INFLUENCES OF INTERCROPPING TWO LEGUME CROPS AND MINERAL NITROGEN FERTILZER ON WHEAT YIELD AND MICRO – ORGANISMS ACTIVITY IN THE RHIZOPSPHERE SOIL.

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By
N. M.A. Eissa , B. R.A. Rashwan* and Sh. H.F. Abozaed**

Crop Intensification Research Department, Field Crops Research Institute,
** Plant Nutrition Departments, Soil, and **Microbiology Departments, Soil, Water and Environment Research Institute, Agricultural Research Center, Giza,Egypt.*

ABSTRACT

Two field trials were carried out at Mallawi Agric. Res. Sta. (Middle Egypt) during 2013/2014 and 2014/2015 seasons to evaluate the effect of different intercropping patterns of two legume crops with wheat under three mineral nitrogen (N) fertilizer levels on soil bacterial activity, yields of intercropped crops and its quality. A split plot design with three replications was used. Main plots were devoted for N fertilizer levels (60, 75 and 90 kg N fed^{-1}). The intercropping patterns (100% wheat + 20% faba bean, 100% wheat + 30% faba bean, 100% wheat + 40% faba bean, 100% wheat + 20% fahl berseem, 100% wheat + 30% fahl berseem and 100% wheat + 40% fahl berseem) were allocated in sub - plots, in addition to sole cultures of wheat, fahl berseem and faba bean. Available soil content of NPK and organic matter , seed yield and its qualities of legume crops except fahl berseem were significantly increased by N levels application, intercropping patterns, and their interactions. The highest values of the studied traits were obtained with 90 kg N fed^{-1} × 100 % wheat + 40 % faba bean compared to the other treatments. Biological properties and wheat traits were significantly affected by mineral N fertilizer levels, intercropping patterns and their interaction. Increasing N fertilizer level from 60 to 75 kg N fed^{-1} increased all the previous traits, ($P \leq 0.05$). Meanwhile the least values of the biological soil properties and wheat traits, except spike length and 1000 - kernel weight were obtained by increasing N fertilizer level to 90 kg N fed^{-1} Land equivalent ratio values were greater than one, which indicate increasing the land productivity per unit area. The highest values were obtained by (1.33) under intercropping pattern 100% wheat + 20.0% faba bean that received 75 kg N fed^{-1} . Wheat crop was more competitive than fahl berseem or faba bean indicating the dominance of wheat on fahl berseem or faba bean. The highest net return was achieved by intercropping patterns 100% wheat + 20% faba bean or 100% wheat + 20% fahl berseem that received 75 kg N fed^{-1} increased net return of farmers by L.E. 2553 and 2488 per fad, respectively, over those of sole wheat. Application of 75 kg N fed^{-1} with the lowest number of plants of intercropped legumes achieved high quality of all the tested crops. Simple correlation was also studied the relationships between soil nitrogen and soil microbial content traits as well as, between spikes m^{-2} and its components traits

Key words: *Intercropping, Wheat, Fahl berseem, Faba bean, Biological, Mineral N fertilizer levels, Soil content, Simple correlation , Quality, Net return.*

1. INTRODUCTION

In Egypt, increasing wheat (*Triticum aestivum* L.) production is a national target to fill the gap between wheat consumption and production. Great attention and efforts have been paid by the Egyptian government and agricultural scientists to narrow wheat security gap. The total cultivated area of wheat, barseem and faba bean have reached about 3.468, 1.297 and 89.710 thousand faddans, respectively (Bulletin of Statistical Cost Production and Net Return, 2015).

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 competition.

Gregorich *et al.* (2001), Chen *et al.* (2004), and Eskandari & Ghanbari (2010) showed that plant height, spike length, no. of grains/spike, weight of 1000 grains and straw yield fed^{-1} of wheat increased by intercropping with faba bean or white clover compared to wheat monoculture. El Naggar *et al.* (1991) found that intercropping systems compared with the sole crop decreased legume crop yields. Intercropping systems had a significant effect on environment consumption, where intercropping systems had more light interception and water, and nutrient uptake compared to sole crops, suggesting the complementarity effect of intercropping components in resources consumption. The ability of wheat and bean was different in intercropping systems in absorbing nutrients because of their differences in root morphology and action exchange capacity (Eskandari, 2011). This may be due to some of the potential benefits for intercropping systems such as high productivity and profitability. Yildirim and Guvence, 2005, Sheha *et al.* (2015) showed that application of mineral N fertilizer doses increased grain yield of intercropped wheat, but had non-significant effect on intercropped green pod yield of pea. Land equivalent ratio (LER) for intercrops was much greater than 1.00, indicating that land requirements of intercropping systems was less than sole wheat. As a result of intercropping; yield, N uptake and net returns were improved in intercropped wheat with pea (Abdel-Wahab and Elmanzalawy, 2016). The results that land equivalent ratio and land equivalent coefficient values for intercrops were much greater than 1.00 and 0.25, respectively, indicating less land requirements of intercropping systems than sole wheat. The results of Basma *et al.* (2016) showed that with increasing the level of mineral nitrogen fertilization from 0, 50, 75 and 100% N fed^{-1} the highest significant values of all studied parameters (1000 grain weight, grain yield, straw yield, protein percentage in grains, N content in grain and straw, nitrogen uptake by grain, nitrogen uptake by straw and total nitrogen uptake by grain and straw) were achieved from application of 75kg N fed^{-1}. Several studies have shown that through biological nitrogen fixation, which is enhanced by inoculation to the compatible host legume leave residual nitrogen in the soil which add organic matter and also becomes a source of cheap nutrients for the next cropping season to cereal crops and other legumes (Zahran,1999). Biological nitrogen fixation is therefore considered to have ecological and economic benefits (Ndakidemi *et al.,* 2006). The ability to secrete a vast array of compounds into the rhizosphere is one of the most remarkable metabolic features of plant roots, with nearly 5% to 21% of all photo-synthetically fixed carbon being transferred to the rhizosphere through root exudates (Marschner, 2001). There were different studies on intercropping either clover or faba bean with wheat over a long period (Abou-Keriasha *et al.,* 2013; Mohammed Wafaa, 2014 ; Bargaz *et al.*, 2015 and Abdel-Wahab and El Manzlawy, 2016). Generally, it is known that any plant obtain mineral nutrients through root uptake from the soil solution. So, it is expected that the interaction in the rhizosphere of those intercrop mineral N fertilizer through activity of soil microorganisms where soil bacterial community composition is altered in response to nitrogen addition (Jian-Gang *et al.*, 2016). Therefore, the main objective of the present research was to evaluate the effect of different intercropping patterns of Egyptian clover or faba bean with wheat under three mineral N fertilizer levels on soil bacterial activity yields and quality of the intercropped field crops.

2. MATERIALS AND METHODS

Two field trials were carried out at Mallawi Agric. Exp. Res. Sta., A.R.C., El-Mania Governorate, Egypt, during 2013/2014 and 2014/2015 seasons. The aim of these experiments was to study the effect of different intercropping patterns of fahl berseem or faba bean with wheat under three mineral nitrogen (N) fertilizer levels on bacterial soil activity, and yields and qualities of the intercropped field crops. Maize was the preceding summer crop in both seasons. A split plot design in three replications was used, where the main plots were devoted to three nitrogen levels (60, 75 and 90 kg N fed^{-1}). Sub-plots were devoted to six intercropping patterns of faba bean or fahl berseem with wheat. These intercropped patterns could be illustrated as follows:

B_1: Wheat grains (60 kg fed^{-1}) were drilled in 6 rows in the middle of the bed (120 cm width) and faba bean seeds (6 kg fed^{-1}) were sown on both sides of the bed then thinned to one plant /hill distanced at 25 cm between plants (100% wheat + 20.0% faba bean, 28.000 plants fed^{-1}).

B_2: Wheat grains (60 kg fed^{-1}) were drilled in 6 rows in the middle of the bed (120 cm width) and faba bean seeds (9 kg fed^{-1}) were sown on both sides of the bed then thinned to one plant /hill only on one side and faba bean plants of the other side were thinned to two plants/hill distanced at 25 cm between plants (100% wheat + 30.0% faba bean, 42.000 plants fed^{-1}).

