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EFFECT OF PRECEDING WINTER CROPS, RELAY CROPPING, INTERCROPPING SYSTEM AND NITROGEN FERTILIZER RATES ON SOME SOIL PHYSICAL, HYDROPHYSICAL AND CHEMICAL PROPERTIES

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ABSTRACT

Field experiments were carried out on clay soil at the experimental farm of El-Gemmeiza Agricultural Research Station, El-Gharbia governorate, during two years (2006 and 2007), to investigate the effect of preceding winter crops, relay cropping, intercropping system and N fertilization levels on soil properties. The experiments were conducted in randomized complete block design in a split–plot, with three replicates, where preceding winter crops (i.e., wheat, sugar beet and faba bean) occupied the main plots and nitrogen fertilizer rates for maize plant (90, 105, 120 and 135 Kg N/fed.) were assigned to the sub plots, in both years.

Results can be summarized as follows:-

1- All preceding winter crops induced significant changes in all soil properties under study, but faba bean was more effective than wheat or sugar beet on decreasing the values of soil bulk density (Db), settling %, water consumption (CU), soil reaction (pH), soluble Ca, Mg and HCO_3 and C/N ratio of the soil, where take the following order: faba bean > sugar beet > wheat. On the other hand, the effects of preceding winter crops on total porosity (E), void ratio (e), pore size distribution (>9µ, 9-0.2 µ and <0.2 µ), hydraulic conductivity (Kh), soil moisture content (θw) just before harvesting, saturation percentage (SP), field capacity (FC), wilting point (WP), available water (AW), water use efficiency (WUE), soil salinity (EC), soluble Na, K, Cl, SO_4, total N, organic carbon (OC) and availability of soil macronutrients (N, P and K) were increased these characters and take the same order.

2- Faba bean planting as a preceding winter crop with the addition of 90 Kg N/fed to maize in summer season gave the lowest values of (CU), while faba bean with 135 Kg N./fed to maize was the best treatment, since it gave the highest value of (WUE) in the first and second years.

3- The addition of 135 Kg N/fed resulted in a decrease of (pH), soluble HCO_3 and C/N ratio of the soil and increase in (WUE), total N, organic carbon (OC) and availability of soil macronutrients (N, P and K).

4- It could be concluded that the sowing of faba bean, sugar beet and wheat plants in winter season, relay cropping and intercropping system with increasing nitrogen fertilizer for summer crops led to a markedly improvement in soil physical, hydrophysical and chemical properties as well as the status of nutrients which reflect on higher yield of summer season crops.

Keywords: Preceding winter crops, relay cropping, nitrogen fertilizer, maize and sunflower plants, soil physical, hydrophysical and chemical properties

INTRODUCTION

Productivity of summer crops, in Egypt, is affected by several factors that include type of preceding winter crop, cropping system and N fertilization level. These factors affect the summer crop either directly through their influence on plant growth or indirectly through their effect on soil properties.

Several investigators reported the effect of preceding winter crop on ameliorating soil physical and chemical propertied (Keisling *et al.*, 1994 and Selim and Othman, 2001). Preceding winter crops, legumes and / or grasses, improved soil physical conditions as reflected by lower soil bulk density, increased aggregate stability and infiltration rates (Singh *et al.*, 1980; Bruce *et al.*, 1990; Folorunso *et al.*, 1992 and Franco-Vizcaino, 1996). Robinson *et al*. (1994) reported that the improvement effect of faba bean on soil structure, as judged from the decreasing in settling percentage, may be attributed to its root exudates, root growth and decay. Villamil *et al.* (2006) and Sultani *et al.* (2007) also, reported a decrease in bulk density, increase in total and storage porosity in addition to increase in available water when winter crops, especially legumes, were included in the crop rotation. Moreover, several researchers reported that, the soil macro and micronutrients, organic matter and C/N ratio of residues were affected by the preceding crops and consequently affect yield and yield components of the following crop (Loomis and Coonor, 1992; El-Hawary *et al.*, 1994; Farghly, 2001 and Sainju *et al.*, 2003).

Intercropping is a cropping system in which more than one crop are grown in the same area. It is a useful practice for intensive crop production which has several advantages, one of which is improvement of soil physical and chemical conditions. Singh *et al.* (1980) reported that when maize was intercropped with legumes, improvement in soil structure was observed, as judged from the decrease in bulk density and settling percentage, and increase in hydraulic conductivity and available water. In addition, both Gao *et al.* (2009) and Qiang (2008) found that water use efficiency was increased with intercropping compared to sole cropping. Farghly (2001) and Negm and El-Meneasy (2006) studied the influence of Sunflower – maize intercropping system on soil conditions and reported a reduction in soil salinity due to the ability of sunflower to absorb some soluble salts, thus improving maize growth.

Nitrogen is an essential element for enhancing growth and productivity of field crops, especially maize which requires high amounts of N fertilization to produce high grain yields. However, increasing N application may affect soil physical, chemical and biological properties. Latif *et al.* (1992) reported that aggregate stability and size of soil aggregates, in maize plots, were significantly increased, with increasing N application, in clay soil. Miglierina *et al.* (2000) observed that N fertilizer applications significantly increased the proportion of large pores in the 0–0.07 m depth of the soil. Liebig *et al.* (2002) reached to the same conclusion and attributed the limitation of these effects in the surface 7.6 cm to the greater abundance of crops roots and residues, and more pronounced effects of management impacts of tillage and fertilization in that depth. They added that increased N-rate resulted in higher organic C and total N but lower microbial biomass and soil pH. Moreover, Yanai *et al.* (1996) found that increased N application had a direct effect resulting in increasing concentrations of Ca^{++} and NO_3^- and electrical conductivity. However, an indirect effect was also observed which include significant increase in concentration of Mg^{++}, K^{+}, Na^{+} and H^{+} whereas that of P was significantly decreased.

The aim of this study was to investigate the effect of preceding winter crops, relay cropping, intercropping system and N fertilization levels on soil physical, hydrophysical and chemical properties and availability of macronutrients under environmental conditions of El-Gharbia governorate.

MATERIALS AND METHODS

Field experiments were carried out on clay soil at the experimental farm of El-Gemmeiza Agricultural Research Station, El-Gharbia governorate, during two years (2006 and 2007). Some properties of the experimental soil are presented in Table (1).

Table (1-a): Initial soil physical and chemical properties in the first and second years (2006 and 2007).

Soil characters		First year (2006)		Second year (2007)		Soil characters		First year (2006)		Second year (2007)	
Soil depth, cm		0-20	20-40	0-20	20-40	Soil depth, cm		0-20	20-40	0-20	20-40
Physical properties											
Particle size distribution	Sand, %	20.63	21.98	20.63	21.98	Pore size distribution as a percent of total porosity	>9 µ	23.43	23.08	23.77	23.26
	Silt, %	34.21	30.87	34.21	30.87		9-0.2 µ	12.73	12.55	12.92	12.64
	Clay, %	45.16	47.15	45.16	47.15		<0.2 µ	15.16	14.94	15.38	15.05
Texture class		Clay	Clay	Clay	Clay	Hydraulic conductivity (Kh, cm hr^{-1})		0.59	0.55	0.62	0.58
Bulk density (Db, g cm^{-3})		1.29	1.31	1.27	1.30	Settling, %		14.21	14.76	13.13	13.45
Total porosity (E, %)		51.32	50.57	52.08	50.94	Void ratio (e)		1.05	1.02	1.09	1.04
Chemical properties											
EC, dSm^{-1}		3.04	3.10	2.97	3.01	pH 1 : 2.5 (Suspension)		7.89	7.96	7.91	7.98
Soluble ions, meq l^{-1}	Ca^{2+}	11.56	12.09	10.47	10.96	$CaCO_3$, %		3.42	3.28	3.46	3.31
	Mg^{2+}	10.99	11.14	10.53	11.35	Organic matter (O.M., %)		2.58	2.13	2.63	2.18
	Na^{+}	7.65	7.59	8.33	7.59	Organic carbon (O.C., %)		1.494	1.237	1.528	1.266
	K^{+}	0.32	0.31	0.30	0.29	Total nitrogen (T.N., %)		0.118	0.105	0.121	0.108
	CO_3^{2-}	0.00	0.00	0.00	0.00	C/N ratio		12.66	11.78	12.63	11.72
	HCO_3^{-}	4.69	4.74	4.66	4.68	Available N, mg Kg^{-1}		34.60	31.95	35.84	32.53
	Cl^{-}	13.60	14.58	13.45	14.23	Available P, mg Kg^{-1}		9.59	7.17	10.56	10.16
	SO_4^{2-}	12.24	11.81	11.52	11.29	Available K, mg Kg^{-1}		281.72	273.71	295.77	285.07

A randomized complete block design in a split–plot with three replicates was used in both years, where the three preceding crops occupied the main plots and the four nitrogen fertilizer levels i.e., 90, 105, 120 and 135 Kg N/fed. for maize as sub plots in both years.

The plot area of the experiment was 10.8 m^2 (3 m in width and 3.6 m in length). Preceding winter crops were sown after Egyptian clover (Berseem) and maize in the previous year.

Planting and harvesting dates of wheat (Triticum aestivum L., Gemmeiza 7), sugar beet (Beta vulgaris L., Beta poly), faba bean (Vicia faba L., Misr 1), sunflower (Helianthus annuus L., Sakha 51) and maize (Zea mays L., three-way cross- Giza 310) are presented in Table (1-b).

Table (1-b): Planting and harvesting dates of preceding and relay crops in the two years.

Crops	First year (2006)		Second year (2007)	
	Planting date	Harvesting date	Planting date	Harvesting date
Wheat	17/11/2005	16/05/2006	14/11/2006	11/05/2007
Sugar beet	25/10/2005	13/05/2006	27/10/2006	12/05/2007
Faba bean	25/10/2005	12/04/2006	27/10/2006	13/04/2007
Sunflower	20/04/2006	08/08/2006	18/04/2007	02/08/2007
Maize	02/06/2006	02/10/2006	30/05/2007	27/09/2007

Seeds of wheat, sugar beet and faba bean were sown on the top of ridges (120 cm in width and 300 cm in length) in rows. Meanwhile sunflower was seeded on both rides of the wide ridge in hills spaced 30 cm apart with one plant per hill. Sunflower was sown relayed on preceding winter crops in both years.

Maize was sown on the top of the ridges after harvesting winter crops in hills spaced 20 cm apart with one plant per hill, and was replaced with sunflower.

