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Mineral Nitrogen Fertilizer and Compost Effects on Wheat and Maize Yields in Crop Sequences Including Intercropped Legumes

M.A. Abou-Keriasha and Nadia M.A. Eissa
Crop Intensification Research Department, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt.

THE EXPERIMENT was conducted at Mallawi Agric. Res. Stn. (Middle Egypt) during three years (2010/2011-2012/2013) to study mineral N fertilizer and compost effect on wheat and their residual effect on maize (second crop) in crop sequence. The experimental design was a split plot in a randomized complete blocks arrangement with three replications. The main plots were devoted to the three fertilizer treatments of wheat (100% mineral N fertilizer, 50% compost + 50% mineral N fertilizer and 25% compost + 75% mineral N fertilizer)-9, while the sub plots were allocated to the three crop sequences, *i.e.* wheat/maize (B_1), wheat + faba bean/maize + cowpea/ fahl berseem (B_2) and wheat + fahl berseem/maize+soybean (B_3). The results showed that the grain yields of wheat and maize in the two fertilizer treatments that included compost were higher than the treatment receiving 100% mineral N. The crop sequence (wheat + fahl berseem/maize + soybean (B_3)) produced the maximum value of weight of kernels/spike, weight of 1000 kernels and grain yield/fed of wheat. The crop sequence (wheat+ faba bean/maize + cowpea/clover (B_2)) produced the maximum values of weight of 100 kernels and grain yield of maize. The yield and yield components of wheat or maize to which mineral N and compost were applied were lower in the first year than those obtained with 100% mineral N, while in the second and third years the values were higher. The yield and yield components of wheat or maize were higher in the third year than in second year and also those in the second year was higher than in the first year. The crop sequence (B_2) and the application of mineral N combined with compost at both rates (A_2 & A_3) had the highest values soil available N,P,K and organic matter (OM) with values before planting. The results also show that growing wheat and maize in crop sequence with inclusion of legume intercrops (B_2 and B_3) and fertilizing with mineral N fertilizer combined with compost (A_2 or A_3) produced the highest values of intensification index and net return.

Keywords: Mineral N fertilizer, Compost, *Triticum aestivum, Zea mays,* Crop intensification .

Wheat (*Triticum aestivum* L.) and maize (*Zea mays* L.) are important, well-adapted grain crops in the world under irrigated and dry land conditions. Both crops are usually grown annually (not in rotation) or in a rotation involving both crops. In Egypt, most farmers have size holdings leading to planted the cereal

crops (wheat and maize) in double crop sequences in the same area every year (monoculture rotation) which led to decreasing the yield.

Rotations avoid yield depressions under monoculture which increase populations of microorganisms that are pathogenic and decrease population of antagonistic microorganisms in the crop root rhizosphere (Cook, 1984) and reduce production of phytoxic allelopathic chemicals and improve physical and chemical conditions of soil (Barber, 1972). Arsheal *et al*. (1998) and Dogan & Bilgili (2010) showed that grown cereal crops (wheat or maize) after legume crops produced more grain yield than those grown after non legume crops. Abou – Keriasha (1998) found that grain and straw yields of wheat grown in crop sequences maize/clover/wheat (3-crop sequence) were higher than in double crops (maize/wheat). Abd El-Hady *et al*. (2000) and Abou – Keriasha *et al*. (2012) showed that available NPK and organic matter were higher in second cycle than that of zero time and the first cycle of the crop rotation.

In cereal – legume rotation or intercropping systems, the cereal benefits from the nitrogen fixed by the legume and the decomposition of nutrient – vies biomass, root and nodules of legume which help to increase soil organic matter as well as reduces weeds population density and biomass production (Gregorich *et al.*, 2001 and Chen *et al.*, 2004). Thorstad *et al*. (2006), Abou – Keriasha *et al.* (2008) and Eskandari & Ghanbari (2010) showed that plant height, spike length, no. of grains/spike, weight of 1000 grains and straw yield/fed of wheat were increased by intercropping with faba bean or white clover compared to wheat monoculture. El Naggar *et al.* (1991) and Yilmaz *et al*. (2007) showed that cereal crops grain yield was increased or not affected by intercropping systems compared with the sole crop, but legume crops yields were decreased. Fininsa (1997) found that the reduction in intercropped maize ranged from 10 to 15%, while, this reduction in legume crops (bean or cowpea) ranged from 45 to 67% of pure stand.

