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SOIL MORPHOLOGICAL FEATURES AND COMPETITION OF INTERCROPPING MUNG BEAN WITH SUGARCANE IN UPPER EGYPT

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Abstract

The Egyptian alluvial soils had been formed by the sedimentation of the suspended matter, which was carried by the annual flood during the most recent geological periods. Many farmers grow sugarcane intercropped with other crops. This agro-technique is expected to expand and gain popularity among farmers who grow spring sugarcane. The aim of this study is to find out competition influences resulting from intercropping mung bean with sugarcane on some agronomic traits and both yield in reltion to soil build up salinity and fertility under natural drainage conditions. Two field trials were conducted at Shandaweel experimental station during 2000/2001 and 2001/2002 seasons for intercropping mung bean, at various densities, with sugarcane.

The soil is taxonomically Typic Torrifluvents and its texture varies between clay loam and loam. The optimum conditions of water table depth, soil salinity and soil fertility are main effective factors on soil productivity of sugarcane yield and cultivation intensity. Mung bean intercropping had a positive effect on soil fertility as it increased the nitrogen and phosphorous in soil due to nitrogen fixation and root activities. Relative yield of sugarcane was larger at low plant density of mung bean, whereas mung bean relative yield was increased with increasing plant density of mung bean. It could be recommended that intercropping three rows of mung bean with sugarcane is successful and profitable under good natural drainage.

INTRODUCTION

Agricultural intensification is considered to be one of the important means of solving or decreasing the large gap between production and consumption of food commodities. In such cases intercropping would help farmers getting additional income during the growing season of sugarcane. Many investigators have shown the importance of crops intercropping with sugarcane. Leadesma and Villarico (1977) studied the feasibility of intercropping mung bean, soybean and maize with sugarcane. They found that intercropping mung bean with sugarcane was highly profitable. Intercropping reduced the cost of weed control and improved soil physical characteristics and fertility. In some instances intercropping improved sugar yield. Bhutada and Parashar (1981) experimented with sugarcane; (i) grown alone, (ii) intercropped with mung bean (*Phaseolus aureus)* and (iii) Urd (*P. mango*). They found that cane yield was 59.6, 57.9 and 50.0 ton/ha, respectively. Arifin (1982) reported that intercropping sugarcane with mung bean did not affect cane yield or sucrose content. El-Gergawy *et al* (1995) showed that yields of cane and other intercropped crops were significantly reduced under intercropping conditions compared with pure stand. El-Gergawy *et al* (1995), Eweida *et al* (1996) cleared that intercropping bean, wheat, beet or soybean crops with sugarcane increased land usage, LER (Land Equivalent Ratio). In addition the high values of the relative crowding coefficient indicated a distinct yield advantage from intercropping these crops with sugarcane. Garcha *et al* (1997) found that the cane and cane equivalent yields were highest when sugarcane was intercropped with summer in 1:1 ratio. Hussain *et al* (2000) found that the maximum sugarcane shoot number/stump was recorded in sole sugarcane while the lowest numbers were given by intercropping.

The present investigation aims to find the competition influence of intercropping mung bean (*Vigna radiata L. wilczek*) with sugarcane on some agronomic traits and both yields in relation to soil salinity build up and fertility status under natural drainage conditions.

MATERLALS AND METHODS

Two field trials were carried out at Shandaweel Agricultural Research Station, Sohag Governorate, Upper Egypt in two successive seasons (2000/2001 and 2001/2002), intercropping mung bean (*Vigna radiata L. wilczek*) with sugarcane. The soil samples was analyzed in the initial and final stages according to Richards (1954), described morphologically according to FAO (1990) and classified according to Soil Survey Staff (1994). Hydraulic conductivity was determined using the auger hole method. Water table depth was monitored during the two years.