Nitrogen fertilizer was added to maize in two equal doses in the form of ammonium nitrate (33.5 % N) as the aforementioned rates, and the other usual agricultural practices were carried out as recommended for each crop according to the recommendations.

At the end of each year after harvesting maize plant, soil samples (0-20 and 20-40cm) were collected from each plot. The collected soil samples were air-dried, ground in a ceramic mortar and passed through 2 mm sieve and stored to determine some soil physical and chemical properties.

Soil bulk density (Db, g/cm^3) was determined using the core methods (Vomocil, 1986). Total porosity (E, %) and void ratio (e) were calculated using the following equations:-

$$E,\ \% = \left(1 - \frac{Db}{Dr}\right) \times 100$$

and $$e = \frac{Dr}{Db} - 1$$

Where: Db = the bulk density, g/cm^3

Dr = the real density, taken as 2.65 g/cm^3

Settling percentage of the soil aggregates was determined in soil aggregates of 2–5 mm size, as the method described by Williams and Cooke (1961) and Hartge (1969).

Hydraulic conductivity (cm/hr) was determined using undisturbed soil cores using a constant water head according to Richards (1954). Soil moisture characteristics and soil moisture content (θw,%) were determined using the method outlined by Stakman (1969) and pore size distribution was calculated according to De Leenher and De Boodt (1965).

Water consumption (CU) was determined by collecting soil samples from each plot before and after 48 hours of every irrigation and computed according to the Israelsen and Hansen's equation (1962)

$$Water\ consumption,\ cm = \frac{\theta_2 - \theta_1}{100} \times Db \times D$$

Where:

θ_2 = Soil moisture percentage on weight basis after 48 hours from irrigation.

θ_1 = Soil moisture percentage before irrigation.

Db = Bulk density, g/cm^3

D = Soil depth, cm

Water use efficiency (WUE) was calculated by dividing the yield crop (kg/fed.) by water consumptive use (cm) according to Jensen equation's (1983):

$$WUE\ ,\ \mathrm{kg\ fed^{-1}\ cm^{-1}} = \frac{Grain\ yield,\ (kg\ fed^{-1})}{Water\ consumption\ (cm)}$$

Soil pH in soil water suspension (1:2.5) and Soil electrical conductivity (EC, dSm^{-1}) in soil paste extract were measured. Soluble cations and anions were determined in soil paste extract using the methods described by Page *et al.* (1982).

Organic matter was determined by Walkely and Black method according to Black (1965). Total N and available NPK were determined according to Hesse (1971). Total N by macro-Kjeldahel and available N (extracted by 2M KCl) determined using the micro-kjeldahel. Available P (extracted by 0.5N $NaHCO_3$ solution at pH 8.3) determined using ascorbic acid method and available K (extracted by ammonium acetate solution at pH 7.0) was determined using the flame photometer.

The collected data were statistically analyzed according to the procedure outlined by Snedecor and Cochran (1981). The main values were compared at 0.05 level using L.S.D.

RESULTS AND DISCUSSION

I- Effect of preceding winter crops, relay cropping, intercropping system and nitrogen fertilizer rates on some physical soil properties.

1- Soil bulk density (Db), total porosity (E) and void ratio (e).

Concerning the effect of preceding winter crops, relay cropping and intercropping system, the results in Tables (2 and 3) show that all winter crops significantly decreased (Db) and significantly increased (E) and (e). The lowest values of (Db) were recorded for faba bean which gave 1.14 and 1.16 g/cm^3, 1.13 and 1.14 g/cm^3 for the two soil depths in the first and second years, respectively. Also, the highest values of (E) and (e) were 57.08 and 56.23 %, 57.55 and 56.98 % for (E) while they were 1.33 and 1.28, 1.36 and 1.33 for (e) at the two soil depths in the first and second years, respectively. These results revealed that faba bean was more effective than wheat or sugar beet in decreasing (Db) and increasing (E) and (e) values which take the following order: faba bean > sugar beet > wheat.

The decreases of (Db) and the increases of (E) and (e) may be attribute to the high content of organic matter (O.M.) in soil as affected by preceding winter crops which refers to formation of soil aggregates and may be indicated by the improvement in soil structure. Similar conclusions were obtained by Keisling *et al.* (1994) and Selim and Othman (2001).

Regarding nitrogen fertilizer rates, the results in Tables (2 and 3) indicate that the values of (Db) of soil were decreased by increasing nitrogen fertilizer rates from 90 to 135 Kg/fed., where the values of (Db) were decreased from 1.18 to 1.12 g/cm^3 at 0-20 cm depth and from 1.20 to 1.15 g/cm^3 at 20-40 cm depth in the first year. The decrease was from 1.17 to 1.11 g/cm^3 at 0-20 cm depth and from 1.19 to 1.14 g/cm^3 at 20-40 cm depth in the second one, respectively. On the other hand, the values of (E) and (e) were increased from 55.47 to 57.74 % and 54.72 to 56.48 % for (E), and from 1.25 to 1.37 % and 1.21 to 1.30 % for (e) at the two soil depths in the first year, while, in the second year, the values raised from 55.97 to 58.24 % and 55.22 to 57.11 % for (E), and from 1.27 to 1.39 % and 1.23 to 1.33 % for (e) at the two soil depths, respectively.

Concerning the interaction between treatments, data in Tables (2 and 3) indicate that all treatments led to a decrease in soil bulk density (Db) and increases in both total porosity (E) and void ratio (e) of the two soil depths (0-20 and 20-40cm) at the end of the two years as compared with the control. The lowest (Db) value was recorded for faba bean with 135 Kg/fed. nitrogen fertilizer dose (N4). The decreases percentage were 13.95 and 13.39 % for 0-20cm depth and 12.98 and 13.85 % for 20-40cm depth in the first and second years, respectively, as compared with the control which was 1.29 and 1.27, 1.31 and 1.30 g/cm^3 for 0-20 and 20-40 cm depths, respectively. Also, the highest (E) and (e) values were recorded from the same treatment where the increases percentage were 13.23, 12.68 % and 12.31, 13.35 % for (E) and 32.38, 29.41 % and 29.36, 31.73 % for (e) in the first and second years, respectively, over the control which were 51.32, 50.57 % and 52.08, 50.94 % for (E) and 1.05, 1.02 and 1.09, 1.04 for (e) in the two soil depths, respectively. Similar results were obtained by Villamil *et al.* (2006) and Sultani *et al.* (2007).

2- Structural stability (settling percentage)

Regarding the effect of preceding winter crops, relay cropping and intercropping system, the results in Tables (2 and 3) indicate that all preceding winter crops imposed significant decrease in settling %, (i.e. higher degree of soil structure stability) compared to the control. Faba bean planting resulted in the lowest values of settling % which were 11.15, 11.64 % and 10.65, 11.04 % at the two soil depths in the first and second years, respectively, and these values were significantly lower than those obtained from wheat or sugar beet planting as preceding winter crops. That may indicate the beneficial effect of faba bean to maintain higher stability of soil structure compared to wheat and sugar beet. These results are in agreement with those of Robinson *et al.* (1994), who reported that the improvement effect of faba bean on soil structure, as judged from decreasing settling %, may be attributed to its root exudates, root growth and decay which led to formation water stable aggregates.

Concerning the nitrogen fertilizer addition, data in Tables (2 and 3) indicate that settling % decreased with increasing nitrogen fertilizer rates.

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The mean values were decreased from 12.80 to 10.46 % and 13.34 to 10.81 % in the first year and from 12.02 to 9.88 % and 12.24 to 10.25 % in the second one, at the two soil depths (0-20 and 20-40 cm), respectively, with increasing nitrogen fertilizer rates from 90 to 135 Kg/fed. These results may be due to the effect of N fertilization on crop roots and residue in the surface layer which were in greatest abundance, and management impacts of tillage and fertilization were most pronounced, **(**Liebig *et al*., 2002). Similar results were obtained by Latif *et al*. (1992), who reported that the stability and size of soil aggregates were significantly increased with increasing added N which reflected on decrease settling percentage.

Data in Tables (2 and 3) indicate also that all treatments led to a decrease in settling % where the preceding winter crops such as wheat, sugar beet and faba bean or relay cropping between them with increasing nitrogen fertilizer rates caused a decrease in settling % at the two soil depths (0-20 and 20-40 cm) at the end of the first and second years. The decreases of settling % ranged between 5.91 and 28.92 %, 5.83 and 29.20 % in the first year, and 6.17 and 27.34 %, 6.91 and 26.62 % in the second one at the two soil depths, respectively compared to the control. The lowest value of settling % was obtained with faba bean planting at 135 Kg N/fed. which gave 10.10, 10.45 % and 9.54, 9.87 % at the two soil depths in the first and second years, respectively. These results reveal that the effect of faba bean, as a preceding winter crop, resulted in higher degree of structure stability than other crops. Similar results were obtained by Selim and Othman (2001), who reported that the lowest value of settling % (i.e. higher degree of soil structure stability) was resulted under continuous faba bean, whereas, the highest value of settling % (i.e. lower degree of soil structure stability) was obtained under continuous wheat.

3- Pore size distribution

Results of pore size distribution as a percent of total porosity, including the large pores (macro pores or drainable, >9 µ), the medium pores (9-0.2 µ) and micro pores (capillary pores, < 0.2 µ) are presented in Tables (2 and 3).

Regarding the effect of preceding winter crops, relay cropping and intercropping system, data in Tables (2 and 3) show that sowing of faba bean led to significantly increases in pore size values where the values of pore size >9 µ, 9-0.2 µ and < 0.2 µ were 26.06, 25.67 %, 14.16, 13.95 % and 16.86, 16.61 % in the first year and were 26.27, 26.01 %, 14.28, 14.14 % and 17.00, 16.83 % in the second one, at 0-20 and 20-40 cm soil depths, respectively. These values are significantly higher than that of wheat which recorded the values 25.58, 25.15 %, 13.90, 13.67 % and 16.55, 16.27 % in the first year and 25.75, 25.37 %, 14.00, 13.79 % and 16.66, 16.41 % in the second one for the same depths and characters, respectively, sugar beet gave intermediate values between them. The addition of nitrogen fertilizer rates from 90 to 135 Kg N/fed led to an increase in the pore size distribution, where the highest values were recorded for the addition of 135 Kg N/fed which were 26.36, 25.78 %, 14.32, 14.01 % and 17.05, 16.68 % in the first year and 26.59, 26.07 %, 14.45, 14.17 % and 17.20, 16.87 % in the second one, respectively. Similar results were obtained by Miglierina *et al*. (2000), who reported that N fertilizer applications significantly increased the proportion of large pores (>8.81 µm) in the 0-0.07 m depth of the cropping system plots.