B_3: Wheat grains (60 kg fed^{-1}) were drilled in 6 rows in the middle of the bed (120 cm width) and faba bean seeds (12 kg fed^{-1}) were sown on both sides of the bed then thinned to two plants/hill distanced at 25 cm between plants. (100% wheat + 40 % faba bean, 58.000 plants fed^{-1}).

B_4: Wheat grains (60 kg fed^{-1}) were drilled in 6 rows in the middle of the bed (120 cm width) and fahl berseem seeds (3 kg fed^{-1}) were broadcasted on bottom of the bed (100% wheat + 20% fahl berseem).

B_5: Wheat grains (60 kg fed^{-1}) were drilled in 6 rows in the middle of the bed (120 cm width) and fahl berseem seeds (4.5 kg fed^{-1}) were broadcasted on bottom of the bed (100% wheat + 30% fahl berseem).

B_6: Wheat grains (60 kg fed^{-1}) were drilled in 6 rows in the middle of the bed (120 cm width) and fahl berseem seeds (6 kg fed^{-1}) were broadcasted on bottom of the bed (100% wheat + 40% fahl berseem).

Subplot area was 24 m^2 (1/175 fed), the wheat bed unit measured 5 m in width and 4 m in length. Bread wheat (cv. Giza 168.) was sown at a seed rate of 60 kg fed^{-1} on the 10^{th} and 15^{th} of November at 2013 and 2014 seasons. Faba bean (cv. Giza 843) and fahl berseem (cv. Gemmiza 1 veriety) were used .Wheat grains (60 kg fed^{-1}), faba bean seeds (30 kg fed^{-1}) and fahl berseem seeds (15 kg fed^{-1}) were grown solid to compare. Water was supplied as furrow irrigation. N fertilizer rates in form of ammonium nitrate (33.5% N) were applied in two equal doses before the first and the second irrigation. Calcium super phosphate (15.5% P_2O_5) at the rate of 150 kg fed^{-1} was side-dressed after ridging and potassium sulfate (48.0 % K_2O) at the rate of 24 kg fed^{-1} was side-dressed before the second irrigation according to the treatments rate. Table (1) shows some physical and chemical properties of the experimental soil before sowing.

2.1. Microbiological determination

In *vivo* studies of both experiments, the total count of bacteria, Azotobacter, Azospirilum and phosphate dissolving bacteria in rhizosphere per gram soil at 45 days after sowing were determined using dilution frequency method (Haskine, 1934). Numbers of phosphate dissolving bacteria were determined as described by Abdel-Moniem *et al.* (1988). Numbers of bacterial total count were determined as described by Allen (1959). Some physical and chemical properties of the surface layer (0 – 30 cm) of the soil at the start of each growing season, samples of soil surface were collected dried, sieved prior to laboratory analysis according to Piper (1950) and Black, (1965). Soil pH was determined in the suspension of soil sample (1 soil: 2.5 water v.:v.) according to Richards, (1954). The electrical conductivity (EC dsm^{-1}) was measured by an electrical conductivity meter in the soil extract (1 soil: 5 water v.:v.) according to Richards (1954). These analyses were done by Environment, Water and Soil Research Institute, A.R.C., Egypt.

2.2. Data recorded

2.2.1. Yield and Its Attributes

On 26^{th} and 29^{th} April, 2014 and 2015 seasons, faba bean plants were harvested, and on 20 th and 25^{th} May 2014 and 2015 seasons, wheat and fahl berseem plants were together harvested. The following traits were measured on ten random plants from each plot:

2.2.1.1. Wheat: Plant height, spike length, number of spikes m^{-2},number of kernels $spike^{-1}$ and 1000 - kernel weight area by harvesting all plants of each sub plot and expressed as ton fed^{-1}.

2.2.1.2. Barseem: Seed yield was recorded on the basis of experimental sub-plot area by harvesting all the plants of each sub plot and expressed as kg fed^{-1}.

2.2.1.3. Faba bean: Seed yield was recorded on the basis of experimental sub-plot area by harvesting all the plants of each sub plot and expressed as kg fed^{-1}.

2.2.2. Chemical composition of yields

At harvest, grain and straw samples were dried in a forced oven at 70 °C till constant weight; ground to a fine powder and sub sample of 0.2 g was wet digested using sulphuric-perchloric acid mixture (1:1) as described by A.O.A.C., (2000) to determine the total N in the acidic extract as follows:

2.2.2.1. Total N (%) was determined by Kjeldahl method as according to Jackson (1967).

2.2.2.2. Crude protein (%) in wheat grains, faba bean seeds and barseem seeds were calculated

Table (1): Physical and chemical properties of the experimental soil (before sowing).

Properties	2013/2014	2014/2015
Physical analysis:-		
Sand (%)	7.75	8.30
Silt (%)	53.70	53.40
Clay (%)	38.55	38.30
Soil texture	Silty clay loam	
Mechanical analysis:-		
Organic matter (%)	1.14	1.19
pH soil – water suspension ratio (1:2.5)	8.30	8.15
EC (ds m^{-1}) soil – water extract ratio (1:5)	1.26	1.22
Soluble cations (meq/L):-		
Ca^{++}	7.45	7.25
Mg^{++}	2.15	2.10
Na^{+}	3.22	3.20
K^{+}	0.20	0.18
Soluble anions (meq/L) :-		
CO_3^{-}	---	---
HCO_3^{-}	3.20	3.18
Cl^{-}	4.10	4.15
SO_4^{--}	5.72	5.40
Available N (ppm)	18.25	18.15
Available P (ppm)	7.58	7.76
Available K (ppm)	156.00	155.00

by multiplying N % by 5.7 for wheat grains, 6.25 for faba bean and barseem seeds according to Tripath *et al.* (1971) and Sadasivam and Manickam (1997).

2.3. Correlation matrix: The coefficients of correlation between all pairs of the studied traits were computed as suggested by Snedecor and Cochran, (1989).

2.4. Competitive relationships

2.4.1. Land equivalent ratio (LER): was estimated according to Mead and Willey (1980) as follows: -The values of LERs were estimated by using data of sole crops. LER of more than 1.00 indicates yield advantage, equal to 1.00 indicates no gain or no loss and less than 1.00 indicates yield loss (Vendemeer, 1989). It can be used for both replacement and additives series of intercropping.

$$LER = (Y_{ab}/Y_{aa}) + (Y_{ba}/Y_{bb})$$

Where Y_{aa} and Y_{bb} is pure stand of crops a and b, Y_{ab} and Y_{ba} were intercropped crops a and b.

2.4.2. Competitive ratio (CR): It was measured as proposed by Willey and Rao, (1980). It gives the exact degree of competition by indicating the times in which one crop is more competitive than the other. Competition ratio (CR) is calculated according to the following equation:

$$R_a = (L_a / L_b) \times (Z_{ba} / Z_{ab})$$

$$R_b = (L_b / L_a) \times (Z_{ab} / Z_{ba})$$

Where R_a and R_b = the competitive ratio of crops a and b.

L_a = LER of crop a L_b = LER of crop $_b$

Z_{ab} = the respective proportion of crop a in the intercropping system

Z_{ba} = the respective proportion of crop b in the intercropping system

2.4.3. Farmer's benefit: It was calculated by determining the total costs and net return of intercropping culture as compared to recommended sole culture as follows:

2.4.3.1. Total return of intercropping cultures = Price of wheat × yield + price of barseem or faba bean × yield (L.E.), to calculate the total return, the average market price 2800 L.E. / ton wheat, 7.400 L.E./ kg faba been 500 L.E/ ton straw yield and 20.00 L.E./ kg seed for barseem fahl prices were used by Bulletin of Statistical Cost Production and Net Return, (2015).

2.4.3.2. Net return = Total return – (fixed costs of wheat + variable costs of barseem or faba bean according to plant density and N fertilizer type).

2.5. Statistical Analysis: All data of the two seasons were statistically analyzed according to Snedecor and Cochran (1989) using MSTAT software Computer V4 (1980). L.S.D. test at 5 % level was used to compare between treatments.

