	6.285	7.119	7.107	1.423	1.909	2.097	0.816	0.404	0.419
B-Derivations from Polynomial equations :	Y=4.238 +2.557 x -0.480x2			Y=2.914 + 2.411 x -0.564x2			Y=1.809 + 1.428 x -0.547x2			Y=1.428 + 0.142 x -0.011x2			Y=6.785 + 1.845 -0.357x2			Y=6.285 + 1.302 x -0.447x2			Y= 1.423 + 0.635 x -0.150x2			Y= 0.816 + 0.200 x -0.054x2		
Relative efficiencies index (Ex)	0.161			0.147			0.102			0.012			0.152			0.150			0.047			0.019		
Price ratio (Pr)	0.013			0.013			0.009			0.009			0.026			0.026			0.014			0.014		
Maximum yield (Ym)	7.705			5.481			2.738			1.857			9.193			7.231			2.097			1.000		
Relative yield (Yr)	97.318			99.913			90.360			89.740			98.420			98.180			91.032			99.760		
Economic yield (Yo)	7.703			5.478			2.738			1.845			9.188			7.518			2.095			1.017		
Nutrient fertilizer efficiency (Fn)	0.264			0.043			0.317			0.039			0.191			0.103			0.141			0.009		
Economic optimum addition (Xo) Kg K2O/ha.	82.037			140.867			76.977			150.693			60.258			154.231			58.767			106.299		

* 1 Dollar = 3.33 L.E. (Egyptian Pounds)

Crop & Fertilizer Prices (1992)

1 Ton Maize Grain = 570 L.E.
1 Ton Soybean seeds = 1000 L.E.
1 Kg K2O = 0.60 L.E.
1 Ton Sugar beet sugar = 1100 L.E.
1 Ton Faba bean seeds = 1600 L.E.

Regarding the movetary values of (Economic optimum k-fertilizer rate)/ (Economic optimum crop yield) ratios, they would be 0.005, 0.010 and 0.020 for single beet, single faba bean and their intercropping, respectively. For the second trial, those ratios were 0.006, 0.016 and 0.029 for single maize , single soybean and their intercropping , respectively.

III- CONCLUSIONS

From the above mentioned results we conclude the following :

1. Potassium fertilization from K-sulfate source was benificial for sugar beet, faba bean, maize and soybean grown in single or intercropped patterns.

2. The relative K-fertilizer efficiencies were lower in intercropped patterns than monocropped patterns.

3. The economic optimum K-fertilizer rates inceased in intercropped patterns relative to single ones.

4. Regarding the values of (E.O. K-rate)/(E.O. Yield peice) ratios, it was decreased in single patterns relative to intercropped ones.

5. Under roevoiling conditions, it is advisable for small farmers in Egypt (who prefer intercropping patterns) to apply 140, 150, 155 and 106 kg K_2O/ha. to sugar beet , faba bean, maize and soybean, respectively in order to obtain optimum economic yields.

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تقييم التسميد البوتاسى لبعض نظم تحميل المحاصيل فى أراضى شمال الدلتا

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أقيمت تجربتان عمليتان حقليتان بمحطة البحوث الزراعية بسخا موسم ١٩٩٢/١٩٩١ بغرض التقييم الإقتصادى للتسميد البوتاسى لبعض محاصيل الحقل عند زراعتها فى نظم فردية (عادية) أو عند زراعتها فى نظم التحميل المقترحة . كانت عوامل التجربة الأولى : التسميد البوتاسى (بمعدلات صفر ، ٢٤ ، ٤٨ كجم بو٢ أ/ف) x نظام الزراعة (بنجر سكر منفرداً ، فول بلدى منفرداً ، تحميل فول بلدى/بنجر سكر)....
وكانت التجربة الثانية : التسميد البوتاسى (بنفس المعدلات) x نظام الزراعة (ذرة شامية منفرداً ، فول صويا منفرداً ، تحميل فول صويا/ذرة شامية).... وإستخدم التصميم الإحصائى للقطع العشوائية فى أربعة مكررات لكل تجربة .

ويمكن تلخيص أهم النتائج فى الآتى :-

(١) للتسميد البوتاسى تأثيراً مفيداً فى زيادة محاصيل بنجر السكر ، الفول البلدى الذرة الشامية ، فول الصويا سواء تم زراعتها بصورة منفردة أو فى نظم محملة (كما هو مقترح لبعض صغار المزارعين).

(٢) إعتمدت الكفاءة النسبية لإستخدام التسميد البوتاسى على نظام زراعة المحصول الحقلى حيث إنخفضت بدرجة ملحوظة عند إضافتة للنظم المحملة بالنسبة للنظم المنفردة .. ونتيجة لذلك إنخفضت الإضافات الإقتصادية المناسبة فى حالة النظم المحملة عنها فى حالة النظم الفردية.

(٣) وبوضع النسب $\frac{\text{قيمة الإضافة الإقتصادية المناسبة}}{\text{قيمة المحصول الإقتصادى المناسب}}$ للنظم المختلفة فى الإعتبار

نجد أنها تزيد فى النظم المحملة عنها فى النظم الفردية العادية.