The data indicate that all treatments increased the large, medium and micro pores values, at the two soil depths (0-20 and 20-40 cm), at the end of the two years. The highest values of pore size distribution were recorded for faba bean planting with 135 Kg N/fed (N4), where it gave 26.53, 26.01 %, 14.42, 14.14 % and 17.16, 16.83 %, respectively at the two soil depths in the first year, while in the second one, it gave 26.70, 26.36 %, 14.51, 14.32 % and 17.28, 17.05 %, respectively, for the same characters and depths. Meanwhile, the lowest values were recorded for wheat planting with 90 Kg N/fed (N1), where it gave 24.98, 24.63 %, 13.58, 13.39 % and 16.16, 15.94 %, respectively, in the first year and 25.32, 24.81 %, 13.76, 13.48 % and 16.38, 16.05 %, respectively, in the second one.

II- Effect of preceding winter crops, relay cropping, intercropping system and nitrogen fertilizer rates on some hydrophysical soil properties.

1- Soil hydraulic conductivity (Kh)

Data in Tables (4 and 5) indicate that all preceding winter crops, relay cropping and intercropping system, caused significant increases in (Kh) values. The effect of sowing faba bean, on increasing (Kh) values was more than the effect of sowing wheat or sugar beet. The highest (Kh) values were recorded for faba bean planting and reached to 0.69, 0.64 cm/hr and 0.73, 0.67 cm/hr in the first and second years, at the two soil depths, respectively. The sowing of wheat gave the lowest (Kh) values, which reached to 0.66, 0.61 cm/hr in the first year and 0.70, 0.64 cm/hr in the second one for the two depths, respectively. Similar conclusion was obtained by Keisling *et al.* (1994), who reported that hydraulic conductivity and bulk density were significantly improved as a result of winter cover crops.

On the other hand, the addition of nitrogen fertilizers dose from 90 to 135 Kg/fed led to insignificant increases of (Kh) values, where the values of (Kh) ranged from 0.63 to 0.70 and 0.60 to 0.66 cm/hr in the first year, and 0.67 to 0.74 and 0.63 to 0.69 cm/hr in the second one for the two soil depths, respectively. Similar conclusion was obtained by Latif *et al*. (1992).

Concerning the interaction between preceding winter crops and nitrogen fertilizers, it can be noticed that all treatments led to an increase in soil hydraulic conductivity of the two soil depths (0-20 and 20-40 cm) at the end of both years, compared to the control. The highest (Kh) values were obtained with faba bean planting and 135 Kg N/fed, which gave increases percentage of 22.03, 21.82 % in the first year and 22.58, 22.41 % in the second one for the two depths, respectively. The lowest (Kh) values were obtained for wheat planting with the addition of 90 Kg N/fed, which gave increase percentages by 3.39, 5.45 % and 4.84, 5.17 % in the first and second years at the two depths, respectively, over the control. These increases in (Kh) may be due to the modification in pore size distribution i.e. the increases in drainable pores, Tables (2 and 3). Similar results were obtained by Singh *et al.* (1980) and Sultani *et al.* (2007), who reported that when maize was intercropped with legumes, improvement in soil structure was observed, as judged from the increase in hydraulic conductivity and available water.

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2- Soil moisture characteristics

Data in Tables (4 and 5) represent the values of soil moisture content just before harvesting (θw) and soil moisture characters, i.e., saturation percentage (SP), field capacity (FC), wilting point (WP) and available water (AW) as affected by preceding winter crops, relay cropping, intercropping system and nitrogen fertilizer rates.

With regard to the sowing of wheat, sugar beet and faba bean as preceding winter crops, the results in Tables (4 and 5) indicate that the sowing of these crops gave significantly increases in soil moisture content and soil moisture characters. The highest values of (θw), (SP), (FC), (WP) and (AW) were recorded for the sowing of faba bean which gave 18.63, 21.88 %; 76.83, 74.59 %; 41.76, 40.54 %; 22.69, 22.03 % and 19.06, 18.51 % at the end of the first year, and gave 23.76, 25.26 %; 77.55, 75.27 %; 42.14, 40.91 %; 22.90, 22.23 % and 19.24, 18.67 % at the end of the second year for the two soil depths (0-20 and 20-40 cm), respectively. The lowest values were obtained from wheat which gave 18.19, 21.63 %; 76.12, 73.93 %; 41.37, 40.18 %; 22.48, 21.84 % and 18.89, 18.34 % in the first year, and gave 23.50, 25.07 %; 76.87, 74.71 %; 41.78, 40.60 %; 22.71, 22.07 % and 19.07, 18.54 % in the second one for the same depths and characters, respectively.

The increase of nitrogen fertilizer rates from 90 to 135 Kg/fed., insignificantly increased soil moisture content at the end of the two years. The mean values differed from 17.54 to 19.45 % and 21.27 to 22.18 %; 74.79 to 78.26 % and 72.80 to 75.58 %; 40.65 to 42.53 % and 39.56 to 41.08 %; 22.09 to 23.11 % and 21.50 to 22.32 % and 18.56 to 19.42 % and 18.06 to 18.75 % in the first year for (θw), (SP), (FC), (WP) and (AW) at the two soil depths, respectively and from 23.24 to 24.06 % and 24.79 to 25.64 %; 75.89 to 78.56 % and 73.45 to 76.25 %; 41.24 to 42.70 % and 39.92 to 41.44 %; 22.41 to 23.20 % and 21.69 to 22.52 % and 18.83 to 19.49 % and 18.22 to 18.92 % in the second one for the same characters and depths, respectively. Similar conclusion was found by Liebig *et al*. (2002), who reported that N fertilization had a more pronounced effect on soil properties than crop sequence, with much of the effect limited to the surface 0.0 to 7.6 cm depth where crop roots and residue were in greatest abundance. On the contrary, Latif *et al*. (1992) reported that soil water properties were not significantly affected by either intercropping or N fertilization.

The interaction between treatments show that the highest values were recorded for faba bean with 135 Kg N/fed., which caused increases by 20.04, 15.56 % for (θw), 6.92, 6.23 % for (SP), 8.08, 6.81 % for (FC), 9.27, 6.24 % for (WP) and 6.70, 7.49 % for (AW) at the two soil depths (0-20 and 20-40 cm) in the first year, while in the second year, the increases percentage were 23.95, 22.65 % for (θw), 5.46, 5.97 for (SP), 6.62, 6.55 % for (FC), 7.77, 5.97 % for (WP) and 5.27, 7.26 % for (AW) at the two depths, over the control. On the other hand, the lowest values of (θw), (SP), (FC), (WP) and (AW) were obtained by wheat while sugar beet gave intermediate values between them.

3- Water consumption (CU) and water use efficiency (WUE).

Data in Tables (4 and 5) indicate the effect of preceding winter crops, relay cropping, intercropping system and nitrogen fertilizer rates on water consumption (CU) and water use efficiency (WUE). The results show that CU values for maize plants, as affected by preceding winter crops were significantly decreased. Faba bean was more effective on decreasing CU for maize than wheat or sugar beet. The values of CU ranged between 57.46 and 66.88 cm at the end of the first year and 55.11 and 64.48 cm at the end of the second one, respectively. On the other hand, WUE take the opposite direction, where the values of WUE significantly increased, where faba bean planting was more effective on increasing WUE than other crops. The values of WUE increased from 50.34 to 60.49 Kg $fed^{-1}cm^{-1}$ in the first year and from 50.04 to 62.68 Kg $fed^{-1}cm^{-1}$ in the second one, respectively. Similar results were obtained by Qiang (2008) and Gao *et al.* (2009), they found that the difference between total water consumption in intercropping system and average of water consumption in sole cropping systems is very limited, but the water use efficiency in intercropping system can be increased by 18% - 99%.

Concerning the effect of nitrogen fertilizers, the results indicate that the values of CU and WUE for maize plant were significantly increased by increasing the addition rates of nitrogen fertilizers, where the CU and WUE values were increased from 60.78 to 62.00, 58.96 to 60.28 cm and 53.21 to 55.12, 53.34 to 55.79 Kg fed^{-1} cm^{-1} in the first and second years, respectively. This increase in CU values may be attributed to increase maize vegetative growth, which means increasing the transpiring surface and better root development. These results reveal that the increase in water use efficiency (WUE) is mainly due to the application of N fertilizer (Gaiser *et al.*, 2004), where the improvement of WUE may be due to the increase of mesophyll capacity, which led to the promotion of photosynthesis (Qu *et al.*, 2000). Similar result was obtained by Taylor *et al.* (1991), who reported that the efficiency of water use in the production of grain (WUE_g) and biomass (WUE_b) were increased with increasing nitrogen additions where the maximum values were measured from treatment N 200 kg/fed.

Regarding the combined effect, the results indicate that faba bean with 90 Kg N/fed (N1) gave the lowest values of CU which decreased to 56.78 and 54.43 cm, as compared to other treatments, while faba bean with 135 Kg N./fed. for maize was the best treatment, since it gave the highest values of WUE where increased to 60.88 and 63.02 Kg $fed^{-1}cm^{-1}$, as compared to other treatments in the first and second years, respectively. These results may be due to this treatment gave the highest yield of maize grains in both years.

III- Effect of preceding winter crops, relay cropping, intercropping system and nitrogen fertilizer rates on some soil chemical properties.

1- Soil reaction (pH)

Concerning the effect of preceding winter crops, relay cropping, intercropping system, the results in Tables (6 and 7) reveal that all crops sown in winter season significantly decreased soil pH compared with the control.

Table (6): Effect of preceding winter crops, relay cropping, intercropping system and nitrogen fertilizer rates on some soil chemical properties in the first year (2006).