3. RESULTS AND DISCUSSIONS

3.1. Soil chemical analyses

3.1.1. Mineral N fertilizer levels

Data in Table (2) show that mineral N fertilizer levels had significant effects on soil

Table (2): Effect of N fertilizer levels, intercropping patterns and their interactions on some soil chemical properties combined data across 2013/2014 and 2014/2015 .

Traits		N (ppm)	P (ppm)	K (ppm)	O. M. %
Nitrogen fertilizer levels					
60 kg fed^{-1}(**F$_1$**)		19.133	7.923	157.864	1.451
75 kg fed^{-1}(**F$_2$**)		19.170	7.975	160.183	1.481
90 kg fed^{-1}(**F$_3$**)		19.284	8.0102	161.680	1.506
L.S.D. 0.05		0.008	0.011	0.200	0.015
Intercropping					
100% wheat +20%faba bean (**B$_1$**)		19.208	7.941	159.683	1.446
100% wheat +30%faba bean (**B$_2$**)		19.218	8.024	160.291	1.465
100% wheat +40 %faba bean (**B$_3$**)		19.226	8.084	160.719	1.524
100% wheat + 20% fahl berseem(**B$_4$**)		19.156	7.954	158.816	1.530
100% wheat +30 % fahl barseem (**B$_5$**)		19.182	7.988	158.932	1.468
100% wheat +40% fahl berseem(**B$_6$**)		19.182	8.023	159.455	1.448
L.S.D. 0.05		0.010	0.039	0.184	0.020
Interaction					
60 kg fed^{-1}(**F$_1$**)	**B$_1$**	19.126	7.782	157.940	1. 385
	B$_2$	19.138	7.994	158.780	1. 455
	B$_3$	19.148	8.084	159.341	1.488
	B$_4$	19.118	7.845	156.786	1.403
	B$_5$	19.127	7.893	157.025	1.438
	B$_6$	19.139	7.929	157.644	1.590
75 kg fed^{-1}(**F$_2$**)	**B$_1$**	19.178	7.890	159.775	1.407
	B$_2$	19.189	7.924	159.900	1. 463
	B$_3$	19.190	7.986	159.947	1.483
	B$_4$	19.130	8.000	158.783	1.390
	B$_5$	19.159	8.034	158.787	1.508
	B$_6$	19.169	8.046	158.904	1.598
90 kg fed^{-1}(**F$_3$**)	**B$_1$**	19.321	8.150	161.335	1.420
	B$_2$	19.327	8.154	162.192	1. 600
	B$_3$	19.340	8. 183	162.869	1.603
	B$_4$	19.219	8.017	160.879	1.398
	B$_5$	19.259	8.038	160.985	1.402
	B$_6$	19.239	8.093	161.817	1.610
L.S.D. 0.05		0.018	0.069	0.318	0.035
Solid wheat		18.187	7.930	158.97	1.437
Solid faba bean		19.372	7.955	159.845	1.465
Solid berseem		19.297	7.947	159.695	1.452

chemical properties . The results show that soil N, P, K and O. M. stocks increased ($P \leq 0.05$) with increasing mineral N fertilizer level from 60 to 90 kg N fed^{-1}. Application of 90 kg N fed^{-1} gave the highest values of soil N, P, K and O. M. contents compared with the others treatments. These results may be due to an increase in N fertilizer application which stabilize organic matter and retard the mineralization of older soil organic matter (Hagedorn *et al.*, 2003). Accordingly, the lowest level of mineral N fertilizer influenced strongly soil O. M. and led to an environmental imbalance between soil biological and chemical processes reflected on action exchange capacity. In this concern, Murphy (2015) found that soil organic matter can contribute to soil quality by aggregate stability and soil porosity, water-holding capacity especially available water, and action exchange capacity.

3.1.2.Intercropping patterns

Data in Table (2) show significant differences in soil N, P, K and O. M. stocks. The highest values *($P \leq 0.05$)* of these traits were observed by intercropping pattern 100% wheat + 40% faba bean, meanwhile the lowest values of soil N, P, K and O. M. were obtained by intercropping pattern 100% wheat + 20% fahl berseem. These results reveal that legume the component in the intercrops had important role in the available soil contents that could increase soil carbon which may contribute to better soil structure (Gibson *et al*., 2006).

It is important to mention that soil N stock of the rhizosphere of intercropped wheat roots was increased by increasing the plant density of legume component from 20 to 30% of the sole culture. Moreover, it is expected that the intercrops will alter the dynamics of organic matter turnover and the rate of nutrient cycling within the soil (Arshad *et al.,* 2016). These results could be due to an increase in plant density of the intercropped fahl berseem or faba bean from 20 to 40% of sole culture increased intra-specific competition between plants of legume component more than competition between plants of the intercrops that differed in their competitive ability for basic growth resources. Moreover, it is known that limited plant-available P is associated with a more horizontal root angle in bean, placing roots in surface soil where P can accumulate because it is highly immobile. These results are similar to those obtained by Abdel-Wahab *et al.* (2016) who noticed that the residual effect of the legume crops had positive effects on soil N, P and K nutrients.

3.1.2. Interaction between mineral N fertilizer levels and intercropping patterns

Soil N, P, K and O. M. stocks of the rhizosphere of wheat roots were affected significantly by the interaction between mineral N fertilizer levels and intercropping patterns in the combined data across the two seasons (Table 2). Intercropping pattern 100% wheat + 40% faba bean with the application of 90 kg N fad^{-1} had the highest values of soil N, P, K and O. M., meanwhile the lowest values of soil chemical properties were obtained by intercropping pattern 100% wheat + 20.0% fahl berseem that received either 60 or 75 kg N fed^{-1}.

3.2. Soil biological analyses

3.2.1. Mineral N fertilizer levels

Total count of bacteria, *Azotobacter*, *Azospirillum* and phosphate solubilizing bacteria were affected significantly by N fertilizer levels (Table 3). Increasing mineral N fertilizer level from 60 to 75 kg N fad^{-1} increased ($P \leq 0.05$) all the previous traits, meanwhile the lowest values of the biological soil properties were obtained by decreasing mineral N fertilizer level at 60 kg N fed^{-1}. Soil or rhizosphere organisms include total, spore-forming .Certainly, there was a wide range of bacterial community which can be affected by mineral N fertilizer (Campbell *et al.* 2010).The number of *Azotobacter, Azospirillum* and phosphate solubilizing bacteria in the rhizosphere of wheat roots had a change trend; first increased and then decreased with increasing mineral N fertilizer level, indicating that high mineral N level had a great inhibitory effect on the number of all the studied bacteria. These results could be attributed to application of 90 kg N fed^{-1} affected negatively all the studied traits of soil biological properties and there by PGPR becomes lazy in the rhizosphere of wheat roots (Sheha *et al.* (2015). These results show that application of 75 kg N fed^{-1} can improve soil nutrients availability through bacterial activity in the experimental soil. Nitrogen fixing bacteria, besides fixing N, solubilize P due to the production of organic acids and enzymes (Kumar and Narula 1999).

3.2.2. Intercropping patterns

Total count of bacteria, *Azotobacter, Azospirillum* and phosphate solubilizing bacteria were affected significantly by intercropping patterns (Table 3). The highest values ($P \leq 0.05$) of all the previous traits were observed by intercropping pattern 100% wheat + 30% faba bean., meanwhile the lowest values of these traits were obtained by intercropping pattern 100% wheat + 20% fahl berseem.

These results could be due to intercropping the legume crops with wheat changed soil bacterial activity by promoting PGPR and phosphate solubilizing bacteria. It has been observed that the roots of intercrops freely intermingle resulting in complementary interactions between the root systems. It seems that plant–microbe interactions in the rhizosphere of wheat roots were increased by increasing the plant density of legume component from 20 to 30% of the sole culture. Certainly, the rhizosphere is a complex environment where roots interact with physical, chemical and biological properties of the soil, and is influenced by the presence and activity of roots (Richardson *et al.,* 2009).