Organic manures are well established to be involved in the fertilization of plants in most world countries, due to their direct and residual effect on the physical, chemical and biochemical characteristics of the soil, which in turn influence the growth and development of plants. Mahmoud (2000) showed that fertilizing the soils with compost increased the dry matter yield, grain and straw yield of sorghum. Delgado *et al*. (2002) showed that the greatest growth was obtained in mixed treatment (12000 kg/ha 'compost' + 380 kg/ha 'urea') and (8000 kg/ha 'compost' + 350 kg/ha 'urea') with 20 and 10% more mineral fertilizer, respectively.

Residual effects of manure or compost application can maintain crop yield level for several years after manure or compost application ceases since only a fraction of the N and the other nutrients in manure or compost become available to plant in the first year after application (Eghball *et al*., 2004). Drija & Kazakove (1975) indicated that the grain yield of maize and winter wheat during three years was increased by 33% from the direct and residual effect of the

application of 10 ton farm yard manure (FYM)/ha. Kapur (1995) reported that the residual effects were equivalent to 28 kg/ha of urea N/ha for sugar beet grown after corn and 22 kg/ha for sugar beet after rice, respectively. Ramamurthy & Shivashankor (1995) noted that the residual effect of application of 10 ton/ha organic manure significantly increased sunflower seed yield grown after soybean or maize plants compared with 0.0 or 5.0 ton/ha.

The purpose of this investigation was to study the effect of mineral N fertilizers, compost and legumes on wheat and maize yield in some crop sequences for the choice of proper system that will lead to increase production of wheat and maize grown in continuous crop sequences.

Materials and Methods

The experiment was conducted at Mallawi Agric. Res. Stn. {Lat. 27°43"55' N, Long. 30°50"28' E, 27 m a.s.l.} (Middle Egypt) during three years (2010/2011, 2011/2012 and 2012/2013). The main objective of this study was to compare three crop sequences and three fertilizer treatments for wheat crop. The experimental design was split plot in a randomized complete blocks arrangement with three replications. The main plots were devoted to the three fertilizer treatments which were applied to the wheat once a year, *i.e.* 100% mineral N fertilizer (A_1), 50% compost+50% mineral N (A_2) and 25% compost+75% mineral N (A_3). The sub – plots were allocated for the three crop sequences which used, wheat/maize (B_1), wheat+faba bean/maize+cowpea/fahl berseem (B_2) and wheat+fahl berseem/maize+soybean (B_3). The sub-plot area was 6.0 m length x 0.7 m width ($^1/_{100}$ fed). Wheat seeds (c.v. Giza 168) at a seed rate of 60kg/fed were sown by hand drilling in rows (20 cm between) during the second and third week of November every year. Wheat + faba bean (intercrop): four wheat rows : two faba bean rows, (80% wheat+20% faba bean). Wheat+fahl berseem : 60 kg wheat seeds + 5 kg fahl berseem seeds (100% wheat + 25% fahl berseem).

In the summer season of the three years (2011, 2012 and 2013), maize (cv. single cross 122) was grown in the same plots as the second crop (after harvested plants of wheat and intercropped crops). The maize grains (solid or intercropped) were planted during the second week of June on one side of the ridges (70 cm, width) with one plant per hill (30 x 70 cm).

Maize+cowpea (intercrop): Cowpea was planted on the other side of all maize ridges with two plants per hill, 20 cm between (100% maize+100% cowpea). Maize+soybean (intercrop): two maize ridges : two soybean ridges (50% maize+50% soybean). Soybean was planted on the two sides of the ridge with one plant per hill (20 x 70 cm). Maize and soybean plants were harvested during the second week of October, while, cowpea was cutting as fresh forage at the two month age.

Addition of mineral nitrogen fertilizer for wheat at rate 70 kg N/fed (100% recommended) in the form of ammonium nitrate (33.5%) was in three doses (at sowing time, 21 and 45 days age). While, addition of compost was at two tons per fed (recommended for cereal crops) during soil preparation (one ton per fed for 50% compost and half ton for 25% compost). Organic compost was obtained from compost El-Nile Industry (Minia) which was manufactured from field crops, vegetables and fruit plants. Chemical analysis of compost is shown in Table 1. Nitrogen fertilizer maize (second crop) was at rate 112.5 kg N/fed (75% of recommended) in three doses after thinning (21 days age) and before second and third irrigation. Calcium superphosphate (15.5% P_2O_5) was added at a rate of 30 and 45 kg P_2O_5/fed for wheat and maize, respectively, during soil preparation. Potassium sulfate (48% K_2O) at a rate of 24 and 48 kg K_2O/fed for wheat and maize, respectively.