Treatments		Depth, cm	Soil pH 1:2.5 Susp.	EC, dSm^{-1}	Soluble ions, meq/l						
Crops sequences	Nitrogen fertilizer				Ca	Mg	Na	K	HCO_3	Cl	SO_4
Wheat-Sunflower-Maize (W-S-M)	N1	0-20	7.77	2.58	11.61	8.77	5.13	0.38	4.97	11.05	9.87
	N2		7.76	2.64	11.77	8.79	5.41	0.39	4.90	11.14	10.31
	N3		7.74	2.68	11.83	8.88	5.72	0.39	4.87	11.44	10.51
	N4		7.72	2.74	12.09	8.97	5.92	0.40	4.83	11.58	10.97
Sugar beet-Sunflower-Maize (SB-S-M)	N1		7.79	2.57	11.67	9.99	3.67	0.33	5.12	10.60	9.94
	N2		7.77	2.62	11.79	10.22	3.76	0.34	5.08	10.84	10.19
	N3		7.76	2.67	11.85	10.45	3.98	0.35	5.03	11.19	10.41
	N4		7.74	2.71	12.13	10.42	4.18	0.36	5.00	11.38	10.72
Faba bean-Sunflower–Maize (F-S-M)	N1		7.76	2.61	11.58	7.28	6.70	0.44	4.80	11.39	9.80
	N2		7.75	2.66	11.71	7.42	6.97	0.45	4.76	11.45	10.33
	N3		7.73	2.70	11.81	7.59	7.18	0.46	4.74	11.56	10.73
	N4		7.71	2.76	12.05	7.62	7.53	0.49	4.72	11.59	11.37
Control			7.89	3.04	11.56	10.99	7.65	0.32	4.69	13.60	12.24
A Crops sequences	W-S-M		7.75	2.66	11.82	8.85	5.55	0.39	4.89	11.30	10.41
	SB-S-M		7.77	2.64	11.86	10.27	3.90	0.34	5.06	11.00	10.31
	F-S-M		7.74	2.68	11.78	7.48	7.09	0.46	4.75	11.50	10.56
	F		70.57*	1662.98*							
	LSD 5%		0.01	0.00							
B Nitrogen fertilizer	N1		7.77	2.59	11.62	8.68	5.17	0.38	4.96	11.01	9.87
	N2		7.76	2.64	11.76	8.81	5.38	0.39	4.92	11.14	10.28
	N3		7.74	2.68	11.83	8.97	5.63	0.40	4.88	11.40	10.55
	N4		7.72	2.74	12.09	9.00	5.88	0.41	4.85	11.51	11.02
	F		NS	22.20*							
	LSD 5%			0.06							
AB	F		NS	NS							
	LSD 5%										
Wheat-Sunflower-Maize (W-S-M)	N1	20-40	7.82	2.66	12.19	9.07	5.09	0.37	4.94	12.01	9.77
	N2		7.81	2.72	12.28	9.18	5.49	0.38	4.90	12.14	10.29
	N3		7.78	2.80	12.47	9.27	5.94	0.39	4.87	12.21	10.98
	N4		7.76	2.85	12.56	9.31	6.36	0.40	4.83	12.24	11.56
Sugar beet-Sunflower-Maize (SB-S-M)	N1		7.84	2.65	12.22	10.48	3.54	0.32	5.03	11.81	9.72
	N2		7.82	2.71	12.29	10.52	3.85	0.33	5.01	11.86	10.11
	N3		7.79	2.78	12.50	10.56	4.29	0.33	4.99	11.95	10.74
	N4		7.78	2.84	12.58	10.62	4.75	0.34	4.96	12.01	11.32
Faba bean-Sunflower–Maize (F-S-M)	N1		7.81	2.68	12.18	7.28	6.83	0.43	4.81	12.23	9.67
	N2		7.79	2.75	12.25	7.55	7.14	0.44	4.80	12.25	10.33
	N3		7.77	2.83	12.45	8.01	7.31	0.46	4.79	12.29	11.14
	N4		7.75	2.87	12.55	8.16	7.44	0.48	4.76	12.33	11.53
Control			7.96	3.10	12.09	11.14	7.59	0.31	4.74	14.58	11.81
A Crops sequences	W-S-M		7.79	2.76	12.37	9.21	5.72	0.39	4.89	12.15	10.65
	SB-S-M		7.81	2.75	12.40	10.54	4.11	0.33	5.00	11.91	10.47
	F-S-M		7.78	2.78	12.35	7.75	7.18	0.45	4.79	12.27	10.67
	F		91.00*	1651.04*							
	LSD 5%		0.01	0.00							
B Nitrogen fertilizer	N1		7.82	2.66	12.20	8.94	5.15	0.38	4.93	12.02	9.72
	N2		7.81	2.73	12.27	9.08	5.50	0.38	4.90	12.08	10.24
	N3		7.78	2.80	12.47	9.28	5.85	0.39	4.88	12.15	10.95
	N4		7.76	2.85	12.56	9.36	6.18	0.41	4.85	12.19	11.47
	F		NS	38.62*							
	LSD 5%			0.06							
AB	F		NS	NS							
	LSD 5%										

The decreases in soil pH ranged from 7.77 to 7.74, 7.81 to 7.78 at the end of the first year and from 7.81 to 7.78, 7.84 to 7.81 in the second one for the two soil depths, respectively. However, the effect of faba bean, as a preceding winter crop, on decrease in soil pH was more effective than sugar beet or wheat, where these crops take the order: Faba bean > wheat > sugar beet.

Regarding the effect of nitrogen fertilizer, it was observed that by increasing nitrogen fertilizer rates, the soil pH values were insignificantly decreased, where the pH values ranged from 7.77 to 7.72, 7.82 to 7.76 in the first year and from 7.82 to 7.77, 7.85 to 7.80 in the second one, respectively, for the two soil depths. Similar results were obtained by Liebig *et al*. (2002), who reported that increased N rate resulted in lower soil pH. These results reveal that there were insignificant effects for the different nitrogen fertilizer rates on soil pH. Dong *et al.* (2004) reported that soil pH at 0-30 cm depth did not vary with N application rate.Data in Tables (6 and 7) indicate that all treatments led to a decrease in soil reaction (pH), at the two soil depths, at the end of the two years compared with the control. The decrease of soil pH differed from 1.27 to 2.28, 1.51 to 2.64 % in the first year, and from 1.01 to 2.02, 1.50 to 2.38 % in the second one, at the two soil depths, respectively. The lowest pH values were obtained by faba bean with 135 Kg N/fed., where pH values were 7.71, 7.75 at the end of the first year and 7.75, 7.79 at the end of the second one for the two soil depths, respectively. Similar results were obtained by Liebig *et al.* (2002). These results reveal that there is no wide variation between the different treatments on soil pH values. This may be due to the magnitude of pH change depends on many soil properties including buffering capacity of soil.

2- Soil salinity (EC) and soluble ions.

The results in Tables (6 and 7) indicate that all preceding winter crops, relay cropping and intercropping system significantly decreased soil EC values as compared with control. The lowest EC value was obtained by sugar beet which were 2.64, 2.75 dSm^{-1} in the first year and 2.55, 2.63 dSm^{-1} in the second one for the two soil depths, respectively. While, the highest EC value was recorded for faba bean, which were 2.68, 2.78 dSm^{-1} in the first year and 2.59, 2.67 dSm^{-1} in the second one for the two soil depths, respectively. These means that sugar beet was more effective in decreasing soil EC values than faba bean or wheat. This may be due to sugar beet tended to absorb Na^+ and K^+ from soil water solution, consequently decrease the salinity (EC).

The results also, indicate that by increasing nitrogen fertilizer rate, the soil EC values were significantly increased, but they were still lower than the control. The EC values differed between 2.59 and 2.74, 2.66 and 2.85 dSm^{-1} and between 2.51 and 2.65, 2.59 and 2.70 dSm^{-1} at the end of the two years for the two soil depths, respectively.

Data in Tables (6 and 7) show that soil EC values were decreased with all treatments for the two soil depths at the end of the two years as compared with control.

The lowest EC values were recorded for sugar beet with 90 Kg N/fed, where the values reached to 2.57, 2.65 dSm^{-1} and 2.49, 2.58 dSm^{-1}, as compared with control, where decreased by 15.46, 14.52 % and 16.16, 14.29 % in the first and second years for the two soil depths, respectively.

Table (7): Effect of preceding winter crops, relay cropping, intercropping system and nitrogen fertilizer rates on some soil chemical properties in the second year (2007).

Treatments		Depth, cm	Soil pH 1:2.5 Susp.	EC, dSm^{-1}	Soluble ions, meq/l						
Crops	Nitrogen fertilizer				Ca	Mg	Na	K	HCO_3	Cl	SO_4
Wheat-Sunflower-Maize (W-S-M)	N1	0-20	7.82	2.51	10.53	8.60	5.52	0.35	5.09	10.42	9.50
	N2		7.81	2.54	10.63	8.79	5.71	0.37	5.07	10.67	9.76
	N3		7.78	2.58	10.70	8.90	5.94	0.38	5.03	11.12	9.77
	N4		7.77	2.65	10.84	9.06	6.10	0.39	5.00	11.39	9.99
Sugar beet-Sunflower-Maize (SB-S-M)	N1		7.83	2.49	10.57	9.84	4.28	0.31	5.17	10.38	9.44
	N2		7.82	2.52	10.66	9.94	4.37	0.32	5.15	10.55	9.59
	N3		7.79	2.56	10.74	10.02	4.64	0.33	5.14	10.89	9.69
	N4		7.78	2.63	10.85	10.11	4.92	0.34	5.12	11.33	9.77
Faba bean-Sunflower-Maize (F-S-M)	N1		7.80	2.52	10.50	7.21	7.22	0.39	4.77	10.70	9.83
	N2		7.79	2.55	10.59	7.31	7.31	0.40	4.74	11.04	9.83
	N3		7.77	2.60	10.68	7.37	7.66	0.41	4.72	11.29	10.11
	N4		7.75	2.67	10.78	7.42	8.01	0.42	4.69	11.59	10.35
Control			7.91	2.97	10.47	10.53	8.33	0.30	4.66	13.45	11.52
A Crops sequences	W-S-M		7.80	2.57	10.67	8.84	5.82	0.37	5.05	10.90	9.75
	SB-S-M		7.81	2.55	10.70	9.97	4.55	0.32	5.14	10.78	9.62
	F-S-M		7.78	2.59	10.64	7.33	7.55	0.40	4.73	11.15	10.03
	F		144.18*	180.99*							
	LSD 5%		0.01	0.01							
B Nitrogen fertilizer	N1		7.82	2.51	10.53	8.55	5.67	0.35	5.01	10.50	9.59
	N2		7.81	2.54	10.63	8.68	5.80	0.36	4.99	10.75	9.73
	N3		7.78	2.58	10.71	8.76	6.08	0.37	4.96	11.10	9.85
	N4		7.77	2.65	10.82	8.86	6.34	0.38	4.93	11.44	10.04
	F		NS	41.35*							
	LSD 5%			0.04							
AB	F		NS	NS							
	LSD 5%										
Wheat-Sunflower-Maize (W-S-M)	N1	20-40	7.85	2.59	11.96	8.84	4.74	0.33	5.13	11.78	8.97
	N2		7.83	2.64	11.99	9.01	5.06	0.34	5.10	11.98	9.32
	N3		7.82	2.67	12.07	9.08	5.33	0.35	5.07	12.10	9.66
	N4		7.80	2.70	12.18	9.03	5.58	0.36	5.03	12.38	9.72
Sugar beet-Sunflower-Maize (SB-S-M)	N1		7.86	2.58	11.99	9.87	3.76	0.30	5.21	11.73	8.97
	N2		7.84	2.62	12.05	9.96	3.94	0.31	5.20	11.78	9.27
	N3		7.83	2.65	12.11	10.10	4.12	0.32	5.17	11.99	9.47
	N4		7.82	2.68	12.21	10.09	4.27	0.33	5.15	12.41	9.33
Faba bean -Sunflower-Maize (F-S-M)	N1		7.83	2.61	11.92	7.04	6.65	0.37	4.80	12.18	9.00
	N2		7.81	2.65	11.96	7.19	7.05	0.38	4.76	12.26	9.56
	N3		7.80	2.68	12.03	7.27	7.22	0.39	4.74	12.51	9.66
	N4		7.79	2.72	12.15	7.36	7.40	0.40	4.72	12.65	9.93
Control			7.98	3.01	10.96	11.35	7.59	0.29	4.68	14.23	11.29
A Crops sequences	W-S-M		7.83	2.65	12.05	8.99	5.18	0.34	5.08	12.06	9.42
	SB-S-M		7.84	2.63	12.09	10.00	4.02	0.31	5.18	11.98	9.26
	F-S-M		7.81	2.67	12.01	7.21	7.08	0.39	4.75	12.40	9.54
	F		59.45*	256.75*							
	LSD 5%		0.01	0.01							
B Nitrogen fertilizer	N1		7.85	2.59	11.95	8.58	5.05	0.33	5.04	11.89	8.98
	N2		7.83	2.64	12.00	8.72	5.35	0.34	5.02	12.00	9.39
	N3		7.82	2.67	12.07	8.82	5.56	0.35	4.99	12.20	9.60
	N4		7.80	2.70	12.18	8.82	5.75	0.36	4.97	12.48	9.66
	F		NS	12.26*							
	LSD 5%			0.06							
AB	F		NS	NS							
	LSD 5%										