3.2.3. Interaction between N fertilizer levels and intercropping patterns

Total counts of bacteria, *Azotobacter*, *Azospirillum* and phosphate solubilizing bacteria were affected significantly by the interaction between mineral N fertilizer levels and intercropping patterns in the combined data across the two seasons (Table 3). Intercropping pattern 100% wheat + 30% faba bean with application of 75 kg N fed^{-1} had the highest

Table (3): Effect of N fertilizer levels, intercropping patterns and their interaction on some soil biological properties, combined data across 2013/2014 and 2014/2015.

Traits		Total count (cfu x 10^5)	Azotobacter (cfu x 10^5)	Azospirillium (cfu x 10^5)	Phosphate solubilizing bacteria (cfu x 10^5)
Nitrogen fertilizer levels					
60 kg fed^{-1}(**F$_1$**)		83.342	1.709	3.842	2.533
75 kg fed^{-1}(**F$_2$**)		89.700	2.287	4.470	4.586
90 kg fed^{-1}(**F$_3$**)		86.431	2.086	4.327	4.009
L.S.D. 0.05		3.219	0.094	0.146	0.019
Intercropping					
100% wheat +20%faba bean (**B$_1$**)		88.349	1.683	4.226	3.477
100% wheat +30%faba bean (**B$_2$**)		119.961	2.233	4.795	4.188
100% wheat +40 %faba bean (**B$_3$**)		106.744	2.108	4.156	3.992
100% wheat + 20% fahl berseem(**B$_4$**)		56.217	1.734	3.689	3.212
100% wheat +30 % fahl barseem (**B$_5$**)		73.744	2.173	4.178	3.744
100% wheat +40% fahl berseem(**B$_6$**)		73.533	1.998	4.235	3.644
L.S.D. 0.05		2.082	0.114	0.069	0.049
Interaction					
60 kg fed^{-1}(**F$_1$**)	**B$_1$**	84.533	1.185	3.388	2.180
	B$_2$	101.350	2.368	4.575	2.688
	B$_3$	114.983	2.110	4.125	2.928
	B$_4$	55.867	0.925	2.925	2.088
	B$_5$	71.250	1.845	4.063	2.585
	B$_6$	72.067	1.820	3.978	2.730
75 kg fed^{-1}(**F$_2$**)	**B$_1$**	93.800	2.185	4.780	4.738
	B$_2$	125.483	3.193	5.388	5.155
	B$_3$	110.400	2.500	3.763	4.818
	B$_4$	57.500	1.380	4.415	4.180
	B$_5$	76.450	2.370	3.983	4.338
	B$_6$	74.567	2.095	4.488	4.288
90 kg fed^{-1}(**F$_3$**)	**B$_1$**	87.900	1.588	3.900	3.513
	B$_2$	108.483	2.803	5.030	4.720
	B$_3$	119.417	2.440	4.578	4.228
	B$_4$	55.283	1.303	3.728	3.367
	B$_5$	73.533	2.305	4.488	4.310
	B$_6$	73.967	2.078	4.238	3.913
L.S.D. 0.05		3.607	0.197	0.120	0.085
Solid wheat		74.50	1.55	3.591	2.484
Solid faba bean		120.417	2.880	4.470	4.310
Solid berseem fahl		88.315	2.173	4.238	3.941

values of *Azotobacter*, *Azospirillum* and phosphate solubilizing bacteria, meanwhile the lowest values of soil biological properties were obtained by intercropping pattern 100% wheat + 20.0% fahl berseem that received 60 kg N fed^{-1}. However, intercropping pattern 100% wheat + 40.0% fahl berseem that received 60 or 90 kg N fed^{-1} achieved the least total count of bacteria compared with the others, probably due to the heterogeneity of the soil physicochemical environment and the abundance of inactive or dormant organisms. It is known that the interaction between soil type, plant species and rhizosphere localization of bacterial community affects bacterial community composition (Marschner *et al.*,2001). The medium plant density of intercropped fahl berseem or faba bean interacted positively with application of 75 kg N fed^{-1} and furnished better above and below - ground conditions for enhancement of PGPR and phosphate solubilizing bacteria compared to the other treatments. These data show that each of these two factors act dependently on the total count of bacteria, *Azotobacter*, *Azospirillum* and phosphate solubilizing bacteria meaning that mineral N fertilizer levels responded differently *($P \leq 0.05$)* to mineral N fertilizer for soil biological properties.

3.2.4. Correlation coefficients

Simple correlation among total count and its relation characters over the two (n = 10)is present in (Table 4) The results of correlation coefficients between traits showed that total count had a positive and significant correlation with *Azotobacter* (r = 0.713**) , *Azotobacter* with *Azospirilum* (r = 0.702**), Phosphate(r = 0.713**) and Nitrogen (r = 0.604**), *Azospirilum* (r = 0.672**), Phosphate with Nitrogen (r = 0.834**), at 1 % probability levels and *Azospirilum* had a positive and significant correlation with Nitrogen(0.487) at 5 % probability levels.

Table (4): Simple correlation coefficients between microbial soil content trait:

Traits	N	PH	AS	AT	TC
N	1				
PH	0.834**	1			
AS	0.487*	0.672**	1		
AT	0.604**	0.713**	0.702**	1	
TC	0.441	0.391	0.396	0.713**	1

Abbreviations: - N: Nitrogen , PH: Phosphate , AS : Azospirilum , AT : Azotobacter and TC : Total count

3.3. Grain yield of wheat and its attributes.

3.3.1. Mineral N fertilizer levels.

Plant height, the number of spikes/m^2, number of kernels/spike, grain and straw yields fad^{-1} were affected significantly by N fertilizer levels, meanwhile spike length and 1000- kernel weight were not affected (Table 5). Increasing N fertilizer level from 60 to 75 kg N fed^{-1} increased ($P \leq 0.05$) plant height, the number of spikes/m^2, number of kernels/spike, grain and straw yields fad^{-1} but these traits except plant height were increased by increasing N fertilizer level from 75 - 90 kg N fed^{-1}.This result is in agreement with those observed by El Naggar *et al.* (1991). Increasing N fertilizer level from 60 to 75 kg N fed^{-1} led to significant increments in the number of spikes m^{-2} by 3.52% number of kernels/spike by 6.00% and grain yield fed^{-1} by 7.63% compared with the lowest N level in the combined data across the two growing seasons. These results are in agreement with the findings of Sharief *et al.*(1998) who reported that using 75 kg N fed^{-1} resulted in a significant increase in plant height, No. of tillers m^2, spike length, spike weight, No. of grains per spike, grain weight spike^{-1} and 100 grain weight which in turn increased,grain, straw and biological yields fed^{-1}. These results could be due to application of 90 kg N fed^{-1} may have influenced negatively soil chemical and biological properties (Tables 2 and 3) which caused rapid cell division of wheat plant, thereby lengthened the vegetative stage and delayed the reproductive stage of the plant. These results indicate that PGPR and phosphate solubilizing bacteria has contributed to decrease intra-specific competition between wheat plants for soil N, P and K and facilitated these nutrients uptake for wheat plants. Accordingly, it is expected that growth resources such as water and nutrients were more completely absorbed and converted to crop biomass during growth and development stages of wheat plants in case of 75 kg N fed^{-1} than those received the others. These results imply that application of 75 kg N fed^{-1} furnished suitable edaphic conditions to roots of wheat plants through soil chemical and biological properties during the early growth stages of the cereal component which decreased intra-specific competition between wheat plants for available environmental conditions.

3.3.2. Intercropping patterns.

Plant height, spike length, the number of spikes m^{-2}, number of kernels/spike, 1000 – kernel weight, grain and straw yields fed^{-1} were affected significantly by intercropping patterns (Table 5). Intercropping pattern 100% wheat + 20% fahl berseem increased *($P \leq 0.05$)* spike length, 1000 – kernel weight and the number of kernels spike^{-1}, followed by number of spikes/m^2 and grain yields fed^{-1} in intercropping pattern 100% wheat + 20% faba bean meanwhile the lowest values of number of spikes m^{-2}, number of kernels spike^{-1}, 1000 – kernel weight and grain yields fed^{-1} were obtained by intercropping pattern 100% wheat + 40% fahl berseem. These findings are in agreement with those obtained by Eskandari (2011). The present results show that intercropping systems had a significant effect on environmental resources consumption, where intercropping systems had more light interception and water, and nutrient uptake compared to sole crops, suggesting the complementarity effect of intercropping components in resources consumption. The ability of wheat and bean was different in intercropping systems in absorbing nutrients because of their differences in root morpholpgy and action exchange capacity.

