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Impact of Green Manure, Mineral and Bio Fertilizers on Soil Fertility, Onion-maize Productivity and N-use Efficiency

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SOIL fertility was and still one of the most important factors controlling the productivity of crops. A field experiment was conducted at Sakha Agricultural Research Station, Egypt to assess the effect of green manure, bio-N fertilizer and mineral nitrogen fertilizer on some soil properties, mineral nitrogen fertilizer efficiency (i.e., N-use efficiency) and yield of onion (in winter season 2015/2016) following by maize (in summer 2016). Treatments included bio-N-fertilizers, mineral nitrogen fertilizer and green manure. The results showed that using all green manures (i.e., Egyptian clover and fenugreek) before planting onion significantly developed soil properties; increased availability of the studied nutrients and total porosity. Inoculations with bio-fertilizer maximize these effects on soil properties and yield of onion and maize. Interaction between fenugreek with bio-fertilizer and mineral N-fertilizer at 120 kg fed^{-1} attained the highest values of total onion yield, averages of bulb weight, diameter, dry matter content and nutrients-uptake of NPK in the first season after green manure application. After cultivation of maize, the highest values of grain and dry stalks yields, 100-grain weight and NPK-uptake were obtained with the interaction of Egyptian clover with bio-fertilizer and N-fertilizer at 90 kg fed^{-1}. The use of Egyptian clover as green manure with bio-fertilizer increased N-use efficiency for onion at 60 kg N fed^{-1} and for maize grain yield was at 120 kg N fed^{-1}. So, the study concluded importance of using green manures to improve soil properties and use efficiency of mineral nitrogen fertilizer**.**

Keywords: Green manures, Soil properties, Nitrogen fertilizer efficiency, Onion and maize yield.

Introduction

Nitrogen is an important component in plant cells of several structural, genetic and metabolic compounds such as proteins, nucleic acids and photosynthesis. It takes up by plant as NH_4^+ and NO_3^- (Leghari et al., 2016). Nitrogen is added to soil by numerous ways; biological fixation by microorganisms, organic manures, crop residues and mineral nitrogen fertilizers. On the other hand, nitrogen can be lost from the soil through fewer ways like leaching, immobilization, denitrification, volatilization, erosion and adsorption on clay colloids **(Hofman and Cleemput 2004).** Also, nitrogen and other nutrients removed and depleted from the soil by consequence crops harvest.

Depletion or diminishing soil fertility especially of nitrogen could be recovered by addition of mineral fertilizers, which production requires a large amount of fossil fuel and energy (Haber-Bosch process). Nowadays the price of mineral nitrogen fertilizer is very high and causes serious risks for the environment (El-Ghinbihi and Ali, 2001). Rationalize the use of mineral nitrogen fertilizers, conserving and improving soil fertility and plant production are considering important global goals. Accordingly, the search about other fertilizers sources to recover plant demands become necessary requirement for building soil fertility and attains sustainability of plant production. Green manure has received renewed attention with emphasis on long term sustainability of agriculture system because it can be used as a source of soil nutrients and alternative to maintenance of soil fertility (Isah et al., 2014).

Green manure is known as any crop grown and plowed under green to improve the condition of the soil is called green manure, whereas such crops are used in addition to a regular rotation and

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occupy the land for only a part of the season, they are known as "cash" crops. Also, green manure use to keep soil from wearing out (Ali et al., 2008; Hasaneen et al., 2009). Green manures may either be obtained from quick growing green manure crops grown in situ or harvested from elsewhere for incorporation into the soil **(Palm 1995).** Green manure after decomposition is supplying soil with humus that plays important roles in improving soil properties; its fertility and consequently plant growth. In general, it may be said that green manures improve poor soil because of their action on the physical, chemical, and bacteriological conditions when used leguminous crops as green manures, which may be attributed to increase soil content of nitrogen through fixed N_2 (Adediran et al., 2004; Ziblim et al., 2013).

Legumes are independent of the nitrogen in the soil if their roots have so-called nodules, or swellings, which contain bacteria. If the entire crop is turned under there is an addition of nitrogen to just the extent to which the nitrogen from the air is stored in the plants. Green manures also bring about an increase in the nitrogen content of soils by encouraging the acidities of the non-symbiotic or free-living bacteria, supplying energy so they can fix nitrogen from the atmosphere in the soil (Tejada et al., 2008).

Egyptian clover (berseem) is the most common crop, and the best known legumes and it has good effects of their use as green manures are a matter of common knowledge. It has been little used for green manure but it has advantages which will certainly make it an important green manure crop in the future; it makes a rank growth and has a deep root system which enables it to bring up food from sources not reached by many other legumes. Also, it grows best in lime rich soils and it has been claimed that its roots decay much more rapidly than those of other legumes.

Onion (*Allium cepa* L.) is one of the most popular and widely consumed vegetables in Egypt, it occupies an important position among vegetable crops due to its multifarious use as local fresh consumption, food processing and exportation; either as fresh bulbs or dehydrated. Among the nutrients required for the shallow rooted onion plants, in large amounts; N is the most essential factor in enhancing growth, bulb development, yield performance and bulb quality (Drost et al., 2002 and Woldetsadik et al., 2003).

Maize is the third food crop after rice and wheat in Egypt **(Majnoon, 2006)**. Maize yield production needs different sources of mineral fertilizers such as N which is very important elements (Khalid and Islam 2001). When nitrogen is available for plants, the yield and its quality will be increased (Sharma, 2002 and Zaremanesh et al., 2017).

The aim of this study was to assess the direct and residual impacts of green fertilization (Egyptian clover and fenugreek) with or without bio-fertilizer inoculation on soil properties, mineral nitrogen fertilizer use efficiency for two successive seasons; winter (onion crop) and summer (maize crop).

Materials and Methods

Lysimeters experiment was carried out at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, Egypt (Latitude 31° 05¯ N, and Longitude 30° 75¯ E) during winter season of 2015/2016 and summer season of 2016. Lysimeters Experiment station had an elevation of about 6 meters above the sea level. Lysimeter shape was a circular (one meter diameter * 60 cm height with filter of sand and gravels about 10 cm); each lysimeter was filled by 626 kg of clayey soil. Experiment included 72 Lysimeter; divided into 3 groups for green fertilizers; every group included 24 lysimeters.

Soil sampling and analysis

Before planting and after harvesting of each crop, soil samples (0-15, 15-30 and 30-45 cm depth) were collected. The composite samples were dried, sieved through 2 mm. The salinity was determined in the soil paste extract and some physical and chemical properties were determined according to **Page, (1982)** and as shown in Table 1 Blake and Hartge (1986).

Experimental design and treatments

The experiments were conducted in split-spilt plot design, with three replications. The main plots were devoted to three types of green manure G1 (control; without green manure), G2 (Egyptian clover *"Trifolium_elexandrinum* L.") and G3 (Fenugreek "*Trigonella foenum graecum* L."). The sub plots were devoted to two treatments of bio-N-fertilizer B1 (control, without inoculation) and B2 (inoculation by Okadeen "bio-N-fertilizer"). The sub-sub plots were arranged in four rates of mineral nitrogen fertilizers N1 (control: without addition), N2 (60 kg N fed^{-1}), N3 (90 kg N fed^{-1}) and N4 (120 kg N

TABLE 1. The mean values of some physical and chemical properties of the experimental soil before cultivation.