In the winter season, of second and third years, wheat in first and second crop sequences was planted in the same plots in the second week of November (after harvest of maize plants). While, wheat in second crop sequence was planted after cutting fahl berseem (first week of December) which was planted in the last week of October. Soil samples before sowing wheat & wheat intercrops (first year) and harvesting maize & maize intercrops in the last year (third year) at 0 – 30 cm were collected from all treatments and analyzed for organic matter (OM) and available N, P, K according to Black (1965). The other normal cultural practices (irrigation, weed, pests and diseases) were practiced as recommended for each crop (wheat & maize).

At harvesting: The following data on plants were recorded as:

Wheat and intercropped

The plants of each sub plot were harvested and recorded the yield components characters of wheat (spike length, number of spikes/m^2, number of kernels/spike, weight of kernels/spike and weight of 100 kernels). Grain and seed yield of wheat, faba bean and fahl berseem were determined from sub plot area (kg/sub plot) and calculated as ardab per fed. (ardab of wheat = 150 kg and ardab of faba bean = 155 kg).

Maize and intercropped

The plants of each sub plot were harvested and recorded yield components of maize (number of ears/plant, weight of kernels/ear and weight of 100 kernels). Grain yield of maize, seed yield of soybean and forage yield of cowpea were determined from each sub plot (kg/sub plot) and calculated as ardab per fed (ardab for maize, ton for soybean seeds and forage cowpea). (Ardab of maize = 140 kg).

Farmer's benefit

Intensification index

The intensification index was calculated using the following formula:

Intensification index = (crop area/land area)

or = (number of crops grown in one year/the cultivated area) according to Shafshak & Debaby (1975).

TABLE 1. Some physical and chemical properties of soil used in the study before cultivation (0 – time) and chemical analysis of compost used in the study in the three years.

Characters	Sand %	Silt %	Clay %	Texture grade	pH (1 – 2.5)	E.C. ds/m (1 – 5)	O.M. (%)	T.C. (%)	C/N	C.E.C. (meg/100 g)	Available		
											N	P	K
Soil before planting (0 – time)	7.63	61.87	30.50	Clay loam	8.01	1.11	1.38	--	--	36.45	(ppm) 34.55	(ppm) 11.15	(ppm) 275.00
Compost	--	--	--	--	7.50 – 8.20	2.5 – 3.0	45 – 55	26.2 – 31.8	10.17 – 18.00	--	140 – 180	60 – 80	100 – 150

Economic evaluation

To calculate the net return of the three crops sequences, the following market prices with Egyptian pound (L.E.) were used: 2800 L.E./ton for wheat, 2500 L.E./ ton for maize, 3200 L.E./ton for faba bean, 1200 L.E./ton for soybean, 20 L.E./ kg seed for fahl berseem, 250 L.E./ton for green forage of both clover and cowpea, 250 L.E./ton compost and 2000 L.E./ton of urea fertilizer (Agricultural Statistics, 2010).

Total revenue = total cost + net return

Statistical analysis

The statistical analysis was carried out for both crops (wheat and maize) in each year and across the three years according to Snedecor & Cochran (1980), through MSTAT-C (1980) software and treatment means were compared by least significant differences (LSD) test at 5% level of probability.

Results and Discussion

Wheat

Effect of applying either mineral N fertilizer alone or combined with compost

Data presented in Table 2 showed that there were significant differences for most studied characters of wheat in the first, second and third years and for the combined analysis. The application of 50% compost + 50 % mineral N (A_2) produced the maximum values in the second and third years and combined years, while, the application of 100% mineral N fertilizer (A_1) produced the minimum values in the second and third years. Analysis of the combined years revealed that the values of most studied characters of wheat in the two fertilizer treatments that included compost (50% compost + 50% mineral N and 25% compost + 75% mineral N) were higher compared to 100% mineral N fertilizer (A_1). The percentage increases in the treatments A_2 and A_3 compared to A_1, were 6.2 and 4.7% for number of kernels/spike, 10.06 and 6.2% for weight of kernels/spike, 4.3 and 5.8% for weight of 1000 kernels and 3.8 and 13.6% for straw yield/fed, respectively.

In general, the mean values obtained from mineral fertilizer combined with compost (A_2 + A_3) during the first year were lower than those obtained from 100% mineral fertilizer, while in the second and third years, the means were higher than those obtained from the application of 100% mineral (A_1). The increases in the second and third years (averages of A_2 and A_3) were 7.4 and 20.3% for number of spikes/m^2, 4.2 and 7.7% for number of kernels/spike, 7.4 and 11.1% for weight of 1000 kernels and 16.4 and 20.8 % for grain yield over the first year, respectively. These results clear that the increasing of yield and yield components in the third year was higher than the second year. These increases in second and third years could be attributed to the residual effect of the application of annual compost which resulted in improvement of physical and chemical properties of soil and nutrient contents of the soil and consequently increased wheat production. Such results are in agreement with those of Eghball *et al*. (2004).