These results are in accordance with those observed by Song *et al.* (2007) who showed that intercropping has significant effects on microbiological and chemical properties in the rhizosphere, which may contribute to the yield enhancement by intercropping.

Table (5): Effect of N fertilizer levels, intercropping patterns and their interaction on wheat grain yield and its attributes, combined data across 2013/2014 and 2014/2015.

Traits		Plant height (cm)	Spike length (cm)	Spikes/ m^2 (No)	1000 kernels (g)	Kernels / Spike (No)	Grain yield (ton/fed)	Straw yield (ton/fed)
Nitrogen fertilizer levels								
60 kg fed^{-1}(**F_1**)		93.29	**9.30**	**397**	**46.1**	**47.31**	**2.494**	**3.554**
75 kg fed^{-1}(**F_1**)		95.16	9.39	411	47.8	50.15	2.686	4.230
90 kg fed^{-1}(**F_1**)		95.89	9.28	367	45.8	47.25	2.338	4.179
L.S.D. 0.05		1.175	NS	8.726	NS	1.164	0.038	0.055
Intercropping								
100% wheat +20%faba bean (**B_1**)		93.71	9.50	428	47.4	51.49	2.677	3.818
100% wheat +30%faba bean (**B_2**)		93.11	9.18	406	468	47.59	2.583	3.440
100% wheat +40%faba bean (**B_3**)		93.87	8.87	380	46.0	45.39	2.486	3.334
100% wheat +20%fahl berseem (**B_4**)		94.81	9.75	401	48.3	51.81	2.603	4.243
100% wheat +30%fahl berseem (**B_5**)		95.33	9.44	383	47.3	48.57	2.399	4.370
100% wheat +40%fahl berseem (**B_6**)		97.94	9.18	357	4.40	44.97	2.286	4.719
L.S.D. 0.05		1.794	0.455	9.492	1.94	1.272	0.066	0.149
Interaction								
F_1	**B_1**	90.67	9.58	409	47.1	51.01	2.647	3.656
	B_2	93.33	9.23	406	46.3	49.04	2.632	3.242
	B_3	95.83	8.87	387	44.9	44.52	2.578	3.139
	B_4	91.60	9.80	388	47.6	50.69	2.498	3.609
	B_5	92.50	9.39	388	46.6	45.48	2.377	3.669
	B_6	95.83	8.92	359	44.1	43.11	2.237	4.009
F_2	**B_1**	95.47	9.56	460	48.4	55.62	2.973	3.981
	B_2	93.17	9.28	429	47.8	48.07	2.795	3.698
	B_3	93.00	9.04	397	46.9	48.76	2.571	3.566
	B_4	96.00	9.66	433	48.5	51.44	2.848	4.418
	B_5	95.50	9.43	418	48.4	50.05	2.472	4.685
	B_6	97.83	9.34	392	46.5	46.94	2.357	5.030
F_3	**B_1**	95.00	9.37	415	46.7	48.85	2.435	3.818
	B_2	92.83	9.03	383	46.4	45.70	2.321	3.380
	B_3	92.50	8.72	356	46.1	42.88	2.308	3.299
	B_4	96.83	9.78	382	48.6	51.01	2.463	4.703
	B_5	98.00	9.49	345	46.8	50.18	2.350	4.756
	B_6	100.17	9.27	320	41.3	44.87	2.265	5.120
L.S.D .05 F x B		3.107	NS	16.441	NS	2.204	0.115	0.258
Solid wheat		92.5	9.51	422	46.5	46.15	2.536	3.675

3.3.3. Interaction between N fertilizer levels and intercropping patterns

Plant height, number of spikes/m^2, number of kernels/spike, grain and straw yields fad^{-1} were affected significantly by N fertilizer levels x intercropping patterns, meanwhile spike length and 1000 - kernel weight were not affected (Table 5). Intercropping pattern 100% wheat + 20% faba bean with the application of 75 kg N fad^{-1} had the highest values of the number of spikes m^{-2}, no of kernels spike^{-1} and grain yield fed^{-1} meanwhile the lowest values of number of spikes m^{-2}, number of kernels spike^{-1} and grain yields fed^{-1} were obtained by intercropping pattern 100% wheat + 40.0% fahl berseem that received either 60 or 90 kg N fed^{-1} compered other treatments.

Although, the medium plant density of legume component contributed largely in enhancing PGPR and phosphate solubilizing bacteria in rhizosphere of wheat roots, but wheat attributes could be closely related to the amount of solar radiation during the growing season. Thus, it is expected that the least plant density of fahl berseem or faba bean integrated with 75 kg N fed^{-1} to activate the least quantity of PGPR and phosphate solubilizing bacteria that promoted efficiency of photosynthetic process of wheat plant indirectly by producing physiologically active gibberellins (Gutierrez–Manero *et al.*, 2001) and altering root growth via nutrient availability through mineralization (Fan *et al.*,2011). These results revealed that intercropping pattern 100% wheat + 20% faba bean or 100% wheat + 20% fahl berseem interacted with 75 kg N fed^{-1} to decrease inter or intra-specific competition between plants of the intercrops or plants of wheat, respectively, for available environmental conditions. These data show that each of these two factors act dependently on plant height, the number of spikes m^{-2}, number of kernels spike^{-1}, grain and straw yields fed^{-1} meaning that mineral N fertilizer levels responded differently *(P≤0.05)* to intercropping pattern for most the studied traits of wheat.

3.3.4. Correlation coefficients

In (Table 6) the results of correlation coefficients between the traits showed that number of spikes m^{-2} had a positive and significant correlation with kernels/spike weight (r = 0.517*) and No of kernels/spike (r =0.466*), kernels/spike weight with 1000 kernels weight (r = 0.546*) at 5 % probability levels, and No of kernels/spike (0.682**) at 1 % probability levels. While spikes m^{-2} number had a negative with 1000 kernels weight (r = -0.030).

3.4. Quality of wheat grains

3.4.1. Mineral N fertilizer levels

Grain N and protein contents were affected significantly by mineral N fertilizer levels in the combined analysis (Table 7). Increasing N fertilizer level from 60 to 75 kg N fed^{-1} increased *(P≤0.05)* grain N and protein contents but it were decreased by increasing N fertilizer level from 75 to 90 kg N fed^{-1}. These results were due to increase in mineral N fertilizer level from 60 to 75 kg N fad^{-1} improved soil chemical and biological properties (Tables 2 and 3) and reflected positively on N, P and K status in the wheat crop. Obviously, excess application of mineral N fertilizer per fed was not economically efficient and reduced grain protein content. These results are in accordance with those obtained by Abedi *et al.*(2011) who studied the effect of N rate application (0, 120, 240 and 360 kg N ha^{-1}) and N timing on grain yield, yield components, grain quality and protein banding pattern in different growth stages of wheat. They found that 240 kg N ha^{-1} application in all timing treatments resulted in maximum grain protein content (5.5 mg protein g^{-1} grain).

3.4.2. Intercropping patterns

Grain N and protein contents were affected significantly by intercropping patterns in the combined analysis (Table 7). Intercropping pattern 100% wheat + 40% faba bean increased *(P≤0.05)* grain N and protein contents, meanwhile the lowest values of grain N and protein contents were obtained by intercropping pattern 100% wheat + 20% faba bean. These results were due to intercropping pattern 100% wheat + 40% faba bean improved soil chemical and biological properties (Tables2 & 3) that reflected positively on grain N and protein contents of the wheat crop.

Similar results were observed by Sarunaite and Kadziuliene (2010) who reported that the significantly higher crude protein concentration was observed in the total intercrops grain yields compared with the sole wheat yield.