However, the highest EC values were recorded for faba bean with 135 Kg N/fed., which were 2.76, 2.87 dSm^{-1} and 2.67, 2.72 dSm^{-1} at the end of the first and second years for the two soil depths, respectively, where decreased by 9.21, 7.42 % and 10.10, 9.63 % in the first and second years, for the same depths, respectively.Similar results were obtained by Yanai *et al.* (1996) and Shi *et al.* (2009), they found that the electrical conductivity (EC) significantly increased in the N treatments as direct effects of N fertilizer application.

The results in Tables (6 and 7) also reveal that the sowing of sugar beet was more effective upon increasing soluble Ca, Mg and HCO_3 and decreasing soluble Na, K, Cl and SO_4 than wheat or faba bean where take the following order: sugar beet > wheat > faba bean.

Increasing nitrogen fertilizer rates, increased soil soluble Ca, Mg, Na, K, Cl and SO_4, where the addition of 135 Kg N/fed gave the highest effect compared with the other rates. The highest values of these ions were 12.09, 9.00, 5.88, 0.41, 11.51 and 11.02 meq/l of 0-20 cm soil depth and 12.56, 9.36, 6.18, 0.41, 12.19 and 11.47 meq/l of 20-40 cm soil depth in the first year and were 10.82, 8.86, 6.34, 0.38, 11.44 and 10.04 meq/l of 0-20 cm soil depth and 12.18, 8.82, 5.75, 0.36, 12.48 and 9.66 meq/l of 20-40 cm soil depth in the second one. On the contrary, soluble HCO_3 decreased by increasing nitrogen fertilizer rates, where the addition of 135 kg N/fed., gave the lowest values, in which were 4.85, 4.85 and 4.93, 4.97 meq/l in the first and second years for the same depths, respectively. Similar conclusions were obtained by Yanai *et al*. (1996), who found that the concentrations of Ca, Mg, K, Na and H^+ increased significantly as indirect effects caused by the re-establishment of chemical equilibria..

The combined effect reveal that soluble Mg, Na, Cl and SO_4 generally decreased, while soluble Ca, K and HCO_3 generally increased with all treatments in the two years, as compared with control. The lowest values of soluble Na, K, Cl and SO_4 recorded for sugar beet with 90 Kg N/fed. The lowest value of soluble Ca and Mg obtained by sowing faba bean with 90 Kg N/fed. Also, the lowest value of soluble HCO_3 was obtained by sowing faba bean with 135 Kg/fed.

IV- Effect of preceding winter crops, relay cropping, intercropping system and nitrogen fertilizer rates on some soil macronutrients.

1- Total nitrogen (T.N), Organic carbon (O.C) and C/N ratio of the soil.

Concerning the effect of preceding winter crops, relay cropping and intercropping system, the results in Table (8) reveal that the highest mean values of soil total N were obtained by sowing faba bean, where they reached to 0.141, 0.124 % and 0.148, 0.127 % at the end of the first and second years, at the two soil depths, respectively. On the other hand, the lowest mean values of total N were recorded for sowing wheat, which reached to 0.129, 0.110 % and 0.133, 0.114 % at the end of the two years, at the same depths, respectively. Similar conclusion was obtained by El-Hawary *et al.* (1994), who reported that soil macro and micro nutrients were affected by the preceding crops and consequently affected yield and yield components of the following crop.

It is obvious from Table (8) that increasing nitrogen fertilizer rates from 90 to 135 Kg/fed, significantly increased total soil N in the two years compared with control. The mean values of total N ranged from 0.132 to 0.137, 0.114 to 0.119 % and 0.137 to 0.143, 0.117 to 0.122 % in the first and second years, at the two soil depths, respectively. Similar conclusion was obtained by Liebig *et al.* (2002), who reported that nitrogen fertilization had a greater influence on soil properties than crop sequence, with much of the influence concentrated in the surface 7.6 cm, where increased N rates resulted in higher total N and lower microbial biomass.

Data in Table (8) indicate that all treatments led to increase total N of soil, at the two soil depths (0-20 and 20-40 cm), at the end of the two years compared with the control. The highest values of total N were recorded by faba bean with 135 Kg N/fed., where the increases percentage of total N were 22.88, 20.95 % and 23.97, 20.37 % in the first and second years, at the two soil depths, respectively. The lowest increases percentage of total N were recorded by wheat with 90 Kg N/fed., where it reached to 7.63, 2.86 % and 6.61, 3.70 % in the two years for the same depths, respectively.

Concerning the effect of preceding winter crops, relay cropping and intercropping system on organic carbon (O.C), the results in Table (8) reveal that the sowing of faba bean gave the highest values of (O.C), where it reached to 1.517, 1.266 % and 1.552, 1.296 % at the end of the two years, at the two soil depths, respectively, while the sowing of sugar beet gave the lowest values of (O.C), where decreased to 1.513, 1.260 % and 1.546, 1.291 % in the two years, at the same depths, respectively. These results indicate that faba bean was more effective in increasing (O.C) content in soil than the other winter crops, which can be arranged as follows: faba bean > wheat > sugar beet. These results may be attributed to greater amounts of plant residues returned to the soil by faba bean than wheat or sugar beet which increased soil O.M. (Selim and Othman, 2001), who found that first year of faba bean resulted in increasing organic matter (OM) by 4.71 % compared to wheat at 0-15 cm of soil depth.

Regarding the effect of nitrogen fertilizer, the results show that the values of (O.C) were significantly increased with increasing nitrogen fertilizer rates in the two years. The highest mean values of (O.C) were recorded for the addition of 135 Kg N/fed, where it reached to 1.524, 1.269 % and 1.562, 1.305 % in the two years for the two soil depths, respectively. Meanwhile, the lowest mean values of (O.C) were obtained when 90 Kg N/fed., was added where it reached to 1.504, 1.254 % and 1.538, 1.284 % in the two years at the same depths, respectively.

Concerning the combined effect, it can be noticed that all treatments significantly increased organic carbon (O.C., %) at the end of the two years, for the two soil depths, comparing to control. The increases in (O.C) ranged between 0.54 and 2.14, 1.21 and 2.75 % in the first year and between 0.46 and 2.42, 1.26 and 3.32 % in the second one, at the two soil depths, respectively.

The highest (O.C) value was recorded for sowing faba bean with 135 Kg N/fed, while the lowest (O.C) value was obtained by sowing sugar beet with 90 Kg N/fed.

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It can be noticed from Table (8) that sowing faba bean was more effective in decreasing C/N ratio of the soil than the other two crops. Similar conclusions were obtained by Loomis and Coonor (1992). On the other hand, it can be observed that the C/N ratio of the soil was significantly decreased with increasing nitrogen fertilizer rates, where the lowest C/N ratio values were 11.18, 10.69 and 10.97, 10.69 in the first and second years, at the two soil depths, respectively, and were recorded by the addition of 135 Kg N/fed. These results reveal that nitrogen fertilization had a significant influence on decreasing C/N ratio, which depends on N applied and soil N content. This may be attributed to the greater abundance of crop roots and residues especially in surface layer of soil. Similar conclusions were obtained by Loomis and Coonor (1992) and Liebig *et al.* (2002).

The results in Table (8) show that the C/N ratio was significantly decreased with all treatments, at the two soil depths, in the two years as compared with the control. The decreases in C/N ratio of the soil ranged between 6.46 and 16.88, 1.36 and 15.05 % in the first year and between 5.59 and 17.38, 2.20 and 14.17 % in the second one, at the two soil depths, respectively. The minimum C/N ratio was obtained for sowing faba bean with 135 Kg N/fed. which reached to 10.52, 10.01 and 10.43, 10.06 in the first and second years for the two soil depths. The maximum C/N ratio was recorded for wheat with 90 Kg N/fed which reached to 11.84, 11.62 and 11.92, 11.46 at the end of the first and second years, at the two soil depths, respectively.

2- Available macronutrients of the soil.