A complete randomized block experiment with four replicates was designed including five treatments: (i) Sugarcane + one row of mung bean (T_1), (ii) Sugarcane + two rows of mung bean (T_2), (iii) Sugarcane + three rows of mung bean (T_3), (iv) Pure stand of mung bean (T_4) and (v) Pure stand of sugarcane (T_5). Plot area was 20 m^2; it consisted of five ridges 4 m length x 1 m width. Sugarcane (cv C9)was cultivated on 5^{th} and 8^{th} April and mung bean, *Vigna radiata L. wilczek* (variety V2010) seeds were sown on 20^{th} and 23^{rd} April for the two seasons, respectively. Sugarcane was planted in rows, one meter apart while mung bean was planted in hills, 15 cm apart. Distances between rows of mung bean were 35cm where intercropping with two and three rows of mung bean, respectively. Recommended fertilization of phosphorus for sugarcane [200 kg/fd calcium superphosphate (15% P_2O_5)] was applied during land preparation. After sowing mung bean and before irrigation 15 kg N/fd was applied as an activating dose for mung bean. The 200 kg/fd Urea (46 %) recommended for sugarcane were split in two equal doses added at two months after planting and before harvesting of mung bean. Potassium sulphate (48% K_2O) was added at the rate of 100 kg/fd with the first dose of nitrogen for sugarcane. Normal agronomic practices for sugarcane and mung bean were applied. Mung bean pods were harvested two times in order to avoid shuttering. Sugarcane was harvested after 12 months from planting. At harvest time of mung bean ten guarded plants, were chosen randomly for recording plant height, number of branches/plant, number of pods/ plant, number of seeds/pod, 100-seed weight (g), seed (yield/plant) and seed (yield/fd). Also, a sample of 20 stalks/plot of sugarcane at harvest time was taken at random for recording morphological and chemical analyses which included: (i) stalk height (cm), (ii) number of millable stalks/fd.(iii) stalk diameter (cm), (iv) Stalk weight (gm) and (v) cane yield (ton/fd.).

Apparent juice purity % of cane was calculated according to Spencer and Mead (1954). The parameters of Brix, sucrose (%), purity (%) and sugar (yield/fd) were calculated according to Yadav and Sharma, (1980), as follows:

Commercial sugar yield = (cane yield x available sugar)/100.

Available sugar = [s-0.4 (B-s) x 0.73], where: (s), sucrose % and (B) Brix % (Brix percent was determine in the laboratory by using Brix hydrometer standardized at 20 C^o).

Competitive relationships and yield advantage:

These studies included calculation of Land Equivalent Ratio, LER, according to Willey (1979), relative crowding coefficient, RCC, according to Hall (1974) and Aggressivity, Agg, according to Mc-Gilchrist (1965). Data collected were subjected to statistical analysis according to Snedecor and Cochran (1988).

RESULTS AND DISCUSSION

(I). Soil Aspects

Soil Morphology and Classification

Soil features varied between clay loam in surface layers to loam in deep layers. Average soil fractions content was: 31.2 % clay, 48 % silt and 20.8 % sand in the 0-40 cm layer, which changed to 17 %, 60 % and 23 % in the 40-80 cm depth layer, respectively. The soil did not develop wide deep cracks or slickenside. Calcium carbonate content varied between 0.85 % and 3.2 %. The soil morphology characteristics changed depending on the depth of water table, soil parent materials, soil structure, texture and drainage conditions. The main morphological aspects considered were the soil color and mottling. They differed with soil profile depth, yet clearly present in deep layers down to 120 cm. The soil profiles are very poor in calcium carbonate nodules and gypsum crystals especially in subsurface layers. The color of mottles differed in value and chroma with matrix color, which varied between 10 YR 4/3 and 10 YR 3/4 in moist condition. The soils under investigation are classified according to soil taxonomy (1994) and FAO (1990) as; Typic torrifluvents, fine, clay loam mixed hyper thermic.

Land form

Physiographic position: Plain.

Land form of surrounding: Almost flat.

Micro-topography: Level.

Slope: Flat

Elevation: 8 m above MSL

Crops : Irrigated mung bean & sugarcane.

Soil climate: torric and themic.

Parent materials: Alluvium deposits.

Water table depth: 135 cm (after equilibrium 24 hr).

Drainage Class: well drained.