3.4.3.Interaction between N fertilizer levels and intercropping patterns

Grain N and protein contents were affected significantly by N fertilizer levels x intercropping patterns in the combined analysis (Table 7). Intercropping pattern 100% wheat + 40% faba bean with the application of 75 kg N fed^{-1} had the highest grain N and protein contents compared to other treatments, meanwhile the lowest values of grain N and protein contents were obtained by intercropping pattern 100% wheat + 20% faba bean that received either 60 or 90 kg N fad^{-1}. These results show that each of these two factors act dependently on grain N and protein contents of wheat meaning that mineral N fertilizer levels responded differently *(P≤0.05)* to mineral N fertilizer for grain N and protein contents of wheat. Similar results were observed by Tosti *et al.* (2016) who indicated that intercropping faba bean with wheat was a promising technique to improve the quality of organic wheat in Mediterranean areas and it had positive effect on both production quality (wheat protein concentration) and the environment (reduction of N leaching losses).

3.5. Seed yields of fahl berseem and faba bean

3.5.1. Mineral N fertilizer levels

Seed yields of fahl berseem and faba bean were affected significantly by N fertilizer levels (Table 8). Increasing N fertilizer level from 60 To 75 kg N fed^{-1} per unit area increased (P≤0.05) seed yield of fahl berseem or faba bean but seed yield of faba bean was decreased by increasing N fertilizer level from 75 to 90 kg N fed^{-1}. Clearly, it is likely that application of 90 kg N fed^{-1} lengthened the vegetative stage of faba bean plant and promoted development of the above ground green tissues more than reproductive organs and could be translated

Table (6): Simple correlation coefficients between No. of Spike m^{-2} and its component traits.

Traits	Spike m^{-2} (No)	kernels/spike (g)	1000 kernels (g)	Kernels/spike (No)
Spike m^{-2}(NO)	1			
kernels/spike (g)	0.517*	1		
1000 kernels(g)	- 0.030	0.546*	1	
Kernels/spike (No)	0.466*	0.682**	- 0.003	1

Table (7): Effect of N fertilizer levels, intercropping patterns and their interaction on quality of wheat grains, combined data across 2013/2014 and 2014/2015.

Traits		Grain N content (%)	Grain protein content (%)
Nitrogen fertilizer levels			
60 kg fed^{-1}(F_1)		1.221	6.962
75 kg fed^{-1}(F_2)		1.321	7.529
90 kg fed^{-1}(F_3)		1.288	7.343
L.S.D. 0.05		0.007	0.037
Intercropping			
100% wheat +20% faba bean(B_1)		1.302	7.423
100% wheat +30% faba bean (B_2)		1.321	7.530
100% wheat +40 % faba bean (B_3)		1.357	7.733
100% wheat + 20% fahl berseem(B_4)		1.196	6.818
100% wheat +30 % fahl barseem (B_5)		1.228	7.001
100% wheat +40% fahl berseem(B_6)		1.257	7.163
L.S.D. 0.05		0.007	0.041
Interaction			
F1	B1	1.222	6.964
	B2	1.252	7.134
	B3	1.315	7.496
	B4	1.150	6.555
	B5	1.168	6.659
	B6	1.222	6.963
F2	B1	1.353	7.714
	B2	1.372	7.819
	B3	1.403	7.999
	B4	1.238	7.059
	B5	1.273	7.258
	B6	1.285	7.325
F3	B1	1.332	7.591
	B2	1.340	7.638
	B3	1.352	7.704
	B4	1.200	6.840
	B5	1.243	7.087
	B6	1.263	7.201
L.S.D. 0.05		0.012	0.071
Solid wheat		1.302	7.421

into alteration of plant height growth rate and increased lodging percentage (Lincoln and Edvardo, 2006; Bozorgi *et al.*, 2011). With respect to seed yield of fahl berseem, there were no significant differences between 75 and 90 kg N fed^{-1} for this trait. Similar results were obtained by Abdel-Wahab and Elmanzalawy (2016). The recommended mineral N fertilizer rate of wheat plants and improved quality of wheat grains without any negative effects on quality of intercropped faba bean seeds.

3.5.2. Intercropping patterns

Seed yields of fahl berseem or faba bean were affected significantly by intercropping patterns (Table 8). Intercropping patterns 100% wheat + 40% barseem fahl or faba bean had the

Table (8): Effect of N fertilizer levels, intercropping patterns and their interaction on seed yields of fahl berseem and faba bean, combined data across 2013/2014 and 2014/2015.

Traits		Seed yield of faba bean (kg fed^{-1})	Seed yield of fahl berseem ($kgfed^{-1}$)
60 kg N fed^{-1}		178.8	47.9
75 kg N fed^{-1}		201.9	56.1
90 kg N fed^{-1}		183.0	55.7
L.S.D. 0.05		**1.25**	**1.84**
100% wheat + 20% faba bean or fahl berseem		150.9	49.6
100% wheat + 30% faba bean or fahl berseem		194.3	53.1
100% wheat + 40% faba bean or fahl berseem		218.5	57.3
L.S.D. 0.05 Intercropping systems		**2.06**	**1.41**
60 kg N fed^{-1}	100% wheat + 20% faba bean or fahl berseem	144.0	43.0
	100% wheat + 30% faba bean or fahl berseem	178.5	47.5
	100% wheat + 40% faba bean or fahl berseem	213.5	53.0
75 kg N fed^{-1}	100% wheat + 20% faba bean or fahl berseem	159.5	53.0
	100% wheat + 30% faba bean or fahl berseem	211.5	57.0
	100% wheat + 40% faba bean or fahl berseem	234.5	60.0
90 kg N fed^{-1}	100% wheat + 20% faba bean or fahl berseem	149.0	53.0
	100% wheat + 30% faba bean or fahl berseem	194.0	55.0
	100% wheat + 40% faba bean or fahl berseem	207.5	59.0
L.S.D. 0.05 Interaction		**3.56**	**N.S.**
Sole culture		964	401

highest *($P \leq 0.05$)* seed yield of legume component, meanwhile the lowest seed yield of legume component was obtained by intercropping patterns 100% wheat + 20% barseem fahl or faba bean.Obviously, plant density of fahl berseem or faba bean played a major role in seed yield per unit area under intercropping conditions and gave the highest seed yield of legume component. Dahmardeh *et al.* (2010) revealed that increasing plant density from 12.5 to 20 plant m^{-2} increased significantly economical yield. Also, Al-Suhaibani *et al.*, (2013) found that increasing plant density resulted in a significant decrease in all yield components of individual plants but seed yield increased with densities up to 8 plants $dripper^{-1}$. Kandil and Sharief, (2016) reported that total yield of Egyptian clover per unit area tended to increase with seeding rates.

3.5.3. Interaction between N fertilizer levels and intercropping patterns

Seed yield of faba bean fed^{-1} was affected significantly by the interaction between N fertilizer levels and intercropping patterns, meanwhile seed yield of fahl berseem fed^{-1} was not affected (Table 8). Intercropping pattern 100% wheat + 40% faba bean with the application of 75 kg N fed^{-1} had the highest seed yield fed^{-1}, but the reverse was true by intercropping pattern 100% wheat + 20% faba bean that received either 60 or 90 kg N fed^{-1}. These data reveal that there were effect ($P \leq 0.05$) of mineral N fertilizer levels x intercropping patterns on seed yield of faba bean fed^{-1}. In this concern, interaction effect of N and planting density on seed yield was significant and maximum yield was obtained from application of 90 kg ha^{-1} N and the highest level of density (Golabi and Lak, 2005). Also, Khamooshi *et al.*, (2012) showed that the effect of plant density and N were significant on faba bean seed yield.

3.6. Quality of fahl berseem and faba bean seeds

3.6.1. Mineral N fertilizer levels

Seed N and protein contents of fahl berseem and faba bean were affected significantly by N fertilizer levels in the combined analysis (Table 9). Increasing mineral N fertilizer level from 60 to 75 kg N fed^{-1} increased ($P \leq 0.05$) seed N and protein contents of fahl berseem or faba bean but it were decreased by increasing mineral N fertilizer level from 75 to 90 kg N fed^{-1}. These results were attributed to the application of the highest mineral N fertilizer level affected negatively all the studied traits of soil biological properties and thereby PGPR becomes lazy compared with the other treatments (Table 2). Similar results were abstained by Abdel-Wahab and Elmanzalawy (2016), the recommended mineral N fertilizer rate of wheat plants and improved quality of wheat grains without any Negative effects on quality of intercropped faba

Table (9): Effect of N fertilizer levels, intercropping patterns and their interaction on quality of faba bean and fahl berseem seeds, combined data across 2013/2014 and 2014/2015.