Properties/ Soil depth	Particle size distribution				Bulk density (kg m^{-3})	Total porosity %	Void ratio (Vr)	OM %	$CaCO_3$ %	SAR
	Sand %	Silt %	Clay %	Texture class						
0-15cm	19.20	29.94	50.86	Clayey	1.25	52.83	1.12	1.45	2.65	10.38
15-30cm	18.87	28.95	52.18	Clayey	1.33	49.81	0.99	1.28	2.32	11.25
30-45cm	21.15	28.20	50.65	Clayey	1.45	45.28	0.83	1.11	2.13	11.93

Properties Soil depth	pH (in 1:2.5 soil: water suspension), EC (in soil paste extract), soluble cations and anions (meq/L soil)										Available NPK (mg kg^{-1})		
	pH	EC dS m^{-1}	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}	N	P	K
0-15cm	7.89	3.86	8.10	4.64	26.20	0.40	N.D	2.50	19.42	17.42	32	8.1	216
15-30cm	8.12	4.72	9.92	6.06	31.80	0.50	N.D	3.5	23.56	21.22	27	7.9	186
30-45cm	8.39	5.12	10.34	6.87	35.0	0.60	N.D	4.0	25.48	23.33	24	7.9	157

fed^{-1}, i.e., 100 % of recommended dose for onion and maize; RD).

Seeds were inoculated before sowing with Okadeen bio-fertilizer (biological inoculant containing strains of *Rhizobium* "≈10^7 CFU/ml"), provided by the Unit of Bio-fertilizers Production, Microbiology Research Department, Soils, Water and Environment Research Institute, Giza, Egypt. Green fertilizer treatments; Egyptian clover and fenugreek were sowing at the first week of October 2015 and after 30 days all plants inside the plot were incorporated into the soil (0- 30 cm). Onion (Giza 20) was planted on 15th November 2015, and harvested on 20th April 2016. At the same plots with the same frequency, maize (single hybrid 10) was sown on 1st May 2016 and harvested on 5th October 2016. The other required cultural practices for every onion and maize were followed properly as recommended for the region.

N fertilizer was applied as urea form 46.5% N. Phosphorus fertilizer was applied at a rate of 300 kg fed^{-1} as single calcium superphosphate fertilizer (15.5% P_2O_5) with soil preparation. Potassium was applied at a rate of 100 kg fed^{-1} (potassium sulfate fertilizer, 48% K_2O) as one dose before sowing. Samples of soil and onion crop were taken from each treatment at harvesting for determination total bulb yield (t fed^{-1}), average bulb weight (g), bulb diameter (cm) bulb dry matter content (%) for chemical analysis. Also, samples of soil and maize crop were taken from each treatment at harvest for determination grain yield (ardab fed^{-1}) (ardab= 140 kg), straw yield (t fed^{-1}), 100-grain weight (g) and grain samples prepared for chemical analysis.

Plant analysis and nutrient uptake

The selected plants for growth and yield were used for analyzing the N, P and K content in the onion bulbs and maize grain. Samples were digested using sulfuric and perchloric acids mixture; then total N was determined using micro Kjeldahl method **(Chapman and Pratt, 1982)**. Phosphorus was determined using spectrophotometer and potassium using flame photometer. The uptake of NPK was calculated by multiplying the content (%) by dry yield. The following equations were used to calculate the fertilizer efficiency. Recovery of N fertilizer (RNF) and nitrogen use efficiency (NUE) were calculated for each treatment according to the following equations according to **Finck (1982).**

Recovery of N fertilizer (%) = [(Total N uptake from fertilizer treatment - Total N uptake from control treatment) / Quantity of N fertilizer applied]*100

N use efficiency (kg yield/kg N applied) = [(yield for N applied - yield for N control) / Quantity of N fertilizer applied]

The results were analyzed statistically according to **Gomez and Gomez (1984)** and means values were compared against least significant difference test (L.S.D.) at 5% level.

Results and Discussion

Soil characters

Soil fertility

Data in Table 2 and Fig. 1 showed that green fertilization as Egyptian clover and fenugreek had significant effect on soil content of available N, P and K. The highest soil content of available N, P and K (76.3, 27.3 and 438 mg kg^{-1}) after onion harvest was obtained at treatment of fenugreek as a green manure (G3). Green manure caused an increase of available N, P and K after onion harvesting from 27.3 mg kg^{-1} average available N before sowing to 76.3 mg kg^{-1} after onion harvesting, P from 7.97 mg kg^{-1} to 27.3 mg kg^{-1} and K from 186 mg kg^{-1} to 438 mg kg^{-1} meanwhile this treatments caused sustainable agriculture by increasing soil fertility. On the other hand, data also showed that treatment of green fertilization as Egyptian clover (G2) had superior effect on available N, P and K after harvest of maize, which recorded the highest values (56.5, 10.4 and 258 mg kg^{-1}, respectively). Inoculated plants of green manures at sowing with bio-N-fertilizer (Rhizobium) had positive effect on soil fertility, where it increased soil content of available N, P and K (as shown in Fig. 1). Also, Fig. 2 shows that increasing the application rate of mineral N-fertilizer significantly enhanced soil content of available N, P and K as compared with control N1 (without addition).

TABLE 2. Effect of green manures, Bio N- fertilizer and nitrogen fertilizer rates on available N, P and K (mg kg^{-1}) after onion and maize harvesting

Treatments			After onion			After maize		
Green manures	**Bio**	**N-rates**	**N**	**P**	**K**	**N**	**P**	**K**
G_1 (Control)	B_1	N_1	29.7	12.2	361	25.9	7.3	203
		N_2	72.5	23.5	248	31.2	7.6	210
		N_3	70.7	21.0	274	34.8	8.0	217
		N_4	68.0	14.3	345	42.7	8.7	232
	B_2	N_1	36.5	13.5	585	31.4	7.8	220
		N_2	81.5	21.8	309	35.5	8.1	230
		N_3	79.7	16.2	320	38.2	8.4	240
		N_4	77.0	16.2	438	45.7	9.2	248
Mean			64.4	17.3	360	35.7	8.1	225
G_2 (Egyptian clover)	B_1	N_1	52.7	20.3	348	36.9	8.4	230
		N_2	88.7	26.6	280	45.0	9.3	241
		N_3	78.8	25.9	361	59.2	9.9	250
		N_4	74.3	24.2	396	71.7	10.5	256
	B_2	N_1	56.3	11.5	510	39.0	9.5	244
		N_2	94.1	23.5	369	54.4	11.0	266
		N_3	83.3	20.3	429	66.9	11.6	284
		N_4	79.7	15.6	470	78.6	12.8	292
Mean			76.0	21.0	395	56.5	10.4	258
G_3 (Fenugreek)	B_1	N_1	56.3	15.5	350	33.9	7.7	216
		N_2	81.5	41.9	510	42.2	8.9	222
		N_3	77.0	38.6	442	51.5	9.3	231
		N_4	72.5	25.9	327	63.9	9.8	245
	B_2	N_1	59.0	9.5	482	35.9	8.9	234
		N_2	99.5	35.5	460	47.6	10.4	263
		N_3	87.8	32.3	465	62.2	11.0	270
		N_4	77.0	19.5	466	75.4	12.3	286
Mean			76.3	27.3	438	51.6	9.8	246
L. S.D. at 5 %:								
Green manure (G)			0.65	0.94	14.11	1.20	0.90	5.80
Biofertilizer (B)			0.48	0.69	9.27	1.15	0.96	4.09
N-rates (N)			0.56	0.79	10.73	1.20	0.21	1.33
Interaction G*B			0.82	1.20	16.11	1.60	0.66	6.50
Interaction G*N			0.96	1.37	18.59	1.85	0.55	6.75
Interaction N*B			0.79	NS	15.18	1.58	0.90	5.60
Interaction G*B*N			1.36	1.93	26.28	2.29	0.50	8.40