TABLE 2. Effect of application either mineral N alone or combined with compost on yield and yield components of wheat in the three years and the combined analysis.

Fertilizer treatments	Spike length (cm)	No. of spikes/m^2	No. of kernels/spike	Wt. of kernels/spike (g)	Wt. of 1000 kernels (g)	Grain yield (adrab/fad)	Straw yield (ton/fad)
	First season						
A_1	10.82	405.44	43.55	2.42	45.00	18.03	3.58
A_2	10.47	368.44	42.00	2.37	40.80	15.69	3.72
A_3	10.41	343.44	43.00	2.41	43.40	16.49	3.78
L.S.D. 0.05	1.12	10.4	0.73	N.S.	0.98	0.47	N.S.
Mean	10.56	372.44	42.85	2.40	43.06	16.73	3.69
	Second season						
A_1	10.26	429.77	42.22	2.21	42.40	18.14	3.19
A_2	11.36	389.88	44.77	2.50	45.40	19.30	3.45
A_3	9.92	375.33	43.88	2.34	45.11	18.21	3.86
L.S.D. 0.05	N.S.	28.5	1.14	0.07	0.87	0.42	N.S.
Mean	10.51	398.32	43.62	2.35	44.30	18.55	3.50
	Third season						
A_1	11.17	343.90	40.00	2.12	40.01	16.34	3.35
A_2	11.32	443.56	46.77	2.61	47.00	21.12	3.35
A_3	11.18	413.21	44.88	2.42	46.70	17.81	3.85
L.S.D. 0.05	N.S.	N.S.	0.61	0.05	1.53	0.92	N.S.
Mean	11.22	400.22	43.88	2.41	44.57	18.42	3.51
	Combined analysis						
A_1	10.75	393.03	41.92	2.25	42.57	17.50	3.37
A_2	11.05	400.62	44.51	2.49	44.40	18.70	3.50
A_3	10.50	377.32	43.92	2.39	45.07	17.50	3.83
L.S.D. 0.05	N.S.	5.38	0.67	0.03	0.83	0.37	0.28

A_1: 100% mineral N fertilizer for wheat A_2: 50% compost + 50% mineral N fertilizer for wheat A_3: 25% compost and 75% mineral N fertilizer for wheat

Effect of crop sequences

Data in Table 3 showed significant differences in most studied characters in the first, second, third years and the combined analysis. The crop sequence, wheat/maize (B_1) produced the maximum values of number of spikes/m^2, grain yield and straw yield in the first year only. The values of yield and yield components in the second and third crop sequences, wheat + faba bean/maize+ cowpea/fahl berseem (B_2) and wheat+fahl berseem/maize+ cowpea (B_3) were higher than the crop sequence, wheat/maize (B_1) in the second and third years. The increase in yield and its components in the two crop sequences (B_2 and B_3) was due to residual effects of crop sequences and inclusion of legume crops which improved soil fertilizer in the second and third year compared with the crop sequence, wheat/maize 'B_1' (Barber, 1972 and Cook, 1984).

Data in the combined analysis showed that the crop sequence, wheat + fahl berseem/maize + soybean (B_3) produced the maximum values of weight of kernels/spike, weight of 1000 kernels and grain yield/fed. While, the crop sequence, wheat + faba bean/ maize + cowpea/fahl berseem (B_2) produced the maximum values of spike length and number of kernels/spike and the minimum values of number of spikes/m^2 and grain yield/fed. The crop sequence, wheat/maize (B_1) produced the minimum values of all studied characters except number of spikes/m^2 and straw yield. The increase in the third crop sequence was estimated to be 3.0 % and 1.7% for weight of kernels/spike, 0.3 and 0.06% for weight of 1000 kernels and 2.5 and 34.7% for grain yield/fed over B_1 and B_2, respectively. The reduction of grain yield in the second crop sequence (wheat + faba been/maize + cowpea/fahl berseem) due to the plant density of wheat was 80% of solid which led to reduced number of spike/m^2 and wheat productivity. Similar results were obtained by Eskandari & Ghanbari (2010) and Abou-Keriasha *et al.* (2012).