Human influence: Good farm management with natural drainage system

Date of examination: April, 20 / 2000

Soil depth (cm)	Description
0 - 30 AP	Dark brown (10 YR 4/3 dry), dark yellowish brown. (10 YR 3/4 moist), clay loam; moderate to weak granular structure; slightly friable; many fine & medium pores; many fine and medium roots, very few small soft lime spots, moderate effervescence with HCl, pH 7.8; clear boundary.
30 – 90 C1	Light yellowish brown (10 YR 6/4 dry), dark yellowish brown (10 YR 3/4 moist); loam; weak to moderate fine and medium sub-angular blocky structure; few fine to medium tubular pores; friable; many fine to very fine roots; weak effervescence with HCl; pH 7.9; clear boundary.
90 – 150 C2	Dark brown (10 YR 4/3 dry), Brown (10 YR 5/3 moist); loam; weak very thin platey structure; friable; few fine pores; few small and very fine nodules, few small gypsum crystals; many yellowish mica flakes, moderate effervescence with HCl; pH 7.9.

Water table depth and Drainage Condition

Average depth of water table varied between 143.5 cm (winter) and 126.3 cm (summer) during 2000 and 2001 seasons. This could be attributed to perfect natural drainage conditions of this location due to the good structure of sub-surface layers. Water table depth did not affect the roots of sugarcane or mung bean growing plants. The water table depths (Table 1) in all treatments are highly suitable for roots growth and for absorption of water and nutrients. The variation of water table depth between winter and summer may be due to changes in water level in the Nile River stream.

Soil Permeability

The hydraulic conductivity values ranged between 1.00 and 1.81 m/day with an average of 1.34 m/day. These indicate a high soil water permeablity due to light texture, granular structure and friable consistency throughout the soil profile layers. All these factors allow easier movement of excess irrigation water back to the Nile stream which acts as a natural drain for the area. The data of infiltration rate vary between 4.88 to 7.90 cm/hr with an average of 6.39 cm/hr. which is considered moderate.

Table 1. The hydraulic conductivity (K) values (m/day), the water table depth (cm) and the infiltration rate (cm/hr.) during winter and summer seasons 2000 and 2001, in the experimental plot area.

Treatment	K (m/day)	Infiltration rate (cm/hr.)	Water table depth (cm)			
			February		August	
			Year 2000	Year 2001	Year 2000	Year 2001
T1	1.810	7.81	147	140	136	128
T2	1.134	7.42	143	148	118	120
T3	1.460	6.42	150	144	124	131
T4	1.300	5.42	135	148	130	128
T5	1.000	4.88	141	139	120	128
Average	1.341	6.39	143.2	143.8	125.6	127
General Average			143.5		126.3	

Soil Salinity and Alklinity

The soil was non-saline, EC in the five treatments was less than 1.00 dS/m. (Table 2). This is due to the deep water table and the good drainage conditions prevailing.

Table 2. Some soil chemical characteristics.

Treatment	Saturation Percentage	EC (dS/m)		pH	CEC Meq/100 g	ESP
		2001	2002			
T1	30	0.40	0.42	7.9	24	12
T2	34	0.60	0.58	7.8	23	12
T3	40	0.90	0.87	7.6	24	11
T4	38	0.72	0.75	7.7	24	13
T5	32	0.42	0.43	7.9	22	10

The soil is non-alkaline, the value of ESP (Exchangble Sodium percintage) is less than 15 for all treatments. The pH values varied between 7.6 and 7.9. The CEC (Cation Exchange Capacity) varied between 22-24 meq/100g. (Table 2)

Soil fertility

Data in Table 3 show that at the begining of the experiment (Initial) available nitrogen is higher than 25 ppm, in all treatments. Phosphorus values are exceeding the critical level of 9 ppm. Potassium is adequate for plant growth in all treatments except in the stand of sugarcane which is poor. The average of Potassium is 384 ppm but in treatment T3 it is 290 ppm which is less than the critical level of 300 ppm. Concerning the micronutrients iron, manganese, zinc and copper, the data obtained indicate that they are suitable for plant growth. The average for iron was 18.8 ppm. Most of low values of iron were found in treatments 3, 4 and 5, respectively. Manganese concentration is concidered adequate in treatments 3, 4 and 5 but not adequate in treatment 1 and 2 being less than 18 ppm. The concentration of available zinc was 2.09 ppm in average. Its values are higher than the critical level of 0.8 ppm. The copper extracted is in average 0.80 ppm, and is concidered suitable for plant growth.