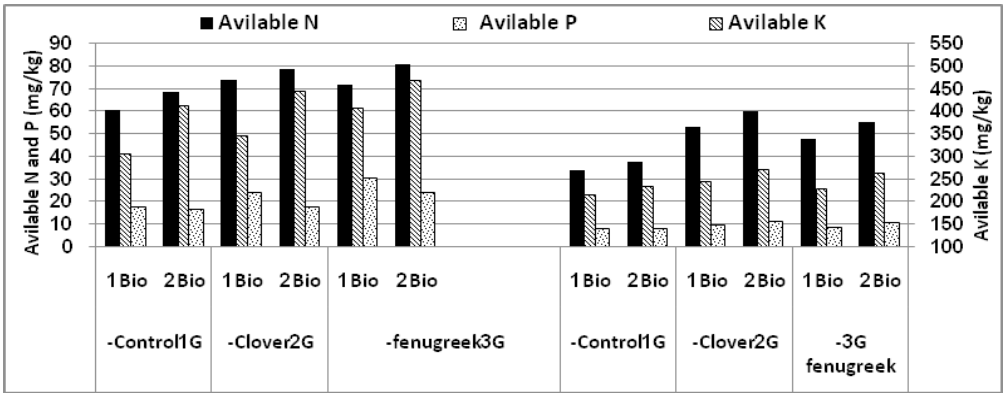

Fig. 1. Effect of green manures and bio-fertilizer on soil available NPK after harvest of onion-maize.

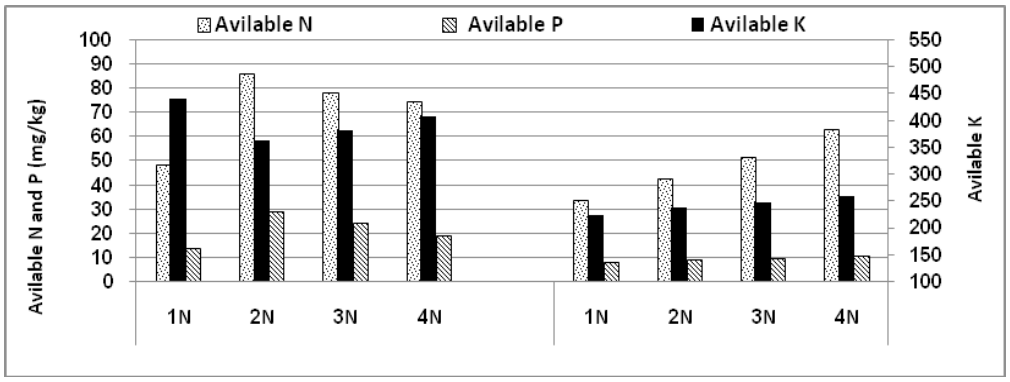

Fig. 2. Effect of mineral N-fertilizer on soil available NPK after harvest of onion-maize.

Data represented in Table 2 declared a significant effect of the interaction among green manures, biofertilizer and the rates of N fertilizer on soil content of available N, P, and K after harvest of onion and maize. The highest content of available N (99.5 mg kg^{-1}) after onion harvest was gained at the interaction of G3*B2*N2, Whereas the highest content of available P and K was recorded at the interaction between G3*B1*N2. On the other hand, the highest soil content of available N, P and K after maize harvest was obtained from the interaction between G2*B2*N4.

These results demonstrated that application of green manures with inoculation with bio-fertilizer enhanced soil content of available N, P and K, which could be attributed to improving soil with organic materials and nutrients which produced by green manures decomposition; also by fixation N_2 in roots of legumes plants (Achu et al., 2013; Adesoji et al., 2014).

In this admiration, Adesoji et al. (2014) showed that incorporation of green manure crops with N-fertilizer on maize significantly increased soil content of total N and P compared with weedy fallow. Inoculation of bio-N-fertilizer supporting plant through fixed the nitrogen (N_2) of air, and enhanced the mineralization of organic nitrogen. Also, leguminous plants form symbiotic associations with Rhizobium bacteria in order to fix N_2 so this fact causes that the green manures, which their principal component are leguminous plant debris, supply to the soil suitable amounts of N (Adediran et al. 2004, Osman 2007; Tejada et al. 2008).

Also, a significant increase that observed in available P with increasing application rate of N-fertilizer, could be attributed to the role of N in mediating the utilization of phosphorus, potassium in plant **(Abril** and **Roca 2008)**. Also, the results of available P could be attributed to high microbial activity induced by the added organic residues which speed up P-cycling (Melero et al., 2007).

Another reason is that decomposition of organic materials which released organic acids that could dissolve inorganic compounds and release the fixed of P and K **(Musandu, 1995**)

Soil EC_e, SAR, bulk density and total porosity

Data in Table 3 showed that the cultivation of green manure effectively in decrease of soil salinity (EC_e) and sodicity (SAR) than before experiment instillation in the soil (0-45 cm depth). The mean values of EC and SAR before experiment were 4.57 dsm^{-1} and 11.19, respectively. The highest reduction of EC_e values through the two growing seasons (after harvesting of onion and maize crops) were recorded under green manure G2 (Egyptian clover) as comparing with other green manure treatments G1 and G3. EC values after onion crop decreased by 5.69, 11.38 and 7.22% with G1, G2 and G3 treatments, whereas it decreased after harvesting of maize crop by 8.53, 15.97 and 12.91% as compared with EC_e before experiment, respectively. The results indicated that the decrease percentage in SAR after harvesting of onion crop were 3.66, 5.0 and 2.77 % for G1, G2 and G3 treatment, respectively. **Abdollah (2015)** found that application of green manure had significant effect on soil EC.

Data in Table 4 illustrated that the green manures before onion improved soil porosity and decreased bulk density. The lowest values of soil bulk density and the highest values of porosity were recorded with application of green manure G2 (Egyptian clover) as compared with control (without green manure) after harvesting of onion and maize. The decrease in the bulk density might be due to increase soil content of organic carbon that improves aggregation of particles (Othman et al., 2011; Yang et al., 2012).

Also, application of green manure could reduce soil bulk density and pH, as well as increase soil organic matter and soil microbes in a tobacco field (Liu et al., 2006). It is widely known that green manure and others crop residues improve the soil chemical and biological properties (Adediran et al., 2004; Biederbeck et al., 2005; Liu et al., 2006; Shahz and Rahman 2010; Ziblim et al., 2013).

Onion yield and its components

Data in Table 5 and Fig. 3 and 4 revealed that application of green manures before onion sowing significantly affected onion yield and its components. The total yield of onion increased by 9.39 and 13.48 % at the applications of green manures: Egyptian clover and fenugreek as compared with control (without green manure). Inoculation of green manures plants to bio-N-fertilizer (B2) significantly enhanced onion yield and its components where total yield increased by 3.20 % (RI) as compared with the control (B1). Also, data revealed that total yield of onion significantly increased with increasing rate of mineral N fertilizer application up to 120 kg N fed^{-1} (N4), where the RI % for the total yield was 13.09, 21.03 and 27.13% with N2, N3 and N4 as compared with N1 (without addition), respectively. Moreover, the average weight of bulb and its diameter and content of dry matter significantly responded to mineral N-fertilizer rates up to N4.