Interaction effects

There was no significant interaction between nitrogen fertilizer (mineral N alone or combined with compost) and crop sequence for all studied characters, except for number of spike/m^2 and grain and straw yield/fed, where the effect of nitrogen fertilizer and crop sequences were generally additive (Table 4). The results show that the third crop sequence (wheat + fahl berseem/maize + cow pea) and application of 50% compost + 50% mineral N (A_2B_3) produced the maximum values of grain yield/fed, while, the first crop sequence (B_1) and application 50% compost + 50% mineral N (A_2B_1) produced the maximum values of number of spike/m^2.

TABLE 3. Effect of crop sequences on yield and yield components of wheat in the three years and the combined analysis.

Characters / Crop sequences	Spike length (cm)	No. of spikes/m^2	No. of kernels/spike	Wt. of kernels/spike (g)	Wt. of 1000 kernels (g)	Grain yield (adrab/fad)	Straw yield (ton/fad)
	First season						
B_1	10.42	396.66	42.44	2.32	43.22	18.24	4.58
B_2	10.75	328.88	43.33	2.44	43.88	14.01	3.45
B_3	10.53	391.77	42.77	2.47	42.55	17.95	3.51
L.S.D. 0.05	N.S.	13.65	0.71	0.06	N.S.	0.43	0.22
	Second season						
B_1	10.54	403.11	43.00	2.33	44.56	19.54	3.64
B_2	10.80	375.22	43.88	2.35	44.11	15.43	3.41
B_3	10.20	403.33	44.00	2.37	44.33	20.67	3.45
L.S.D. 0.05	N.S.	10.00	1.08	N.S.	N.S.	0.46	N.S.
	Third season						
B_1	10.77	418.33	43.22	2.37	44.11	19.95	3.64
B_2	11.94	381.44	45.00	2.36	44.33	14.65	3.37
B_3	10.96	414.22	43.44	2.41	45.55	20.66	3.49
L.S.D. 0.05	0.72	8.80	1.31	N.S.	N.S.	0.39	N.S.
	Combined analysis						
B_1	10.57	406.03	42.88	2.34	44.00	19.24	3.94
B_2	11.16	361.84	44.07	2.38	44.11	14.64	3.41
B_3	10.56	403.10	43.40	2.41	44.14	19.76	3.48
L.S.D. 0.05	0.33	7.83	0.69	0.04	N.S.	0.13	0.15

TABLE 4. Effect of interaction of fertilizer and crop sequences on yield and yield components of wheat (combined analysis).

Fertilizer treatments	Crop sequences	Spike length (cm)	No. of spikes/m^2	No. of kernels/spike	Wt. of kernels/spike (g)	Wt. of 1000 kernels (g)	Grain yield (adrab/fad)	Straw yield (ton/fad)
A_1	B_1	10.76	404.66	41.53	2.21	42.00	18.60	3.63
	B_2	11.75	371.85	42.43	2.30	41.77	14.30	3.07
	B_3	10.81	402.55	41.73	2.27	42.11	19.46	3.42
A_2	B_1	10.56	420.66	43.83	2.44	45.00	20.00	3.74
	B_2	10.70	365.85	45.30	2.50	45.70	15.23	3.43
	B_3	10.66	415.32	44.30	2.54	45.55	20.73	3.34
A_3	B_1	10.37	392.77	43.20	2.37	44.88	19.03	3.98
	B_2	11.04	347.77	44.40	2.36	45.55	14.40	3.76
	B_3	10.22	391.44	44.06	2.45	44.88	19.00	3.69
L.S.D. 0.05		N.S.	13.56	N.S.	N.S.	N.S.	0.23	0.18

A_1: 100% mineral N fertilizer for wheat A_2: 50% compost + 50% mineral N fertilizer for wheat A_3: 25% compost and 75% mineral N fertilizer for wheat

B_1: Wheat / maize B_2: Wheat + faba bean / maize + cowpea / fahl berseem B_3: Wheat + fahl berseem / maize + soybean

Maize

Residual effect of mineral N fertilizer alone or combined with compost

Data in Table 5 showed that maize grown after wheat which was fertilized with 100% mineral N (A_1) produced the maximum values of weight of kernels/ear and weight of 100 kernels in the first and their combined data. While maize grown after wheat which was fertilizerd with 50% compost + 50% mineral N produced the maximum values of most studied characters (number of ears/plant, weight of 100 kernels and grain yield/fed) in the second and third years. The increase in maize grown after wheat which was fertilized with 50% compost + 50% mineral N (A_2) in the three years and the combined analysis was estimated by 17.4, 7.2, 7.6 and 12.3% for number of ears/plant and 3.7, 20.2, 61.0 and 27.4% for grain yield over application of 100% mineral N fertilizer (control), respectively. Maize grown after wheat which was fertilized with 25% compost + 75% mineral N produced the minimum values in the three years in most characters. The reduction in grain yield of maize grown after wheat which was fertilized with 25% compost + 75% mineral N (A_3) may be due to the rate of N fertilizer added with 75% recommended which was not enough.