The data obtained after 2 years (final) in Table 3 indicated that nitrogen and phosphorus increased in treatments 3 and 4 this could be due to the effect of mung bean roots which fix nitrogen and increase the availability of phosphorus and micronutrients in the soil. The data indicated that intercropping mung bean can be effective in improving soil fertility than sugarcane only.

Table 3. The macro- and micro-nutrients status in the different treatments (values are in ppm).

Tr.	N		P		K		Fe		Mn		Zn		Cu	
	I	F	I	F	I	F	I	F	I	F	I	F	I	F
T1	30	30	14	16	400	458	24	26	16	14	2.20	1.9	0.92	0.80
T2	32	36	23	23	400	380	26	22	13	16	2.40	3.4	0.72	0.61
T3	37	42	16	19	330	290	18	21	19	16	2.20	2.3	0.65	0.70
T4	37	45	17	21	400	410	16	16	17	19	1.67	1.7	0.85	0.66
T5	29	31	19	17	430	380	18	14	19	19	1.96	1.9	0.84	0.60
Total	165	184	89	96	1960	1918	102	99	84	84	10.43	11.2	3.98	3.37
Avr.	33	36.8	17.8	19.2	392	384	20.4	19.8	16.8	16.8	2.09	2.24	0.80	0.67

I = Initial (beginning of the exprimental) F = Final (after two years)

(II). Agronomic Traits

Mung bean

Obtained results in Table 4 indicated that intercropping mung bean with sugarcane had significant effects on the measured characters of mung bean in both seasons. These were for number of branches/plant and number of seeds/pod in the first season and plant height and number of seeds/pod characters in the second season.

Pure stand had the highest values of plant height, number of pods/plant and seed yield/plant. The lowest values of these characters were obtained by intercropping three rows of mung bean with sugarcane. Seed yield of mung bean was consistently reduced with intercropping patterns. The intercropped yield of mung bean was 56, 69 and 77% in the first season and 47, 66 and 75 % in the second season for pure stand with intercropping one, two and three rows of mung bean, respectively.

Table 4. Data show the effect of intercropping patterns of mung bean with sugarcane on growth, yield and yield components of mung bean plants in 2000 and 2001 seasons.

Treatments	Plant height (cm)	No. of branches/ plant	No. of pods/ plant	No. of seeds/pod	100 seed weight (gm)	Seed yield/ plant (gm)	Seed yield (ton/fd)
	Season 2000						
T_1	52.5	2.5	68.5	11.6	8.5	65.33	453.3
T_2	51.03	2.4	63.53	10.8	8.35	57.5	561.7
T_3	47.7	2.3	63	9.9	7.87	52.97	626.7
T_4	54.87	2.7	72.33	11.7	7.93	55.67	816.7
LSD (0.05)	2.1	NS	5.75	NS	0.34	3.25	41.5
	Season 2001						
T_1	53.93	2.6	59.2	11.37	8.05	57.13	385.3
T_2	51.93	2.5	55.2	11.3	7.87	52.03	548.3
T_3	51.7	2.2	53	10.03	7.45	48.67	620
T_4	54.33	2.4	73	11.2	7.88	62.47	826.7
LSD (0.05)	NS	0.28	3.96	NS	0.22	4.42	33.6

Faddan (fd) = 4200 m^2 = 0.42 ha

The lower values of plant height, number of branches and pods/ plant, 100 - seed weight and seed yield / plant exist especially under the high population density of mung bean plants. The reduction in mung bean yield may be due to the severe inter-specific competition between mung bean and sugarcane plants for light, water and nutrients. These results are in agreement with those obtained by El-Gergawy *et al* (1995). They noted that the highest yields of sesame and soybean crops were attained from pure stand compared with one of the intercropping patterns.

Sugarcane

In general, results in Table 5 indicate that except stalk diameter in the first season and stalk number and cane yield characters in the second season, there were no significant differences between planting patterns of mung bean with sugarcane. The results show also that plant height, stalk number and cane yield in the first season and plant height and stalk diameter in the second season are unaffected by intercropping patterns.