TABLE 3. Effect of green fertilization on EC_e and SAR of soil, and rate of change before experiment and after harvesting onion and maize crops.

Green fertilization	Ec_e (dSm^{-1})					SAR				
	Soil depth (cm)					Soil depth (cm)				
Treatments	0-15	15-30	30-45	mean	Rate of change (± %)	0-15	15-30	30-45	Mean	Rate of change (± %)
Before exp.	3.86	4.72	5.12	4.57	----	10.38	11.25	11.93	11.19	-----
After one season (onion crop)										
G1	3.97	4.89	5.62	4.83	5.69	10.55	11.70	12.56	11.60	3.66
G2	3.26	4.08	4.82	4.05	11.38	9.60	10.66	11.63	10.63	5.00
G3	3.49	4.28	4.96	4.24	7.22	9.88	10.96	11.79	10.88	2.77
After second season (maize crop)										
G1	4.11	4.97	5.79	4.96	8.53	10.74	11.80	12.75	11.76	5.09
G2	3.12	3.87	4.52	3.84	15.97	9.34	10.44	11.25	10.34	7.60
G3	3.32	4.16	4.46	3.98	12.91	9.64	10.81	11.14	10.53	5.90

TABLE 4. Effect of green fertilization on bulk density and total porosity of soil before experiment and after harvested onion and maize crops.

Green fertilization Treatments	Bulk density (kg m^{-3})				Total porosity (%)			
	Soil depth (cm)				Soil depth (cm)			
	0-15	15-30	30-45	mean	0-15	15-30	30-45	mean
Before exp.	1.25	1.33	1.45	1.34	52.83	49.81	45.28	49.31
After one season (onion crop)								
G1	1.23	1.32	1.43	1.32	53.58	50.19	46.04	49.94
G2	1.18	1.25	1.34	1.26	55.47	52.83	49.43	52.58
G3	1.22	1.29	1.37	1.29	53.96	51.32	48.30	51.19
After two season (maize crop)								
G1	1.22	1.30	1.41	1.31	53.96	50.94	46.79	50.56
G2	1.15	1.23	1.31	1.23	56.60	53.58	50.56	53.58
G3	1.20	1.26	1.34	1.27	54.72	52.45	49.43	52.20

TABLE 5. Effect of green manures, Bio N-fertilizer and mineral nitrogen fertilizer rates on onion yield and its components.

Treatments			Total yield of bulbs (t. fed^{-1})	*RI %	**NUE	Average bulb weight (g)	Bulb diameter (cm)	Bulb dry matter content (%)
Green manure	Bio	N-rates						
G_1	B_1	N_1	12.480	0.00	0.00	112.75	4.94	9.68
		N_2	13.627	9.19	19.1	117.11	5.25	10.21
		N_3	15.353	23.02	31.9	121.18	5.79	10.56
		N_4	16.893	35.36	36.8	130.02	6.16	11.29
	B_2	N_1	13.323	6.76	0.00	115.18	5.27	9.86
		N_2	14.113	13.09	13.2	119.25	5.92	10.57
		N_3	16.757	34.27	38.2	124.16	6.28	11.04
		N_4	17.417	39.56	34.1	132.26	6.61	11.57
Mean			14.995	0.00	--	121	5.78	10.60
G_2	B_1	N_1	14.350	14.98	0.00	116.43	4.96	9.74
		N_2	16.280	30.45	32.2	121.18	5.47	10.46
		N_3	16.980	36.06	29.2	125.80	6.26	10.92
		N_4	17.537	40.52	26.6	135.11	6.82	11.78
	B_2	N_1	13.800	10.58	0.00	121.93	5.16	10.12
		N_2	16.817	34.75	50.3	126.35	5.92	11.15
		N_3	17.353	39.05	39.5	131.77	6.88	11.67
		N_4	18.113	45.14	35.9	135.91	7.37	12.22
Mean			16.404	9.39	--	127	6.10	11.01
G_3	B_1	N_1	14.807	18.64	0.00	120.09	5.36	9.93
		N_2	16.943	35.76	35.6	125.63	5.77	10.73
		N_3	17.210	37.90	26.7	128.72	6.71	11.39
		N_4	18.157	45.49	27.9	135.95	7.85	12.37
	B_2	N_1	15.300	22.60	0.00	124.97	5.65	10.45
		N_2	17.287	38.51	33.1	132.16	6.35	11.16
		N_3	17.690	41.75	26.6	136.34	7.09	11.58
		N_4	18.747	50.21	28.7	138.21	8.09	13.12
Mean			17.018	13.48	--	130	6.61	11.34
L. S.D. at 5 %								
Green manures (G)			*0.116*	--	--	*0.10*	*0.08*	*0.15*
Biofertilizer (B)			*0.092*	--	--	*0.10*	*0.07*	*0.13*
N-rates (N)			*0.102*	--	--	*0.15*	*0.10*	*0.08*
Interaction G*B			*0.159*	--	--	*0.18*	*NS*	*NS*
Interaction G*N			*0.177*	--	--	*0.25*	*0.17*	*0.14*
Interaction N*B			*0.144*	--	--	*0.21*	*0.14*	*NS*
Interaction G*B*N			*0.250*	--	--	*0.36*	*NS*	*0.20*

*RI %: (relative increase percentage);
**NUE: nitrogen fertilizer use efficiency (kg yield/kg N applied).

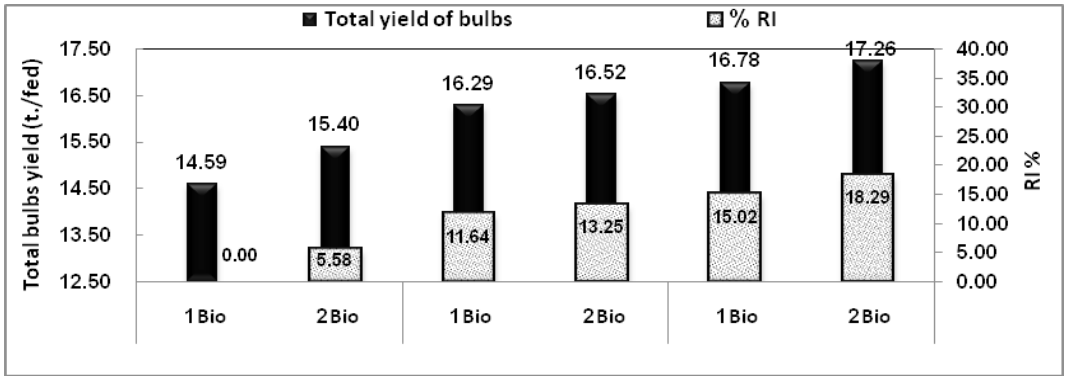

Fig. 3. Effect of green manures bio-fertilizer on onion yield and relative increase percent (RI %)

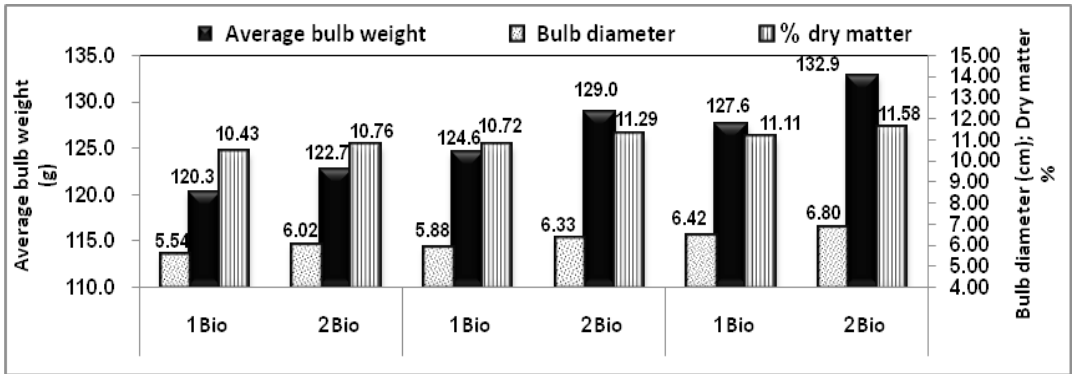

Fig. 4. Effect of green manures ± bio-fertilizer on onion yield components and dry matter %.