Regarding the effect of preceding winter crops, relay cropping and intercropping system, data in Table (9) show that sowing faba bean gave the highest mean values of soil available N, P and K, where they reached to 39.43, 36.23 and 40.48, 36.99 ppm for available N, 11.24, 8.22 and 12.38, 11.48 ppm for available P and 332.53, 318.12 and 351.25, 332.63 ppm for available K at the end of the first and second years, at the two soil depths, respectively. On the other hand, sowing wheat gave the lowest mean values of available N, which reached to 35.45, 32.62 and 36.94, 33.52 ppm at the end of the two years, at the same depths, respectively. While, the lowest mean values of available P and K were recorded for sowing sugar beet, where they were 9.91, 7.41 and 10.90, 10.44 for P, and 292.78, 280.61 and 310.32, 296.18 ppm for K in the two years at the same depths, respectively. These results revealed that faba bean, as a preceding winter crop, enriched the soil with N, P and K and its residues had beneficial effects on improving soil chemical properties (Farghly, 2001). Similar conclusion was obtained by Olasantan (1998), who reported that the preceding winter crops had a significant effect on soil nutrient changes, where increased the N, P and K status of the soil.

It is obvious from Table (9) that increasing nitrogen fertilizer rates from 90 to 135 Kg/fed., significantly increased soil available N, P and K in the two years compared with control. The mean values of available N, P and K ranged from 36.77 to 38.18; 33.93 to 35.10 ppm and 37.99 to 39.50; 34.71 to 36.04 ppm for available N, 10.39 to 10.85; 7.69 to 8.00 ppm and 11.43 to 11.93; 10.74 to 11.19 ppm for available P, and 304.76 to 319.98; 292.52 to 305.31 ppm and 322.31 to 338.79; 308.21 to 321.46 ppm of available K in the first and second years, at the two soil depths, respectively. Similar conclusions were obtained by Liebig *et al.* **(**2002).

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Data in Table (9) indicate that all treatments led to increase available N, P and K of soil, at the two soil depths of the two years compared with the control. The highest values of available N, P and K were recorded by faba bean with 135 Kg N/fed., where the increases percentage of available N were 16.04, 15.02 % and 15.07, 14.51 %, available P 19.50, 16.46 % and 19.41, 15.94 %, and available K 21.24, 18.41 % and 21.19, 18.54 % in the first and second years, at the two soil depths, respectively. The lowest increases percentage of available N were recorded by wheat with 90 Kg N/fed., where reached to 0.12, 0.22 % and 0.08, 0.28 % in the two years for the same depths, respectively. Also, the lowest increases percentage of soil available P and K were recorded for sugar beet with 90 Kg N/fed., where reached to 0.52, 0.84 % and 0.38, 0.79 % for available P, and 1.66, 1.04 % and 1.82, 1.70 % for available K in the two years at the same depths, respectively.

From the aforementioned results, it could be concluded that sowing preceding winter crops such as wheat, sugar beet and especially fabe bean plants with different ratios of nitrogen fertilizer for summer crops (i.e., maize) led to a markedly improvement in soil physical, hydrophysical and chemical properties as well as the status of nutrients which reflect on higher yield in summer season.

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تـأثير المحاصـيل الشـتوية السـابقة والتعاقـب المحصـولي ونظـم التحميـل ومعـدلات التسـميد النتروجينـي علـي بعـض الخـواص الطبيعيـه والـهيدروفيزيائيـه والكيماويـه للتربة

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نفذت تجارب حقلية علي ارض طينية في المزرعة البحثية لمحطة البحوث الزراعية بالجميزة ، محافظة الغربية ، خلال عامي (2006 و 2007) لدراسة تأثير المحاصيل الشتوية السابقة والتعاقب المحصولي ونظم التحميل ومستوي التسميد النتروجيني علي خصائص التربة . وكان تصميم التجربة قطاعات كامله العشوائيه في قطع منشقة في ثلاث مكررات حيث كانت المحاصيل الشتوية السابقة وهي القمح وبنجر السكر والفول البلدي والتي تمثل القطع الرئيسية ، ومعدلات التسميد النتروجيني لنبات الذره وهي 90 ، 105 ، 120 و 135 كجم نتروجين للفدان في القطع الثانوية في كلا العامين .

ويمكن تلخيص نتائج التجربة كالتالي:-

1- نتج عن كل المحاصيل الشتوية السابقة تغيرات معنوية في كل خصائص التربة تحت الدراسة ، حيث كان الفول البلدي اكثر تأثيرا من القمح وبنجر السكر في نقص قيم الكثافة الظاهرية للتربة ، ونسبة التحبب ، والاستهلاك المائي ، ودرجة تفاعل التربة ، وايونات الكالسيوم والماغنسيوم والبيكربونات ونسبة الكربون الي النتروجين في التربة حيث اخذت الترتيب : الفول البلدي > بنجر السكر > القمح . علي الجانب الاخر فان تأثير المحاصيل الشتوية السابقة علي المسامية الكلية ، ونسبة المسام ، والتوزيع الحجمي للمسام ، والتوصيل الهيدروليكي ، ومحتوي رطوبة التربة قبل الحصاد ، ومحتوي رطوبة التربة عند التشبع والسعة الحقلية ونقطة الذبول ، والماء الميسر ، وكفاءة استخدام المياة ، وملوحه التربه وايونات الصوديوم والبوتاسيوم والكلوريد والكبريتات الذائبة ، والنتروجين الكلي ، والكربون العضوي ، وتيسير العناصر الغذائيه الكبري (النتروجين والفوسفور والبوتاسيوم) تأخذ الاتجاة العكسي حيث زادت قيم هذه الخواص .

2- زراعة الفول البلدي كمحصول شتوي سابق مع اضافة 90 كجم نتروجين للفدان للذره في الموسم الصيفي اعطي اقل استهلاك مائي ، بينما زراعة الفول البلدي مع اضافة 135 كجم نتروجين للفدان للذره سجلت اعلي كفاءة في استخدام المياة في السنتين .

3- نتج عن اضافة 135 كجم نتروجين للفدان نقص في درجة تفاعل التربة والبيكربونات الذائبه ونسبة الكربون الي النتروجين في التربة وزياده في النتروجين الكلي والكربون العضوي وتيسير العناصر الغذائيه الكبري في التربه (النتروجين والفوسفور والبوتاسيوم).

4- بصفة عامة يمكن التوصية بزراعة الفول البلدي وبنجر السكر والقمح في الموسم الشتوي مع التسميد النتروجيني للمحاصيل الصيفيه الذي يؤدي الي تحسن واضح في الخصائص الطبيعية والهيدروفيزيائية والكيميائية للتربة مما ينعكس علي ارتفاع المحصول في الموسم الصيفي .

قام بتحكيم البحث

أ.د / محمد وجدى العجرودى	**كلية الزراعة – جامعة المنصورة**
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Table (2): Effect of preceding winter crops, relay cropping, intercropping system and nitrogen fertilizer rates on some soil physical properties in the first year (2006).

Treatments		Bulk Density Db, g/cm3		Total porosity (E, %)		Void ratio (e)		Settling, %		Pore size distribution as a percent of total porosity					
										>9 µ		9-0.2 µ		<0.2 µ	
Crops sequences	Nitrogen fertilizer	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm
Wheat-Sunflower-Maize (W-S-M)	N1	1.20	1.22	54.72	53.96	1.21	1.17	13.37	13.90	24.98	24.63	13.58	13.39	16.16	15.94
	N2	1.18	1.19	55.47	55.09	1.25	1.23	12.00	12.53	25.32	25.15	13.76	13.67	16.38	16.27
	N3	1.15	1.18	56.60	55.47	1.30	1.25	11.34	11.81	25.84	25.32	14.04	13.76	16.72	16.38
	N4	1.13	1.17	57.36	55.85	1.35	1.26	10.86	11.17	26.19	25.50	14.23	13.86	16.94	16.50
Sugar beet-Sunflower-Maize (SB-S-M)	N1	1.18	1.20	55.47	54.72	1.25	1.21	12.74	13.41	25.32	24.98	13.76	13.58	16.38	16.16
	N2	1.17	1.18	55.85	55.47	1.26	1.25	11.72	12.03	25.50	25.32	13.86	13.76	16.50	16.38
	N3	1.14	1.17	56.98	55.85	1.32	1.26	11.19	11.65	26.01	25.50	14.14	13.86	16.83	16.50
	N4	1.12	1.15	57.74	56.60	1.37	1.30	10.41	10.82	26.36	25.84	14.32	14.04	17.05	16.72
Faba bean-Sunflower-Maize (F-S-M)	N1	1.16	1.18	56.23	55.47	1.28	1.25	12.28	12.72	25.67	25.32	13.95	13.76	16.61	16.38
	N2	1.15	1.17	56.60	55.85	1.30	1.26	11.35	11.91	25.84	25.50	14.04	13.86	16.72	16.50
	N3	1.13	1.15	57.36	56.60	1.35	1.30	10.88	11.48	26.19	25.84	14.23	14.04	16.94	16.72
	N4	1.11	1.14	58.11	56.98	1.39	1.32	10.10	10.45	26.53	26.01	14.42	14.14	17.16	16.83
Control		1.29	1.31	51.32	50.57	1.05	1.02	14.21	14.76	23.43	23.08	12.73	12.55	15.16	14.94
A Crops sequences	W-S-M	1.17	1.19	56.04	55.09	1.28	1.23	11.89	12.35	25.58	25.15	13.90	13.67	16.55	16.27
	SB-S-M	1.15	1.18	56.51	55.66	1.30	1.26	11.52	11.98	25.80	25.41	14.02	13.81	16.69	16.44
	F-S-M	1.14	1.16	57.08	56.23	1.33	1.28	11.15	11.64	26.06	25.67	14.16	13.95	16.86	16.61
	F	109.00*	51.06*	182.02*	165.39*	237.53*	333.24*	62.06*	56.63*	202.13*	167.09*	188.43*	154.37*	189.26*	166.57*
	LSD 5%	0.01	0.01	0.23	0.27	0.01	0.01	0.29	0.29	0.10	0.12	0.06	0.07	0.07	0.08
B Nitrogen fertilizer	N1	1.18	1.20	55.47	54.72	1.25	1.21	12.80	13.34	25.32	24.98	13.76	13.58	16.38	16.16
	N2	1.17	1.18	55.97	55.47	1.27	1.25	11.69	12.16	25.55	25.32	13.89	13.76	16.53	16.38
	N3	1.14	1.17	56.98	55.97	1.32	1.27	11.14	11.65	26.01	25.55	14.14	13.89	16.83	16.53
	N4	1.12	1.15	57.74	56.48	1.37	1.30	10.46	10.81	26.36	25.78	14.32	14.01	17.05	16.68
	F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	LSD 5%														
AB	F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	LSD 5%														

Table (3): Effect of preceding winter crops, relay cropping, intercropping system and nitrogen fertilizer rates on some soil physical properties in the second year (2007).