TABLE 5. Residual effect of fertilizing wheat with mineral alone or combined with compost on yield and yield components of maize in the three years and the combined analysis.

Characters / Fertilizer treatments	No. of ears/plant	Wt. of kernels/ear (g)	Wt. of 100 kernels (g)	Grain yield (adrab/fad)
	First season			
A_1	1.00	219.22	37.95	20.11
A_2	1.21	205.44	33.51	20.86
A_3	1.00	206.55	33.88	17.42
L.S.D. 0.05	0.04	4.31	2.4	1.1
Mean	1.08	210.40	35.11	19.46
	Second season			
A_1	1.10	205.00	31.44	18.60
A_2	1.18	217.88	32.00	22.37
A_3	1.11	188.88	30.66	17.63
L.S.D. 0.05	0.04	8.40	N.S.	N.S.
Mean	1.13	203.92	31.36	19.53
	Third season			
A_1	1.05	221.44	30.98	18.00
A_2	1.13	205.44	32.94	29.05
A_3	1.08	190.77	30.20	18.72
L.S.D. 0.05	N.S.	12.3	N.S.	1.5
Mean	1.08	205.84	31.37	21.94
	Combined analysis			
A_1	1.05	215.22	33.46	18.91
A_2	1.18	209.58	32.81	24.10
A_3	1.06	195.41	31.43	17.92
L.S.D. 0.05	0.03	5.5	1.16	0.76

A_1: 100% mineral N fertilizer for wheat A_2: 50% compost + 50% mineral N fertilizer for wheat
A_3: 25% compost and 75% mineral N fertilizer for wheat

Generally, the mean values of the yield and yield components of maize under application of both A_1 & A_2 in the second and third years were higher than those under application of 100% mineral fertilizer (A_1). This indicated the beneficial residual effect of compost used. Our results are in agreement with those reported by Kapur (1995), Ramamurthy & Shirashankar (1995) and Eghball *et al.* (2004).

Effect of crop sequences

Data in Table 6 showed insignificant effect of crop sequences on all studied characters of maize, except weight of kernels/ear in third year and grain yield in the first year and the combined analysis. Maize grown in the crop sequence (B_2) produced the maximum values of grain yield in first year and the combined analysis. Maize grown in the third crop sequence, wheat + fahl berseem/maize + soybean (B_3) produced the maximum values of weight of kernels/ear and the minimum values of grain yield in first year and the combined analysis. This reduction in grain yield of maize in the third crop sequence was due to the fact that plant density in maize + soybean was equal to 50% of solid. Similar results were observed by Fininsa (1997) and Abou-Keriasha *et al.* (2012).

Interaction effect

There was no significant interaction between fertilizer treatment and crop sequences for any studied characters.

TABLE 6. Effect of crop sequences on yield and yield components of maize in the three years and the combined analysis.

Characters / Crop sequences	No. of ears/plant	Wt. of kernels/ear(g)	Wt. of 100 kernels (g)	Grain yield (adrab/fad)
	First season			
B_1	1.05	207.44	35.02	19.11
B_2	1.06	209.66	35.11	20.66
B_3	1.10	214.11	35.22	18.62
L.S.D. 0.05	N.S.	N.S.	N.S.	0.8
	Second season			
B_1	1.10	201.33	30.44	20.04
B_2	1.14	201.44	32.00	19.42
B_3	1.14	209.00	31.66	19.14
L.S.D. 0.05	N.S.	N.S.	N.S.	N.S.
	Third season			
B_1	1.05	204.66	30.83	20.31
B_2	1.10	199.44	31.81	22.27
B_3	1.10	213.55	31.48	19.27
L.S.D. 0.05	N.S.	10.06	N.S.	N.S.
	Combined analysis			
B_1	1.06	204.47	32.09	19.82
B_2	1.10	203.51	32.97	20.78
B_3	1.11	212.22	32.18	19.01
L.S.D. 0.05	N.S.	N.S.	N.S.	0.71

B_1: Wheat / maize B_2: Wheat + faba bean / maize + cowpea / fahl berseem
B_3: Wheat + fahl berseem / maize + soybean

Effect of fertilizer (mineral N and compost) and crop sequence on soil available N, P and K and organic matter