The interaction between green manure that inoculated by bio-N-fertilizer and N-fertilizer rates significantly affected onion yield and its components (Table 5). The highest values of total bulbs yield, average bulb weight, bulb diameter, and bulb dry matter content (17.018t.fed^{-1}, 130g, 6.61cm and 11.34%, respectively); were obtained with the interaction between green manure as a Fenugreek (G2) with inoculation by bio N-fertilizer (B2) and N fertilizer at a rate of 120 kg fed^{-1} (N4), as well as it recorded the highest RI % (50.21). These results agree with those obtained by Radwan and Hussein (2001) and Alkaff et al. (2002). In this context, the use of green manure together with adequate residue management and crop rotation is crucial to conserve or increase soil organic matter content and promote nutrient cycling at farm scale to be benefit for crops (Mazzoncini and Barberi, 2002).

Concerning to use efficiency of mineral N-fertilizer (NUE), Fig. 5 and 6 showed that the highest efficiency (32.73 kg onion/kg N-added) was obtained with N-fertilizer rate N3 (90 kg N fed^{-1}). Interaction of green manure with bio fertilizer enhanced the use of mineral N-fertilizer, where the interaction of green manure as Egyptian clover biofertilizer and N at 60 kg N fed^{-1}. (G2*B2*N2) had attained the highest values of NUE (50.28 kg onion/kg N-added). These results could be supported with those obtained by Yaso et al., (2007) who observed that increasing mineral nitrogen fertilizer levels and inoculation with bio fertilizer (Azospirillum, Azotobacter and Klebsiella) led to significant increases in average bulb weight and total bulb yield.

Also, the obtained results were agreed with those reported by Al-Moshileh (2001), Drost et al., (2002) and El-Desuki et al., (2006) who showed that the total onion bulbs yield and its components were improved as a result of increasing the level of mineral N-fertilizer. On the other hand, the enhancing effect of using the bio fertilizer might be attributed to supporting the growth of plants with available N (Al-Moshileh, 2001; Shaheen et al., 2007).

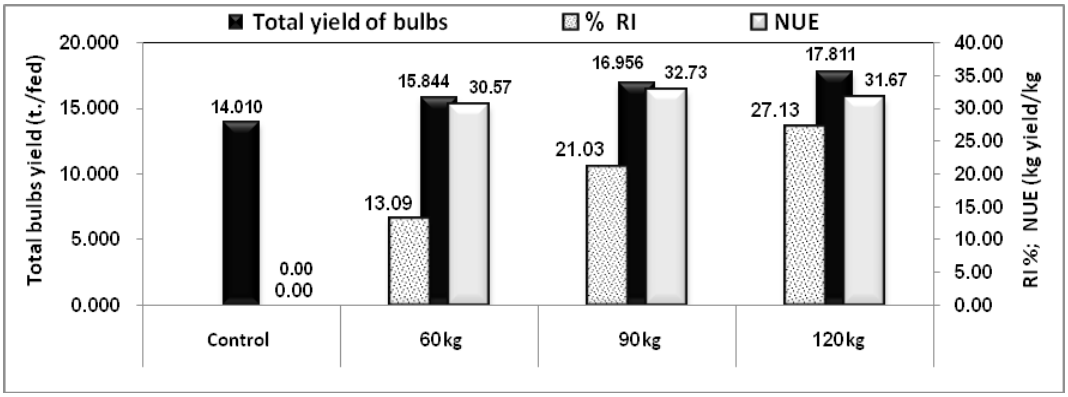

Fig. 5. Effect of mineral N-fertilizer rates on onion yield, RI% and N-use efficiency.

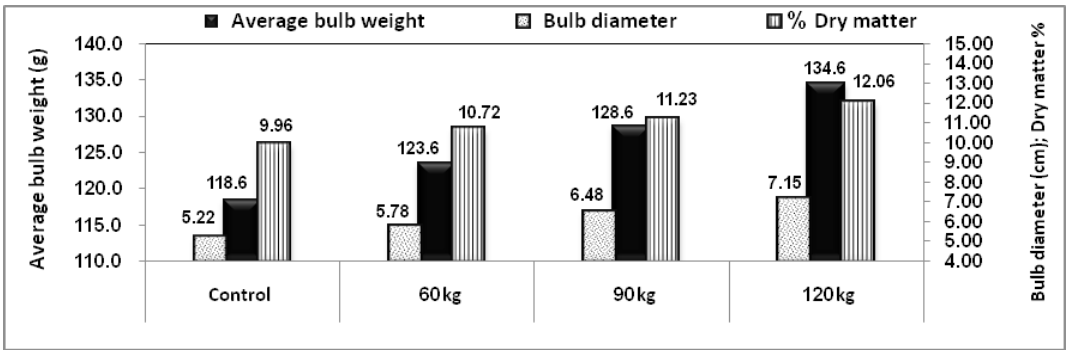

Fig. 6. Effect of mineral N-fertilizer rates on onion yield components and dry matter %

Nutrients uptake of onion (kg fed^{-1})

Data in Table 6 and Fig. 7 and 8 demonstrate that the uptake of N, P and K of onion yield significantly affected by applications of green manures, inoculation by bio-N-fertilizer and mineral N fertilizer rates; whereas treatments of G3, B2 and N4 produced the highest uptake of N, P and K. The interaction between green manure, bio-N-fertilizer and nitrogen fertilizer rates significantly affected the uptake of N, P and K, and the recovery of N fertilizer. The maximum uptake of N, P and K (51.89, 21.15 and 47.06 kg fed^{-1}, respectively) were obtained with the interaction of G3*B2*N4. Furthermore, data in the same table showed that the highest Recovery of N fertilizer (RNF) was recorded with the interaction of G3*B2*N4 (22.19%).

These results agree with **Prakash** et al. (2018) who observed that, application of inorganic fertilizer with organic manure and bio fertilizer significantly increased N, P and K content in onion bulb. The influence of N-fertilization on N, P and K content of bulb appeared to be due to improved nutritional environment both in the root zone and the plant system. Also, high nutrient content in bulbs as a result to activity of roots for longer duration under this treatment. The increase in N, P and K content in bulb were also observed by Sharma et al., (2003), Shaheen et al., (2007), Lee et al., (2015) and Mahala et al., (2018).

Maize yield and its components

Data presented in Table 7 and Fig. 9 and 10 showed that application of green manures as a residual effect for second season had significant effect on maize yield and its components. The superior in maize yield and its components were obtained with of Egyptian clover as a green manure with inoculation with bio-N-fertilizer, which recorded the highest relative increase percent (14.17%).