Treatments		Bulk density Db, g/cm3		Total porosity (E, %)		Void ratio (e)		Settling, %		Pore size distribution as a percent of total porosity					
										>9 µ		9-0.2 µ		<0.2 µ	
Crops sequences	Nitrogen fertilizer	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm
Wheat-Sunflower-Maize (W-S-M)	N1	1.18	1.21	55.47	54.34	1.25	1.19	12.32	12.52	25.32	24.81	13.76	13.48	16.38	16.05
	N2	1.17	1.19	55.85	55.09	1.26	1.23	11.47	11.81	25.50	25.15	13.86	13.67	16.50	16.27
	N3	1.15	1.16	56.60	56.23	1.30	1.28	10.88	11.33	25.84	25.67	14.04	13.95	16.72	16.61
	N4	1.12	1.15	57.74	56.60	1.37	1.30	10.23	10.58	26.36	25.84	14.32	14.04	17.05	16.72
Sugar beet-Sunflower-Maize (SB-S-M)	N1	1.17	1.19	55.85	55.09	1.26	1.23	12.07	12.28	25.50	25.15	13.86	13.67	16.50	16.27
	N2	1.15	1.17	56.60	55.85	1.30	1.26	11.00	11.65	25.84	25.50	14.04	13.86	16.72	16.50
	N3	1.13	1.15	57.36	56.60	1.35	1.30	10.68	11.19	26.19	25.84	14.23	14.04	16.94	16.72
	N4	1.10	1.14	58.49	56.98	1.41	1.32	9.87	10.29	26.70	26.01	14.51	14.14	17.28	16.83
Faba bean-Sunflower-Maize (F-S-M)	N1	1.15	1.16	56.60	56.23	1.30	1.28	11.68	11.91	25.84	25.67	14.04	13.95	16.72	16.61
	N2	1.13	1.15	57.36	56.60	1.35	1.30	10.89	11.44	26.19	25.84	14.23	14.04	16.94	16.72
	N3	1.12	1.13	57.74	57.36	1.37	1.35	10.47	10.92	26.36	26.19	14.32	14.23	17.05	16.94
	N4	1.10	1.12	58.49	57.74	1.41	1.37	9.54	9.87	26.70	26.36	14.51	14.32	17.28	17.05
Control		1.27	1.30	52.08	50.94	1.09	1.04	13.13	13.45	23.77	23.26	12.92	12.64	15.38	15.05
A Crops sequences	W-S-M	1.16	1.18	56.42	55.57	1.30	1.25	11.23	11.56	25.75	25.37	14.00	13.79	16.66	16.41
	SB-S-M	1.14	1.16	57.08	56.13	1.33	1.28	10.91	11.35	26.06	25.63	14.16	13.93	16.86	16.58
	F-S-M	1.13	1.14	57.55	56.98	1.36	1.33	10.65	11.04	26.27	26.01	14.28	14.14	17.00	16.83
	F	461.20*	70.95*	212.74*	182.74*	232.75*	222.94*	86.72*	84.45*	203.82*	191.79*	223.70*	197.72*	190.63*	202.67*
	LSD 5%	0.00	0.01	0.24	0.32	0.01	0.02	0.19	0.18	0.11	0.14	0.06	0.08	0.07	0.09
B Nitrogen fertilizer	N1	1.17	1.19	55.97	55.22	1.27	1.23	12.02	12.24	25.55	25.21	13.89	13.70	16.53	16.31
	N2	1.15	1.17	56.60	55.85	1.30	1.27	11.12	11.63	25.84	25.50	14.04	13.86	16.72	16.50
	N3	1.13	1.15	57.23	56.73	1.34	1.31	10.68	11.15	26.13	25.90	14.20	14.08	16.90	16.76
	N4	1.11	1.14	58.24	57.11	1.39	1.33	9.88	10.25	26.59	26.07	14.45	14.17	17.20	16.87
	F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	LSD 5%														
AB	F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	LSD 5%														

Table (4): Effect of preceding winter crops, relay cropping, intercropping system and nitrogen fertilizer rates on some soil hydrophysical properties in the first year (2006).

Treatments		Hydraulic conductivity (Kh, cm/hr)		Soil moisture content (Θw, %) Just before harvesting		Soil moisture characters %						Available water (AW, %)		Water Consu-mption (CU, cm)	Water use efficiency (WUE, Kg fed^{-1} cm^{-1})	Maize grain, Kg/fed
						Saturation percentage (SP)		Field capacity (FC)		Wilting point (WP)						
Crops sequences	Nitrogen fertilizer	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm			
Wheat-Sunflower-Maize (W-S-M)	N1	0.61	0.58	17.38	21.13	74.44	72.38	40.46	39.34	21.99	21.38	18.47	17.96	66.31	49.09	3255.00
	N2	0.66	0.61	17.80	21.50	75.29	73.52	40.92	39.96	22.24	21.72	18.68	18.24	66.49	50.11	3332.00
	N3	0.67	0.62	18.38	21.86	76.78	74.47	41.73	40.47	22.68	22.00	19.05	18.48	67.23	50.91	3423.00
	N4	0.68	0.64	19.19	22.01	77.98	75.36	42.38	40.96	23.03	22.26	19.35	18.70	67.48	51.24	3458.00
Sugar beet-Sunflower-Maize (SB-S-M)	N1	0.63	0.60	17.56	21.27	74.84	72.82	40.67	39.58	22.11	21.51	18.57	18.07	59.24	50.55	2994.60
	N2	0.67	0.62	17.92	21.67	75.61	73.78	41.09	40.10	22.33	21.79	18.76	18.31	59.57	50.79	3025.40
	N3	0.68	0.63	18.62	21.93	77.14	74.82	41.92	40.66	22.78	22.10	19.14	18.56	60.32	52.24	3151.40
	N4	0.70	0.66	19.45	22.16	78.18	75.56	42.49	41.07	23.09	22.32	19.40	18.75	60.52	53.23	3221.40
Faba bean - Sunflower-Maize (F-S-M)	N1	0.65	0.61	17.69	21.41	75.09	73.19	40.81	39.78	22.18	21.62	18.63	18.16	56.78	59.99	3406.20
	N2	0.69	0.63	18.25	21.77	76.15	74.22	41.39	40.34	22.49	21.92	18.89	18.41	57.24	60.34	3453.80
	N3	0.70	0.65	18.87	21.96	77.48	75.13	42.11	40.83	22.89	22.19	19.22	18.64	57.81	60.76	3512.60
	N4	0.72	0.67	19.71	22.36	78.61	75.83	42.72	41.21	23.22	22.40	19.50	18.81	58.00	60.88	3530.80
Control		0.59	0.55	16.42	19.35	73.52	71.38	39.53	38.58	21.25	21.08	18.28	17.50			
A Crops sequences	W-S-M	0.66	0.61	18.19	21.63	76.12	73.93	41.37	40.18	22.48	21.84	18.89	18.34	66.88	50.34	3367.00
	SB-S-M	0.67	0.63	18.39	21.76	76.44	74.25	41.54	40.35	22.58	21.93	18.97	18.42	59.91	51.70	3098.20
	F-S-M	0.69	0.64	18.63	21.88	76.83	74.59	41.76	40.54	22.69	22.03	19.06	18.51	57.46	60.49	3475.85
	F	8.46*	217.75*	112.51*	164.98*	207.33*	185.42*	200.93*	203.94*	193.02*	186.25*	184.57*	195.10*	7144.26*	7280.48*	7255.17*
	LSD 5%	0.04	0.01	0.13	0.06	0.15	0.15	0.08	0.08	0.05	0.04	0.04	0.04	0.35	0.39	13.89
B Nitrogen fertilizer	N1	0.63	0.60	17.54	21.27	74.79	72.80	40.65	39.56	22.09	21.50	18.56	18.06	60.78	53.21	3218.60
	N2	0.67	0.62	17.99	21.65	75.68	73.84	41.13	40.13	22.35	21.81	18.78	18.32	61.10	53.75	3270.40
	N3	0.68	0.63	18.62	21.92	77.13	74.81	41.92	40.66	22.78	22.10	19.14	18.56	61.79	54.64	3362.33
	N4	0.70	0.66	19.45	22.18	78.26	75.58	42.53	41.08	23.11	22.32	19.42	18.75	62.00	55.12	3403.40
	F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	303.47*	546.59*	1508.74*
	LSD 5%													0.17	0.15	9.77
AB	F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	5.10*	113.27*	58.28*
	LSD 5%													0.22	0.20	13.01

Table (5): Effect of preceding winter crops, relay cropping, intercropping system and nitrogen fertilizer rates on some soil hydrophysical properties in the second year (2007).