The intercropped yield of sugarcane was 99, 98 and 97 % in the first season and 98, 93 and 92 % in the second season in relation to the pure stand when intercropped in T_1, T_2 and T_3, respectively. It is noticed that the high density of intercropped mung bean, three rows treatment (T_3) resulted the greatest yield reduction 3% in the first season and 8% in the second season. It may be worthwhile to mention that lowering stalk number and cane yield are due to the intraand inter-specific competition between mung bean and sugarcane plants especially under the high population density of mung bean which consequently affect, the sugarcane yields. These resulte are in agreement with those found by Bhutada and Parashar (1981), Arifin (1982) and Hussain *et al* (2000).

Table 5. Data show the effect of intercropping mung bean with sugarcane on yield and yield components of sugarcane in the two seasons 2000/2001 and 2001/2002.

Treatments	Plant height (cm)	Stalk number/meter^2	Stalk diameter (cm)	Cane yield (ton/fd)
	Season 2000/2001			
T1	275.67	9.67	2.85	58.07
T2	277.67	9.93	2.74	57.77
T3	281.67	9.53	2.72	56.57
T5	271.67	10.47	2.86	58.53
LSD (0.05)	NS	NS	0.09	NS
Season 2001/2002				
T1	290.33	12.13	2.83	59.87
T2	292.33	11.67	2.83	56.93
T3	297.00	11.40	2.77	56.40
T5	285.00	12.50	2.79	61.07
LSD (0.05)	NS	0.69	NS	2.65

The obtained results in Table 6 indicate that juice quality was significantly affected with intercropping treatments. The results show that brix, sucrose, purity, reducing sugar, rendment pecentages and sugar yield/fed in both seasons were affected by intercropping patterns. These results are in harmony with those obtained by El-Geddawy *et al* (1994) and El-Gergaway *et al* (1995).

Sugar yield ton/fed was consistently reduced with intercropping patterns. The intercropping sugar yield was 98.4 , 93.2 and 84.8% and 90.6 , 83.9 and 78.8% of pure stand when intercroped by one, two and three rows of mung bean in both seasons, respectivly. These results are in agreement by Bhutada and Parashar (1981).

Table 6. Results of intercropping mung bean with sugarcane on juice quality of sugarcane in the two seasons 2000/2001 and 2001/2002.

Treatments	Season 2000/2001					
	Brix degree	Sucrose %	Purity %	Reducing Sugar %	Rendment %	Sugar yield (ton/fd)
T_1	22.17	19.4	90.67	16.67	14.07	8.17
T_2	21.51	18.98	88.24	17.67	13.39	7.74
T_3	20.54	18.63	84.84	20.33	12.43	7.04
T_5	21.63	19.58	90.51	15	14.17	8.3
LSD (0.05)	0.57	0.19	3.08	1.79	0.81	0.68
Season 2001/2002						
T_1	21.63	18.9	89.4	19.00	13.53	8.13
T_2	21.73	18.73	88.7	20.40	13.27	7.53
T_3	22.14	18.07	86.3	22.40	12.47	7.07
T_5	20.6	19.67	93.1	16.50	14.63	8.97
LSD (0.05)	0.96	0.49	2.29	4.10	0.64	0.58

Competitive relationships

Data of competitive relationships and yield advantages for intercropping mung bean with sugarcane under three different patterns are presented in Table 7. The results show that intercropping mung bean with sugarcane resulted in an advantage in land equivalent ratio, LER. The value of LER is greater than one; which means increasing the land productivity. The highest value of LER is 1.74 obtained by intercropping three rows of mung bean . The lowest value is 1.45 obtained from intercropping one row of mung bean. Sugarcane relative yield, RY, is larger at low plant density of mung bean, whereas, mung bean relative yield, RY, increases with increasing the density of mung bean plants.

Table 7. Calculated data of competitive relationships and yield advantage for intercropping mung bean with sugarcane, in the two seasons 2000/2001-2001/2001.