The results in Table 7 indicated that there is significant effect of green manure, bio fertilizer and N fertilizer rates on yield of grain, stalks and weight of 100-grain. Data show that G2 treatment gave the highest values (19.59 ardb.fed^{-1}, 3.511 ton.fed^{-1} and 38.20g) of grain, stalks and 100 grain weight, respectively as compared with

TABLE 6. Effect of green manures, Bio N-fertilizer and mineral nitrogen fertilizer rates on uptake of N, P and K (kg fed^{-1}) in onion yield

Treatments			N	*RNF (%)	P	K
Green manures	Bio	N-rates				
G_1 (Control)	B_1	N_1	14.62	0.00	2.78	9.07
		N_2	17.25	4.37	3.85	13.63
		N_3	21.40	7.53	5.13	18.91
		N_4	28.22	11.33	6.67	24.59
	B_2	N_1	17.35	0.00	4.03	11.96
		N_2	19.80	4.09	5.67	18.06
		N_3	26.90	10.61	9.44	25.54
		N_4	31.64	11.91	13.30	31.43
Mean			22.15	--	6.36	19.15
G_2 (Egyptian clover)	B_1	N_1	17.61	0.00	3.68	12.72
		N_2	25.39	12.97	5.28	20.04
		N_3	29.16	12.84	6.67	24.29
		N_4	36.43	15.69	8.06	29.96
	B_2	N_1	20.53	0.00	4.80	14.43
		N_2	30.95	17.37	7.88	27.77
		N_3	37.66	19.04	12.62	32.20
		N_4	43.37	19.04	16.59	40.06
Mean			30.14	--	8.20	25.18
G_3 (Fenugreek)	B_1	N_1	20.30	0.00	4.56	14.41
		N_2	30.55	17.09	6.49	22.00
		N_3	35.68	17.10	7.45	27.05
		N_4	44.49	20.16	9.43	36.18
	B_2	N_1	25.26	0.00	5.76	17.91
		N_2	35.31	16.75	9.45	31.90
		N_3	38.93	15.19	14.14	36.48
		N_4	51.89	22.19	21.15	47.06
Mean			35.30	--	9.80	29.12
L. S.D. at 5 %						
Green manure (G)			0.68	--	0.196	0.68
Biofertilizer (B)			0.54	--	0.189	0.37
N-rates (N)			0.47	--	0.132	0.31
Interaction G*B			0.94	--	0.328	0.63
G*N			0.81	--	0.228	0.53
N*B			0.66	--	0.187	0.43
G*B*N			1.15	--	0.323	0.75

*RNF (%): Recovery of N fertilizer.

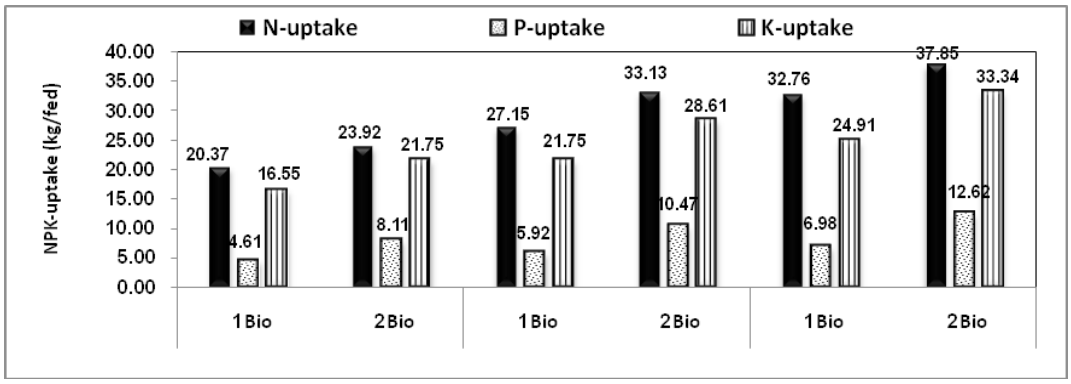

Fig. 7. Effect of green manures ± bio-fertilizer on NPK-uptake of onion (kg fed-1).

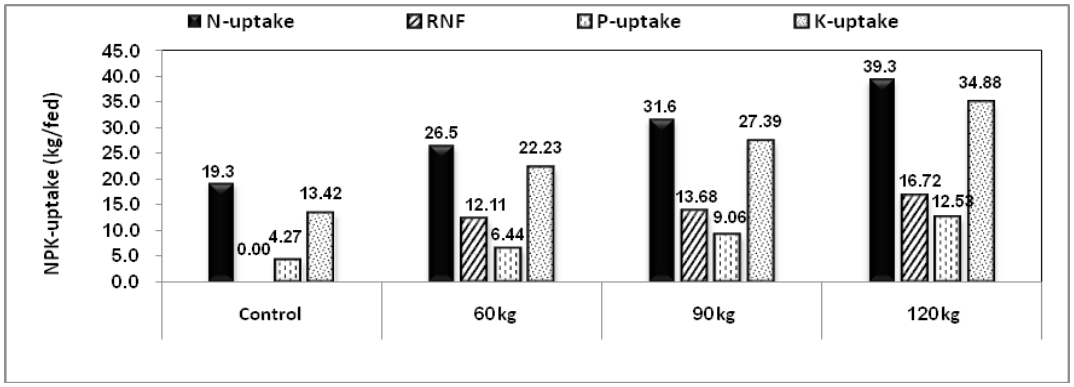

Fig. 8. Effect of N-fertilizer rates on NPK-uptake of onion (kg fed-1) and recovery of N-fertilizer.

control treatment. Also bio-fertilizer inoculation (B2) gave the highest values of grain, stalks yields and 100 grain weight (19.05, 3.404 and 37.63, respectively) as compared with without inoculation. Moreover, maize yield and its components significantly responded to mineral N-fertilizer rate up to N4 (120 kg N fed^{-1}), which had the highest values of the same previous parameters (20.91, 3.921 and 38.24, respectively) as compared with control (without N-fertilizer) which attained the lowest values of grain, stalks and 100 grain weight, respectively (Fig. 11).

Data in Table 7 revealed that interaction between treatments understudies had significant effect on grain yield and stalks yield of maize, but there is a significant effect of interaction between treatments on 100-grain weight (g). From the data it was observed that (G2*B2*N4) treatments gained the highest value of 100-grain weight (43.58 g). These results may be attributed to the increase in microorganisms activity and efficiency and its effect on reduction of soil pH by secreting organic acids and consequently more solubility and availability of nutrients for plants. Also bio fertilizer can lead to effect on plant growth through increasing the phytohormones, enzymes activity, N2-fixation (Yadava et al., 2002; Eidi et al., 2010). Also, the application of biological fertilizer increased yield by increasing plant hormones production such as IAA and GA (Senthil et al., 2009; Yazdani et al., 2009).