Treatments		Hydraulic conductivity (Kh, cm/hr)		Soil moisture content (Θw, %) Just before harvesting		Soil moisture characters %						Available water (AW, %)		Water Consu-mption (CU, cm)	Water use efficiency (WUE, Kg fed^{-1}cm^{-1})	Maize grain, Kg/fed
Crops sequences	Nitrogen fertilizer					Saturation percentage (SP)		Field capacity (FC)		Wilting point (WP)						
		0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm			
Wheat-Sunflower-Maize (W-S-M)	N1	0.65	0.61	23.06	24.73	75.59	73.18	41.08	39.77	22.33	21.62	18.75	18.16	64.07	49.08	3144.40
	N2	0.70	0.64	23.43	24.94	76.40	74.35	41.52	40.41	22.57	21.96	18.96	18.45	64.29	49.80	3201.80
	N3	0.72	0.65	23.62	25.10	77.24	75.25	41.98	40.90	22.81	22.23	19.16	18.67	64.38	50.84	3273.20
	N4	0.73	0.67	23.88	25.49	78.26	76.06	42.53	41.34	23.12	22.47	19.42	18.87	65.17	50.44	3287.20
Sugar beet-Sunflower-Maize (SB-S-M)	N1	0.67	0.63	23.29	24.81	75.83	73.32	41.21	39.85	22.40	21.66	18.81	18.19	58.38	48.59	2836.40
	N2	0.71	0.65	23.57	24.98	76.72	74.68	41.70	40.59	22.66	22.06	19.03	18.53	58.74	49.17	2888.20
	N3	0.73	0.66	23.74	25.28	77.56	75.64	42.15	41.11	22.91	22.34	19.24	18.77	59.25	51.35	3042.20
	N4	0.74	0.69	24.08	25.66	78.47	76.23	42.65	41.43	23.18	22.52	19.47	18.91	59.98	53.92	3234.00
Faba bean-Sunflower-Maize (F-S-M)	N1	0.69	0.64	23.36	24.84	76.24	73.84	41.43	40.13	22.52	21.81	18.92	18.32	54.43	62.35	3393.60
	N2	0.72	0.66	23.62	25.02	77.08	74.91	41.89	40.71	22.77	22.13	19.12	18.59	55.00	62.57	3441.20
	N3	0.75	0.68	23.85	25.40	77.91	75.87	42.34	41.23	23.01	22.41	19.33	18.82	55.31	62.80	3473.40
	N4	0.76	0.71	24.22	25.78	78.95	76.45	42.91	41.55	23.32	22.58	19.59	18.97	55.69	63.02	3509.80
Control		0.62	0.58	19.54	21.02	74.86	72.14	40.25	38.99	21.64	21.31	18.61	17.69			
A Crops sequences	W-S-M	0.70	0.64	23.50	25.07	76.87	74.71	41.78	40.60	22.71	22.07	19.07	18.54	64.48	50.04	3226.65
	SB-S-M	0.71	0.66	23.67	25.18	77.15	74.97	41.93	40.74	22.79	22.14	19.14	18.60	59.09	50.75	3000.20
	F-S-M	0.73	0.67	23.76	25.26	77.55	75.27	42.14	40.91	22.90	22.23	19.24	18.67	55.11	62.68	3454.50
	F	141.14*	323.99*	166.32*	174.54*	179.22*	182.96*	179.18*	202.11*	233.76*	218.44*	148.77*	171.01*	7034.00*	3114.90*	2978.15*
	LSD 5%	0.01	0.00	0.06	0.05	0.15	0.13	0.08	0.07	0.04	0.03	0.04	0.03	0.33	0.76	25.33
B Nitrogen fertilizer	N1	0.67	0.63	23.24	24.79	75.89	73.45	41.24	39.92	22.41	21.69	18.83	18.22	58.96	53.34	3124.80
	N2	0.71	0.65	23.54	24.98	76.73	74.65	41.70	40.57	22.66	22.05	19.04	18.52	59.34	53.85	3177.07
	N3	0.73	0.66	23.74	25.26	77.57	75.59	42.16	41.08	22.91	22.33	19.25	18.75	59.65	55.00	3262.93
	N4	0.74	0.69	24.06	25.64	78.56	76.25	42.70	41.44	23.20	22.52	19.49	18.92	60.28	55.79	3343.67
	F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	277.66*	36.93*	90.63*
	LSD 5%													0.17	0.77	45.53
AB	F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	10.68*	18.09*	17.79*
	LSD 5%													0.22	1.03	60.65

Table (8): Effect of different treatments on total nitrogen, organic carbon and C/N ratio in the first and second years.

Treatments		First year (2006)						Second year (2007)					
Crops sequences	Nitrogen fertilizer	Total N, %		OC, %		C/N ratio		Total N, %		OC, %		C/N ratio	
		0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm
Wheat- Sunflower-Maize (W-S-M)	N1	0.127	0.108	1.504	1.255	11.84	11.62	0.129	0.112	1.538	1.284	11.92	11.46
	N2	0.128	0.109	1.513	1.259	11.82	11.55	0.132	0.113	1.543	1.289	11.69	11.41
	N3	0.129	0.110	1.517	1.264	11.76	11.49	0.134	0.114	1.551	1.297	11.57	11.38
	N4	0.130	0.111	1.525	1.268	11.73	11.42	0.135	0.115	1.562	1.305	11.57	11.35
Sugar beet-Sunflower-Maize (SB-S-M)	N1	0.131	0.113	1.502	1.252	11.47	11.08	0.137	0.116	1.535	1.282	11.20	11.05
	N2	0.132	0.115	1.511	1.257	11.45	10.93	0.138	0.118	1.542	1.286	11.17	10.90
	N3	0.133	0.116	1.515	1.262	11.39	10.88	0.139	0.120	1.549	1.295	11.14	10.79
	N4	0.135	0.119	1.522	1.267	11.27	10.65	0.143	0.122	1.559	1.302	10.90	10.67
Faba bean - Sunflower- Maize (F-S-M)	N1	0.138	0.120	1.507	1.256	10.92	10.47	0.145	0.124	1.541	1.285	10.63	10.36
	N2	0.140	0.122	1.514	1.261	10.81	10.34	0.147	0.126	1.546	1.291	10.52	10.25
	N3	0.142	0.125	1.519	1.274	10.70	10.19	0.149	0.127	1.555	1.298	10.44	10.22
	N4	0.145	0.127	1.526	1.271	10.52	10.01	0.150	0.130	1.565	1.308	10.43	10.06
Control		0.118	0.105	1.494	1.237	12.66	11.78	0.121	0.108	1.528	1.266	12.63	11.72
A Crops sequences	W-S-M	0.129	0.110	1.515	1.262	11.79	11.52	0.133	0.114	1.549	1.294	11.69	11.40
	SB-S-M	0.133	0.116	1.513	1.260	11.39	10.88	0.139	0.119	1.546	1.291	11.11	10.85
	F-S-M	0.141	0.124	1.517	1.266	10.74	10.25	0.148	0.127	1.552	1.296	10.50	10.22
	F	541.53*	512.64*	48.99*	1038.24*	5431.86*	6524.51*	749.76*	462.49*	91.80*	55.48*	5569.34*	5718.09*
	LSD 5%	0.002	0.002	0.002	0.001	0.04	0.05	0.002	0.002	0.002	0.002	0.05	0.05
B Nitrogen fertilizer	N1	0.132	0.114	1.504	1.254	11.41	11.06	0.137	0.117	1.538	1.284	11.25	10.96
	N2	0.133	0.115	1.513	1.259	11.36	10.94	0.139	0.119	1.544	1.289	11.13	10.85
	N3	0.135	0.117	1.517	1.267	11.28	10.85	0.141	0.120	1.552	1.297	11.05	10.80
	N4	0.137	0.119	1.524	1.269	11.18	10.69	0.143	0.122	1.562	1.305	10.97	10.69
	F	186.42*	385.54*	391.97*	7.72*	56.35*	130.34*	272.14*	329.23*	613.12*	1045.42*	75.53*	71.00*
	LSD 5%	0.0005	0.0005	0.002	0.011	0.06	0.06	0.0005	0.0005	0.002	0.001	0.06	0.06
AB	F	12.00*	21.61*	NS	NS	6.75*	9.14*	10.28*	13.76*	NS	NS	8.75*	6.38*
	LSD 5%	0.001	0.001			0.08	0.08	0.001	0.001			0.08	0.08

Table (9): Effect of different treatments on soil available macronutrients (ppm) in the first and second years.

Treatments		First year (2006)						Second year (2007)					
Crops sequences	Nitrogen fertilizer	N		P		K		N		P		K	
		0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm
Wheat-Sunflower-Maize (W-S-M)	N1	34.64	32.02	10.47	7.71	303.50	289.84	35.87	32.62	11.52	10.77	321.10	308.19
	N2	35.28	32.42	10.55	7.81	308.96	294.69	36.53	33.29	11.61	10.88	326.54	312.40
	N3	35.72	32.83	10.74	7.93	314.68	302.16	37.37	33.75	11.81	11.02	333.79	317.42
	N4	36.17	33.21	10.91	8.05	319.94	307.44	37.99	34.42	12.00	11.15	339.24	322.73
Sugar beet-Sunflower-Maize (SB-S-M)	N1	36.79	33.98	9.64	7.23	286.41	276.55	38.21	34.87	10.60	10.24	301.15	289.92
	N2	37.16	34.43	9.83	7.35	291.91	278.60	38.63	35.33	10.81	10.38	307.39	293.33
	N3	37.60	34.85	10.00	7.47	294.37	282.91	38.83	35.99	10.99	10.50	314.04	297.73
	N4	38.22	35.33	10.17	7.59	298.44	284.38	39.25	36.44	11.19	10.63	318.71	303.73
Faba bean-Sunflower-Maize (F-S-M)	N1	38.87	35.79	11.08	8.12	324.38	311.17	39.89	36.64	12.19	11.22	344.68	326.53
	N2	39.24	35.99	11.17	8.18	329.05	315.57	40.22	36.87	12.30	11.38	348.93	331.51
	N3	39.46	36.38	11.27	8.21	335.11	321.64	40.57	37.19	12.42	11.52	352.98	334.55
	N4	40.15	36.75	11.46	8.35	341.56	324.11	41.24	37.25	12.61	11.78	358.43	337.93
Control		34.60	31.95	9.59	7.17	281.72	273.71	35.84	32.53	10.56	10.16	295.77	285.07
A Crops sequences	W-S-M	35.45	32.62	10.67	7.88	311.77	298.53	36.94	33.52	11.74	10.96	330.17	315.18
	SB-S-M	37.44	34.65	9.91	7.41	292.78	280.61	38.73	35.65	10.90	10.44	310.32	296.18
	F-S-M	39.43	36.23	11.24	8.22	332.53	318.12	40.48	36.99	12.38	11.48	351.25	332.63
	F	543.16*	544.38*	625.06*	619.89*	643.00*	638.79*	413.38*	480.28*	662.26*	621.00*	642.05*	635.87*
	LSD 5%	0.52	0.47	0.16	0.10	4.77	4.52	0.53	0.49	0.18	0.13	4.92	4.40
B Nitrogen fertilizer	N1	36.77	33.93	10.39	7.69	304.76	292.52	37.99	34.71	11.43	10.74	322.31	308.21
	N2	37.23	34.28	10.52	7.78	309.97	296.29	38.46	35.16	11.57	10.88	327.62	312.41
	N3	37.59	34.69	10.67	7.87	314.72	302.24	38.92	35.64	11.74	11.01	333.60	316.56
	N4	38.18	35.10	10.85	8.00	319.98	305.31	39.50	36.04	11.93	11.19	338.79	321.46
	F	932.16*	820.53*	10.47*	8.86*	13.29*	11.28*	1049.71*	1011.43*	10.48*	9.23*	14.33*	9.99*
	LSD 5%	0.09	0.08	0.27	0.20	8.03	7.72	0.09	0.08	0.30	0.28	8.51	8.07
AB	F	10.43*	7.12*	NS	NS	NS	NS	62.07*	72.27*	NS	NS	NS	NS
	LSD 5%	0.12	0.11					0.12	0.11				