Data presented in Table 7 showed that the available N, P and K contents and organic matter in soil were increased due to the applications of 50% compost + 50% mineral N (A_2) followed by the application of 25% compost + 75% mineral N (A_3), while the application of 100% mineral N (A_1) decreased these available nutrients and OM after three years compared with soil analysis before the experiment began (0 – time). The increases from the application of 50% compost + 50% mineral N were 35.02% for N, 42.14% for P, 29.83% for K and 15.32% for OM compared to mineral N alone. While, the increase resulted from the application of 25% compost + 75% mineral N was 29.2% for N, 33.19% for P, 26.55% for K and 12.92% for OM. It is clear that NPK and OM were increased with increasing rate of the compost. Increasing NPK contents and organic matter in the soil due to the application of compost might be a result of its decomposition and the production of organic acids, which increase the nutrients availability and organic matter in soil. Similar results were reported by Kapur (1995) and Ramamurthy & Shivashankav (1995).

TABLE 7. Effect of application of mineral N alone or combined with compost and crop sequences on NPK contents and organic matter (OM) levels in soil last year (third year).

Crop sequences		Available nutrients (ppm)			O.M. (%)
		N	P	K	
Before planting (0 – time)		34.55	11.15	275.0	1.38
A_1	B_1	24.65	9.05	268.0	1.23
	B_2	30.50	9.80	267.0	1.25
	B_3	30.00	10.00	279.0	1.25
	Mean	28.35	9.61	276.6	1.24
A_2	B_1	33.60	11.50	315.0	1.30
	B_2	41.75	15.80	375.0	1.55
	B_3	39.50	13.70	372.0	1.49
	Mean	38.28	13.66	354.0	1.43
A_3	B_1	34.15	10.10	305.0	1.29
	B_2	38.90	14.50	361.0	1.46
	B_3	36.80	13.80	359.0	1.45
	Mean	36.63	12.80	345.0	1.48
B_1		30.80	10.20	296.0	1.27
B_2		37.05	13.36	334.3	1.42
B_3		35.43	12.50	336.1	1.39

The data also show that soil content of NPK and organic matter were increased in the two crop sequences which include legume crops. The maximum values of soil content of available NPK and organic matter were recorded with the second crop sequence, wheat + faba bean / maize + cowpea / fahl berseem (B_2). While, the minimum values were recorded with the first crop sequence (control). This increase in N, P, K contents and OM levels in the two crop sequences which include legume crops may be due to the residual effect of interaction between the legume crops (faba bean, cowpea and fahl berseem) and

compost that improve soil fertility and macro and micro environmental factors. These observation are in agreement with Thorsted *et al*. (2006).

Farmer's benefit

Effect of fertilizer (mineral and compost) and crop sequence effect on intensification index

Data in Table 8 show that fertilizer treatments had a small effect on intensification index. However, the intensification index for treatments including compost (A_2 and A_3) were higher than for the application of 100% mineral N. The intensification in the second and third crop sequences (B_2 and B_3) was increased by 37.0 and 30.0%, respectively, compared to the control. The maximum value of intensification index (2.81) was recorded by the second crop sequence (3-crop sequence) with application of 50% compost + 50% mineral N or 100% mineral N.

TABLE 8. Effect of application (mineral N alone or combined with compost) and crop sequences on intensification index and average of net return x 1000.

Fertilizer treatments	Crop sequences	Intensification index	Economic evaluation (L.E.)		
			Total revenue	Total cost	Net return
A_1	B_1	2.00	14.609	7.407	7.200
	B_2	2.81	18.944	7.617	11.330
	B_3	2.54	16.480	7.562	8.930
	Mean	2.45	16.680	7.530	9.150
A_2	B_1	2.00	16.780	7.407	9.370
	B_2	2.81	21.172	7.617	13.689
	B_3	2.63	18.689	7.562	11.280
	Mean	2.48	18.880	7.530	11.440
A_3	B_1	2.00	14.180	7.407	6.770
	B_2	2.60	18.656	7.617	11.04
	B_3	2.63	16.393	7.562	8.830
	Mean	2.47	16.410	7.562	8.880
B_1		2.00	15.190	7.407	7.780
B_2		2.74	19.590	7.617	12.020
B_3		2.60	17.187	7.617	9.680

A_1: 100% mineral N fertilizer for wheat
A_2: 50% compost + 50% mineral N fertilizer for wheat
A_3: 25% compost and 75% mineral N fertilizer for wheat
B_1: Wheat / maize
B_2: Wheat + faba bean / maize + cowpea / fahl berseem
B_3: Wheat + fahl berseem / maize + soybean

Effect of fertilizer (mineral N and compost) and crop sequence on the average of net return (combined analysis of the three years).