Nutrient uptake of maize

Data in Table 8 illustrated that the uptake of N, P and K in maize grain are is significantly affected by green manures and nitrogen fertilizer rates. The highest uptake was recorded with green fertilization treatment G2. On the other hand, the difference between treatments of bio-fertilizer for maize uptake of NPK was insignificant. However, interaction of mineral N fertilizer rates with bio-fertilizer which added with onion gained the highest values of NPK-uptake in grain **(El-Azab and El-Dewiny 2018)**. These results may be attributed to beneficial impacts of inoculation green manures with bio-fertilizer on soil content of available N, P and K as a result to increase the population of beneficial microorganisms in the soil such as mycrorhizal, phosphate dissolving

TABLE 7. Effect of green manures, Bio N-fertilizer and nitrogen fertilizer rates on maize yield and its components

Treatments			Grain yield (ardab fed^{-1})	*RI %	NUE	Dry Stalks yield (t.fed^{-1})	RI %	100-grain weight (g)
Green manures	**Bio**	**N-rates**						
		N_1	14.86	0.00	0.00	1.280	0.00	32.32
	B_1	N_2	15.75	5.94	14.7	1.833	43.23	33.19
		N_3	17.35	16.71	27.6	2.340	82.81	33.83
G_1		N_4	18.48	24.33	30.1	2.867	123.96	34.46
(Control)		N_1	16.56	11.44	0.00	1.363	6.51	33.59
	B_2	N_2	16.16	8.70	12.3	2.447	91.15	34.25
		N_3	18.22	22.61	26.7	3.117	143.49	34.97
		N_4	19.87	33.68	33.7	3.923	206.51	35.37
Mean			17.16	0.00	--	2.396	0.00	34.00
		N_1	16.97	14.20	0.00	2.117	65.36	34.83
	B_1	N_2	18.42	23.93	24.1	2.753	115.10	35.45
		N_3	19.81	33.30	31.6	3.273	155.73	36.53
G_2		N_4	21.18	42.52	35.1	3.907	205.21	38.11
(Egyptian clover)		N_1	17.45	17.40	0.00	2.847	122.40	36.85
	B_2	N_2	19.67	32.36	37.1	3.840	200.00	39.21
		N_3	20.32	36.69	31.8	4.407	244.27	41.08
		N_4	22.86	53.82	45.1	4.947	286.46	43.58
Mean			19.59	14.17	--	3.511	46.53	38.20
		N_1	16.20	8.97	0.00	1.827	42.71	34.19
	B_1	N_2	17.78	19.62	26.4	2.360	84.38	34.78
		N_3	19.08	28.35	32.0	2.897	126.30	35.27
G_3		N_4	20.94	40.91	39.6	3.530	175.78	36.66
(Fenugreek)		N_1	16.91	13.75	0.00	2.423	89.32	36.00
	B_2	N_2	18.67	25.63	29.4	3.193	149.48	37.31
		N_3	19.77	32.99	31.8	3.983	211.20	38.03
		N_4	22.14	48.96	43.6	4.353	240.10	41.27
Mean			18.94	10.37	--	3.071	28.15	36.69
L. S.D. at 5 %								
Green manure (G)			*0.254*	--	--	*0.178*	--	*0.185*
Biofertilizer (B)			*0.200*	--	--	*0.063*	--	*0.147*
N-rates (N)			*0.277*	--	--	*0.113*	--	*0.110*
Interaction G*B			*NS*	--	--	*0.110*	--	*0.254*
G*N			*0.480*	--	--	*NS*	--	*0.191*
N*B			*NS*	--	--	*0.160*	--	*0.156*
G*B*N			*NS*	--	--	*NS*	--	*0.270*

*__RI %: (relative increase percentage);__ __ardab=140 kg__

TABLE 8. Effect of green manures, Bio N-fertilizer and nitrogen fertilizer rates on uptake of N, P and K (kg fed^{-1}) in maize grain yield

Treatments			N	P	K
Green manures	**Bio**	**N-rates**			
		N_1	30.94	5.92	6.19
		N_2	29.96	6.66	6.16
	B_1	N_3	40.04	5.81	7.52
G_1		N_4	34.83	6.58	7.46
(Control)		N_1	31.55	5.20	6.78
		N_2	29.25	5.90	6.52
	B_2	N_3	33.20	7.23	8.14
		N_4	38.35	7.59	8.28
Mean			33.52	6.36	7.13
		N_1	32.17	6.99	7.43
		N_2	38.68	6.18	9.41
	B_1	N_3	43.04	7.07	9.27
G_2		N_4	46.59	8.95	8.28
(Egyptian clover)		N_1	36.67	6.84	14.75
		N_2	39.15	6.88	16.40
	B_2	N_3	53.68	9.36	13.08
		N_4	45.36	9.91	15.22
Mean			41.92	7.77	11.73
		N_1	27.60	6.30	6.19
		N_2	39.61	7.70	6.57
	B_1	N_3	50.55	8.75	7.13
G_3		N_4	40.58	9.79	6.83
(Fenugreek)		N_1	33.86	6.04	5.66
		N_2	35.38	7.35	6.40
	B_2	N_3	40.27	9.13	11.03
		N_4	45.12	9.16	12.93
Mean			39.12	8.03	7.84
L. S.D. at 5 %					
Green manure (G)			0.79	0.52	0.67
Biofertilizer (B)			NS	0.18	0.33
N-rates (N)			2.13	0.50	0.61
Interaction G*B			NS	0.31	0.57
G*N			3.69	0.87	1.06
N*B			3.01	0.71	0.87
G*B*N			5.22	NS	1.50

bacteria and fungi (Manjarrez et al., 2000; Srivastava et al., 2002).

Table 8 represented that the interaction among green manures, bio-fertilizer and N-rates on the uptake of N, P and K. Significantly effects on N-uptake were detected; the highest N uptake (53.68) was obtained with application of Egyptian clover as green manure (G2) which inoculated with bio-N-fertilizer (B2) with mineral N fertilizer at the rate of N3 (90 kg N fed^{-1}), whereas the interaction of G*B*N had insignificant effect on the uptake of P. Also, K-uptake was significantly affected by interaction with superior the interaction of G2*B2*N2. These results may be attributed to the use of green manures, it is generally accepted that the release of N and other nutrients from decomposing green manure residues may be well timed with plant uptake, possibly increasing N uptake efficiency and crop yield. Accordingly, green manures are considered an important part of farming system as they help in building soil fertility in the long term and are particularly useful when growing crops need higher demand of N (Sincik et al., 2008; Canali et al., 2010; Achu et al., 2013).

Conclusion

Results supported the hypothesis that two types of legumes plants that used as green manures, and inoculated with bio-N-fertilizer (Okadeen) along with mineral N fertilizer significantly affected soil properties and plays an important role in the production of the highest yield of onion and maize. The obtained results concluded that sowing of Egyptian clover as a green manure with bio-fertilizer inoculation before planting onion, and with nitrogen fertilizer at a rate of 90 kg fed^{-1} can be recommended to enhance soil fertility, and obtain a high yield of onion and maize with the highest use efficiency of nitrogen fertilizer.

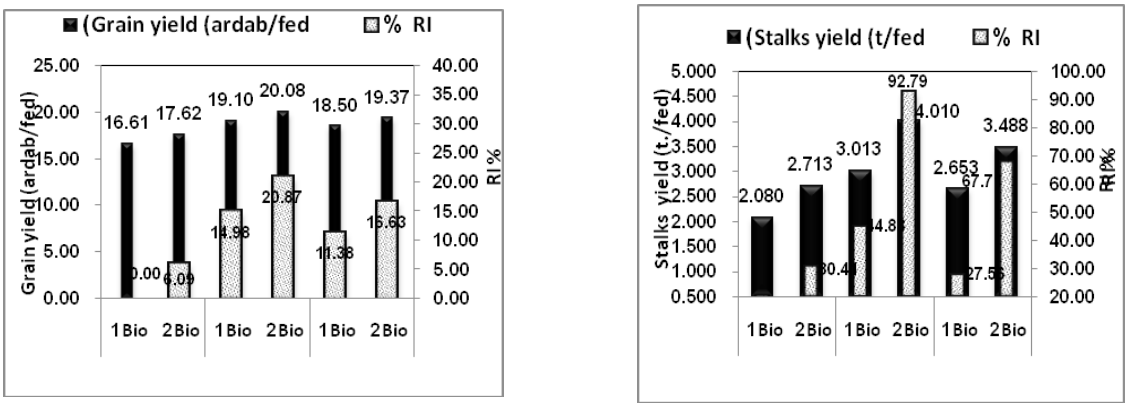

Fig. 9. Effect of green manures bio-fertilizer on maize grain and stalks yields and RI%.