Traits		Faba bean (%)		Fahl berseem (%)	
		Seed N content	Seed protein content	Seed N content	Seed protein content
60 kg N fed^{-1}		3.25	20.36	2.43	15.23
75 kg N fed^{-1}		3.91	24.48	2.64	16.52
90 kg N fed^{-1}		3.27	20.46	2.59	16.19
L.S.D. 0.05 N fertilizer levels		**0.06**	**0.42**	**0.05**	**0.32**
100% wheat + 20% faba bean or fahl berseem		3.28	20.54	2.52	15.76
100% wheat + 30% faba bean or fahl berseem		3.51	21.98	2.56	16.04
100% wheat + 40% faba bean or fahl berseem		3.62	22.65	2.58	16.13
L.S.D. 0.05 Intercropping systems		**0.03**	**0.20**	**0.04**	**0.25**
60 kg N fed^{-1}	**100% wheat + 20% faba bean or fahl berseem**	3.03	18.96	2.41	15.06
	100% wheat + 30% faba bean or fahl berseem	3.33	20.81	2.45	15.33
	100% wheat + 40% faba bean or fahl berseem	3.55	22.20	2.44	15.29
75 kg N fed^{-1}	**100% wheat + 20% faba bean or fahl berseem**	3.77	23.60	2.62	16.37
	100% wheat + 30% faba bean or fahl berseem	3.86	24.15	2.64	16.51
	100% wheat + 40% faba bean or fahl berseem	3.89	24.33	2.67	16.68
90 kg N fed^{-1}	**100% wheat + 20% faba bean or fahl berseem**	3.05	19.06	2.54	15.87
	100% wheat + 30% faba bean or fahl berseem	3.35	20.98	2.62	16.37
	100% wheat + 40% faba bean or fahl berseem	3.42	21.40	2.61	16.33
L.S.D. 0.05 Interaction		**0.05**	**0.36**	**NS**	**NS**
Sole culture		3.91	37.76	2.64	16.52

bean seeds.

3.6.2. Intercropping patterns

Seed N and protein contents of fahl berseem and faba bean were affected significantly by intercropping patterns in the combined analysis (Table 9). Intercropping pattern 100% wheat + 40% fahl berseem or faba bean increased *($P \leq 0.05$)* seed N and protein contents, meanwhile the lowest values of seed N and protein contents of fahl berseem and faba bean were obtained by intercropping pattern 100% wheat + 20% fahl berseem and 20% faba bean, respectively. These results were due to intercropping pattern 100% wheat + 40% fahl berseem or faba bean improved N, P, K and O. M. in rhizosphere of wheat roots (Table 2) which reflected positively on decreasing inter-specific competition between the intercrops for basic growth resources. Similar results were observed by Sarunaite and Kadziuliene (2010) who found that the significantly higher crude protein concentration was observed in the total intercrops grain yields compared with the sole wheat yield.

3.6.3. Interaction between N fertilizer levels and intercropping patterns

Seed N and protein contents of faba bean were affected significantly by N fertilizer levels x intercropping patterns in the combined analysis, meanwhile seed N and protein contents of fahl berseem were not affected (Table 9). Intercropping pattern 100% wheat + 40% faba bean with the application of 75 kg N fed^{-1} had the highest seed N and protein contents, meanwhile the lowest values of grain N and protein contents were obtained by intercropping pattern 100% wheat + 20% faba bean that received either 60 or 90 kg N fed^{-1}.

3.7. Competitive relationships

3.7.1. Land Equivalent ratio (LER)

The total LER values were greater than one in all the studied treatments. The highest values were obtained by (1.25) under intercropping pattern 100% wheat + 20.0% barseem fahl that received 75 kg N fed^{-1} and (1.33) under intercropping pattern 100% wheat + 20% faba bean that received 75 kg N fed^{-1} .While, The lowest values were obtained by (1.04) under intercropping pattern 100% wheat+ 40.0% barseem fahl with the application of 90 kg N fed^{-1} and (1.10) under intercropping pattern 100% wheat + 40% faba bean with the application of 90 kg N fed^{-1} (Fig. 1) and (Table10).

Table (10): Effect of nitrogen fertilizer levels and intercropping faba bean or fahl barseem on LER,CR and average of net return (the combined analysis).

Nitrogen levels	Intercropping treatments	Intercropping Yields			LER			CR		Economic evaluation (L.E.)		
		Wheat Ton fed^{-1}	Faba bean kg/fed	Fahl berseem kg/fed	L_w	L_b	Total	CR_w	CR_b	Total revenue	Total cost	Net return
60 kg N fed^{-1}	B_1	2.647	144.0	-	1.04	0.15	1.19	1.39	0.72	10282	7542	2740
	B_2	2.632	178.5	-	1.04	0.19	1.22	1.64	0.61	10240	7572	2668
	B_3	2.578	213.5	-	1.02	0.22	1.24	1.85	0.54	10282	7602	2680
	B_4	2.498	-	43.0	0.99	0.11	1.09	1.80	0.56	9659	7542	2117
	B_5	2.377	-	47.5	0.94	0.12	1.06	2.35	0.43	9440	7572	1868
	B_6	2.237	-	53.0	0.88	0.13	1.01	2.74	0.37	9328	7602	1726
Average										**9871**	**7572**	**2299**
75 kg N fed^{-1}	B_1	2.973	159.0	-	1.16	0.17	1.33	1.36	0.73	11358	7595	3763
	B_2	2.795	211.5	-	1.10	0.22	1.32	1.50	0.67	11156	7625	3531
	B_3	2.571	234.5	-	1.01	0.24	1.26	1.68	0.59	10623	7655	2968
	B_4	2.849	-	53.0	1.12	0.13	1.25	1.72	0.58	11313	7595	3718
	B_5	2.472	-	57.0	0.97	0.14	1.12	2.10	0.48	10404	7625	2779
	B_6	2.357	-	60.0	0.93	0.15	1.08	2.48	0.40	10315	7655	2660
Average										**10908**	**7625**	**3283**
90 kg N fed^{-1}	B_1	2.435	149.0	-	0.96	0.15	1.11	1.28	0.78	9770	7647	2123
	B_2	2.321	194.0	-	0.92	0.20	1.12	1.37	0.73	9547	7677	1870
	B_3	2.308	207.5	-	0.91	0.22	1.13	1.65	0.60	9564	7707	1857
	B_4	2.463	-	53.0	0.97	0.13	1.10	1.49	0.67	10308	7647	2661
	B_5	2.350	-	55.0	0.93	0.14	1.06	1.99	0.50	10058	7647	2411
	B_6	2.265	-	59.0	089	0.15	1.04	2.37	0.42	10082	7677	2405
Average										**9888**	**7667**	**2221**
Solid wheat		2.536 ton fed^{-1}			-	-	1	-	-	8937	7707	1230
Solid Faba bean		0.964 ton fed^{-1}			-	-	1	-	-	7432	6101	1331
Solid Fahl berseem		0.401 ton fed^{-1}			-	-	1	-	-	9015	6937	2078

L_w: Land equivalent ratio of wheat. **L_b: Land equivalent ratio of faba bean or fahl berseem**

CR_w: Competitive ratio of Wheat. **CR_i: Competitive ratio of faba bean or fahl berseem**

B_1:100%wheat+20% faba bean **B_2: 100% wheat +30%faba bean** **B_3: 100% wheat +40 %faba bean**

B_4: 100% wheat + 20% fahl berseem **B_5: 100% wheat +30 % fahl barseem** **B_6: 100% wheat +40% fahl berseem.**

Generally, these results reveal that intercropping pattern 100% wheat + 20% barseem fahl or 100% wheat + 20% faba bean interacted with 75 kg N fed^{-1} to decrease inter or intra-specific competition between plants of the intercrops or plants of wheat, respectively, for available environmental conditions. In other words, the lowest of plant density of legume component increased inter-specific complementary interactions between the intercrops for basic growth.Resources and this effect was improved by increasing mineral N fertilizer level from 60 to 75 kg N fed^{-1}. These results are in accordance with those observed by Abdel-Wahab and El Manzlawy, (2016) who indicated that the highest LER (1.32) was obtained by intercropping faba bean with four rows of wheat with the application of 100 kg N fed^{-1} under sandy soil conditions.