Treatments	Land equivalent ratio (LER) L_c + L_m = ER	Relative crowding coefficient (RCC) K_c x K_m = K	Aggressivity (Agg) A_c	A_m
Season 2000/2001				
T_1	0.99 + 0.56 = 1.55	126.2 x 1.25 = 157.8	+0.43	-0.43
T_2	0.99 + 0.69 = 1.68	76.01 x 2.20 = 167.9	+0.30	-0.30
T_3	0.97 + 0.77 = 1.74	28.86 x 3.29 = 94.9	+0.20	-0.20
Season 2001/2002				
T_1	0.98 + 0.47 = 1.45	49.90 x 0.87 = 43.4	+0.51	-0.51
T_2	0.93 + 0.66 = 1.59	13.75 x 1.97 = 27.1	+0.27	-0.27
T_3	0.92 + 0.75 = 1.67	12.10 x 2.99 = 36.2	+0.17	-0.17
A_c: Agg sugarcane	K_c: RCC (sugarcane)	L_c: LER sugarcane		
A_m: Agg mung bean	K_m: RCC (mung bean)	L_m: LER mung bean		

Data of the relative crowding coefficient (RCC) presented in Table 7 show that it increased with increasing mung bean plant density. It could be concluded that the product of the coefficient showed that intercropping sugarcane and mung bean increased the land use efficiency. Aggressivity (Agg) was affected by intercropping patterns (Table7). Aggrissivety values of sugarcane were positive (dominant) while those of mung bean were negative (dominated). These results of competition relationship and yield advantage are in agreement with those obtained by El-Gergawy et al (1995), Ewida et al (1996) and Garcha et al (1997).

In summary, it could be recommended that intercropping mung bean with sugarcane was successful and profitable for production under good natural drainage in Upper Egypt. Further studies have to be conducted on optimum crop-soil management for intercropping sugarcane with mung bean to maximize crop production.

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الملامح المورفولوجية للتربة و تنافس تحميل فول المانج على قصب السكر في مصر العليا

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تكونت الأراضي الرسوبية المصرية أساسا بترسيب المواد العالقة المحملة سنويا مع مياة الفيضان خلال الحقبة الجيولوجية الحديثة ، وقد أعتاد كثير من المزارعين تحميل محاصيل أخرى على محصول قصب السكر .ومن المتوقع انتشار هذا الأسلوب من الزراعة بصورة شائعة خاصة بين مزارعي قصب السكر الربيعي .والهدف الرئيسي للبحث هو دراسة خواص الارض المورفولوجية و تأثير تحميل فول المانج مع قصب السكر على إنتاجية المحصول وملوحة التربة و خصوبتها .ولهذا الغرض اجريت تجربة بمحطة البحوث الزراعية بشندويل بمصر العليا خلال موسمي ٢٠٠٠، ٢٠٠١/ ٢٠٠١، ٢٠٠٢ بتحميل فول المانج بكثافات مختلفة مع محصول قصب السكر باستخدام تصميم القطاعات الكاملة العشوائية.

تم عمل التعريف المورفولوجي لصفات الأرض الظاهرية من حيث خصائصها و خصوبتها وصنفت على حسب التقسيم الدولي .Typic Torrifluvent. ومن الملاحظ ان الظروف المثلى لعمق الماء الأرضي وملوحة التربة وخصوبتها تعتبر من المؤشرات الرئيسية علي إنتاجية التربة ومحصول قصب السكر فى التكثيف الزراعي . حيث إن تحميل فول المانج على قصب السكر أدى إلى زيادة خصوبة التربة نتيجة لعملية تثبيت الأزوت الجوى والنشاط الجذرى الحيوي.

وكان المحصول النسبى لقصب السكر أكبر عند كثافات منخفضة من نباتات فول المانج المحملة .بينما زاد المحصول النسبي لفول المانج بزيادة كثافة نباتات فول المانج وعلية يمكن التوصية بأن تحميل فول المانج مع قصب السكر الربيعي فى مصر العليا يكون ناجحاً ومربحاً خصوصاً فى حالة استخدام الكثافة العالية وهى الزراعة فى ٣ سطور من فول المانج.