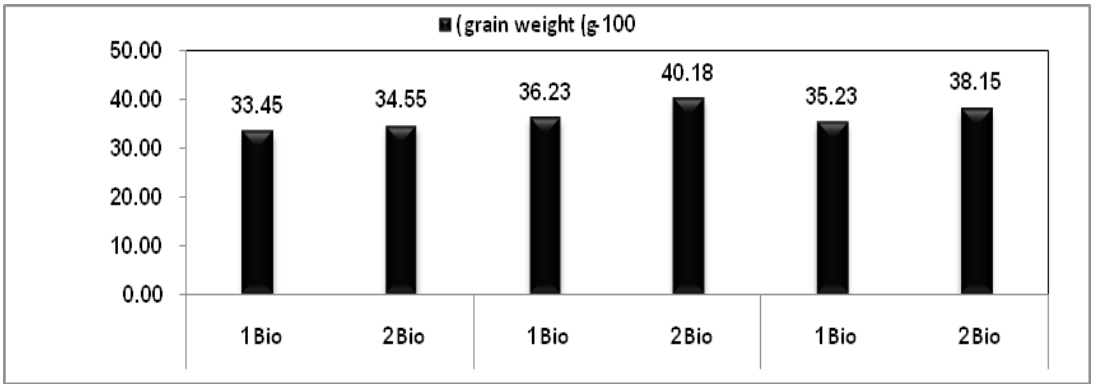

Fig. 10. Effect of green manures ± bio-fertilizer on 100-grain weight (g).

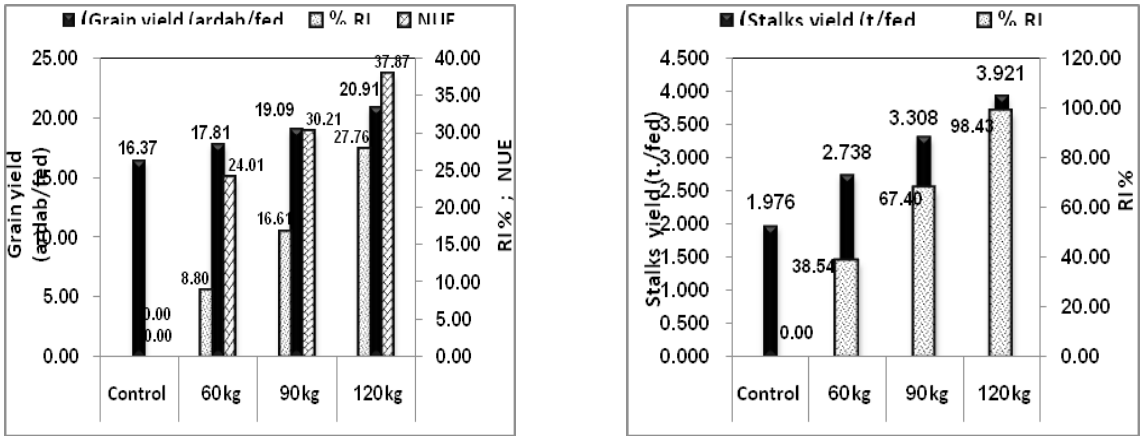

Fig. 11. Effect of mineral N-fertilizer rates on maize grain and stalks yields, RI % and NUE

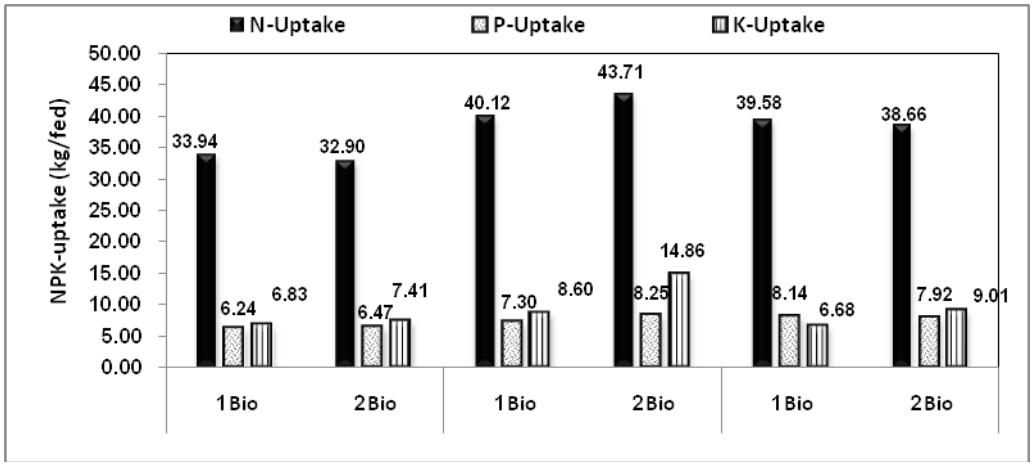

Fig. 12. Effect of green manures ± bio-fertilizer on NPK-uptake of grain (kg fed-1).

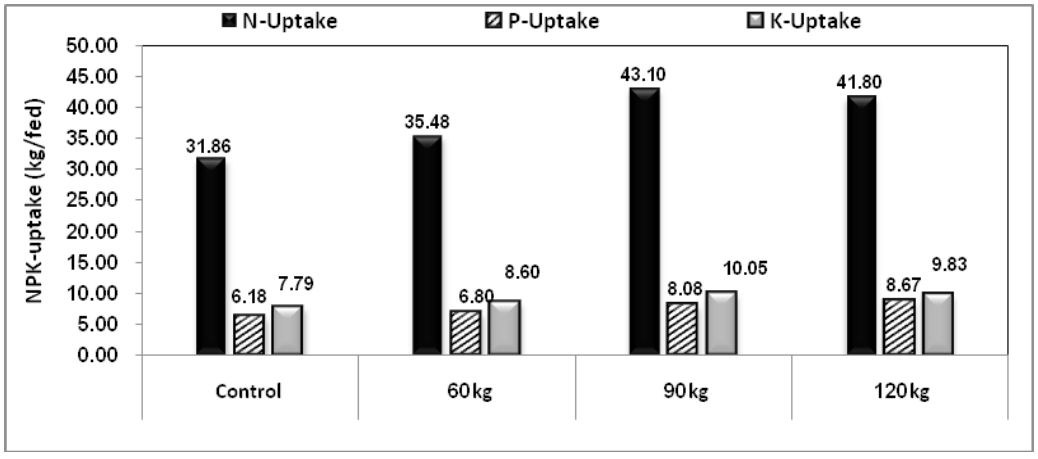

Fig. 13. Effect of mineral N-fertilizer rates on NPK-uptake of grain (kg fed-1).

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