Data in Table 8 revealed that the application of 50% compost + 50% mineral N recorded the maximum values of total revenue and net return, while the application of 25% compost + 75% mineral N recorded the minimum values. The increase in the application of 50% compost + 50% mineral N was 13.19 and 25.03% for total revenue and net return over the application of 100% mineral N.

While for the application of 25% compost + 75% mineral N, total revenue and net return were reduced by 1.6 and 2.9% as compared the application of 100% mineral, respectively.

Data also show that the values of total revenue and net return were increased in the second and third crop sequences (B_2 and B_3) as compared to the first crop sequence (B_1). These increases in the second crop sequences were 28.96 and 54.49%, while, the increase in the third crop sequence were 13.15 and 24.42% over the first crop sequence (B_1), respectively. Similar results were reported by Abou – Keriasha *et al.* (2012).

Finally, the results indicated that the crop sequences which include legume crops and use mineral N fertilizer combined with compost led to increase in soil N, P, K and OM contents thereby enhancing soil fertility and increased the production of wheat and maize grown in continuous crop sequences.

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تأثير التسميد المعدنى والعضوى على القمح والذرة الشامية فى تعاقبات تضم محاصيل بقولية محملة

محمد أبو العيون مصطفى أبوكريشة و نادية محمد أحمد عيسى
قسم بحوث التكثيف المحصولى – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية – الجيزة - مصر .

نفذت التجربة بمحطة بحوث ملوى (مصر الوسطى) خلال ثلاث سنوات متتالية لدراسة تأثير التسميد العضوى والمعدنى المضاف لمحصول القمح على محصول القمح والمحصول التالى (الذرة الشامية). الثلاثة تعاقبات التى أستخدمت هى قمح/ذرة شامية، قمح+فول بلدى/ذرة شامية+لوبيا علف/برسيم فحل، قمح+برسيم فحل/ذرة شامية+فول صويا. إستخدم تصميم القطع المنشقة مرة واحدة ولقد وضعت معاملات االتسميد الثلاثة (معدنى ١٠٠% ، ٥٠% عضوى + ٥٠% معدنى ، ٢٥% عضوى + ٧٥% معدنى) فى القطع الرئيسية ووزعت الثلاثة تعاقبات على القطع الشقية فى ثلاث مكررات.

النتائج توضح أن محصول القمح والذرة الشامية كان عاليا عند إستخدام التسميد المعدنى المخلوط مع العضوى (٥٠% عضوى + ٥٠% معدنى ، ٢٥% عضوى + ٧٥% معدنى). متوسط المعاملات المسمدة معدنى مع عضوى فى السنة الأولى كان منخفضا عن التى سمدت بالمعدنى فقط لكن فى العام الثانى والثالث كانت المعدلات عالية مع التسميد العضوى مع المعدنى عن التى تم تسميدها معدنى فقط.

التعاقب المحصولى الثالث (قمح + برسيم فحل/ ذرة شامية + فول صويا) أعطت قيم أعلى لكل من وزن حبوب السنبلة ووزن الـ ١٠٠٠ حبة ومحصول الفدان للقمح. أما التعاقب الثانى (قمح + فول بلدى/ ذرة شامية + لوبيا علف/ برسيم فحل) أعطت قيم أعلى لكل من وزن الـ ١٠٠ حبة ومحصول الفدان للذرة الشامية.

متوسط الصفات لمحصولى القمح والذرة الشامية عندما تم التسميد بمخلوط السماد العضوى والمعدنى (B_2 , B_3) أعطت فى العام الأول قيم أقل من التى سمدت بمعدل ١٠٠% معدنى ولكن فى العام الثانى والثالث أعطت قيم أعلى من التى سمدت بمعدل ١٠٠% معدنى.

المحصول ومكوناته لمحصولى القمح والذرة الشامية كانت عالية فى السنة الثالثة عن السنة الثانية وأيضا كان عاليا فى السنة الثانية عن السنة الأولى.

التعاقب الثانى (B_2) مع التسميد بمخلوط المعدنى مع العضوى (٥٠% عضوى + ٥٠% معدنى ، ٢٥ % عضوى + ٧٥% معدنى) أعطت قيم أعلى من محتوى التربة N, P, K والمادة العضوية عن المعاملات الأخرى.

النتائج توضح أخيرا أن زراعة القمح والذرة الشامية فى تعاقب محتوى على محاصيل بقولية مع إستخدام تسميد عضوى مع المعدنى أعطى زيادة فى معدل التكثيف والعائد النقدى للمزارع.