3.7.2. Competitive ratio (CR)

Data in Fig. (2) and Table (10) Show CR values that express the exact degree of competitive. CRw of wheat was higher than CRb of fahl barseem or faba bean in all treatments. Wheat crop was more competitive than fahl barseem or faba bean indicating the dominance of wheat on fahl barseem or faba bean. CRw of wheat was increased by increasing the plant density of legume component but the reverse was true for CRb of fahl barseem or faba bean.

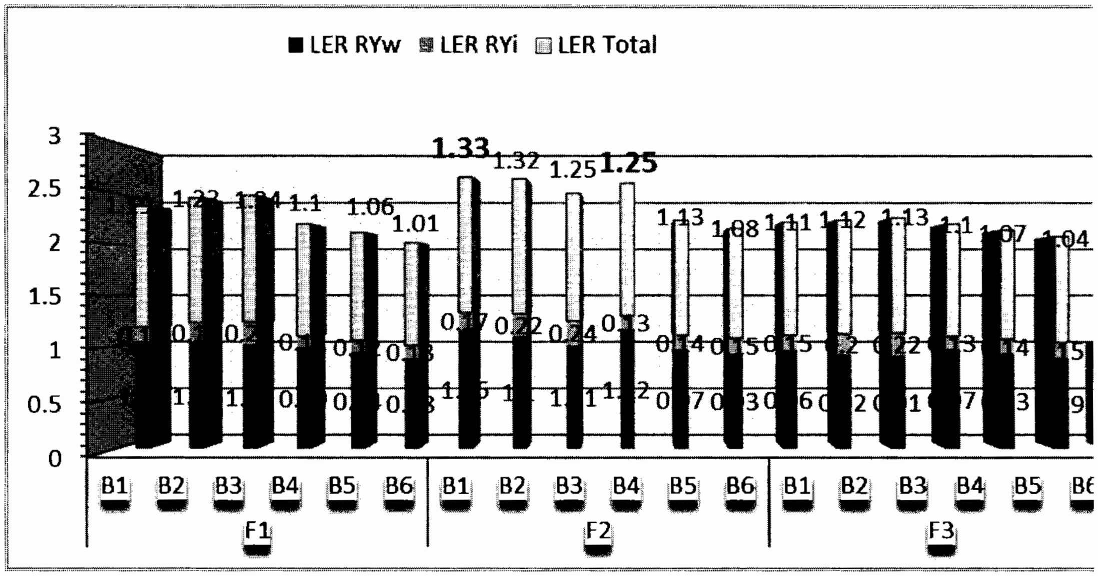

Fig. (1): Land equivalent ratio (LER) as affected by N fertilizer levels, intercropping patterns and their interaction, combined data across 2013/2014 and 2014/2015.

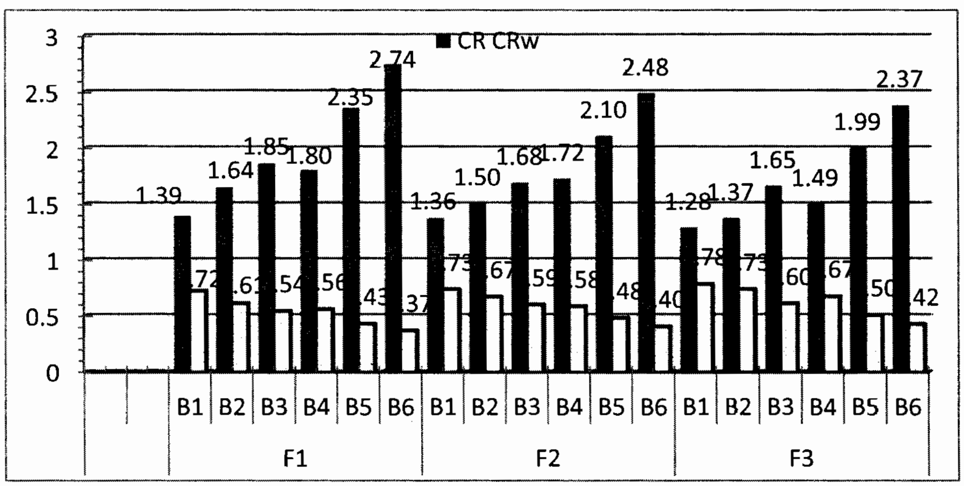

Fig. (2): Competitive ratio (CR) as affected by mineral N fertilizer levels, intercropping fahl barseem or faba bean and their interactions, combined data across 2013/2014 and 2014/2015.

3.7.3. Financial return

The financial returns of intercropped wheat as compared to sole wheat are shown in (Table 10). Intercropping fahl barseem or faba bean increased total and net returns compared to sole wheat. Net return of intercropped wheat varied from L.E. 1726 to 3783 fed^{-1} compared to sole wheat (L.E. 1230 fed^{-1}). Clearly, application of 75 kg N fed^{-1}achieved the highest net return of farmers compared to the other mineral N fertilizer levels. Accordingly, intercropping patterns 100% wheat + 20% faba bean and 100% wheat + 20% fahl barseem that received 75 kg N fed^{-1} increased net return of farmers by L.E. 2553 and 2488 per fed, respectively, over those of sole wheat. These results are in accordance with those obtained by Agegnehu *et al.* (2006) who found that mixed intercropping faba bean in normal barley culture at a density not less than 37.5% of the sole faba bean gave better overall yield and income than sole culture of each crop species. Also, Mohammed Wafaa,

(2014) showed that intercropping faba bean with wheat that received 285.6 kg/ha gave higher net income compared to sole wheat

Conclusion

Our results demonstrated that intercropping legumes with wheat had significant effects on bacterial community diversity in the rhizosphere of wheat and helped to increase availability of soil N, P, K and O. M. contents without excessive mineral N in the same season. Intercropping berseem or faba bean with wheat can be a practicable alternative to reduce the use of mineral N fertilizer per unit area by increasing inter-specific complementary interactions between the intercrops. intercropping patterns 100% wheat + 20% faba bean and 100% wheat + 20% fahl berseem that received 75 kg N fed^{-1} increased net return of farmers by L.E. 2553 and 2488 per fed, respectively, over those of sole wheat.

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تأثير تحميل اثنين من المحاصيل البقولية و التسميد الآزوتي المعدني علي محصول القمح ونشاط الكائنات الحية الدقيقة في منطقة انتشار الجذور.

نادية محمد احمد عيسي - بسمة رشوان احمد رشوان* - شيماء حسن فتحي ابو زيد **

قسم بحوث التكثيف المحصولي – معهد بحوث المحاصيل الحقلية– مركز البحوث الزراعية - مصر
*قسم بحوث تغذية النبات و **قسم بحوث الميكروبيولجي –معهد بحوث الاراضي و المياه والبيئة
مركز البحوث الزراعية – مصر

ملخص

أجريت تجربتين حقليتين في محطة البحوث الزراعية بملوي (مصر الوسطي) خلال الموسمين (2014/2013 و 2015/2014) لتقييم تأثير نظم تحميل الفول البلدى والبرسيم الفحل تحت ثلاثة مستويات من التسميد الأزوتي علي محصول القمح والفول البلدى والبرسيم الفحل و النشاط البكتيري في التربة .استخدم تصميم القطع المنشقة مرة واحدة في ثلاث مكررات .وزعت مستويات التسميد المعدني الأزوتي في القطع الرئيسية (90 , 75, 60 كجم نتروجين /فدان). بينما نظم التحميل (100٪ قمح + 20٪ فول بلدي، 100٪ قمح + 30٪ فول بلدي، 100٪ قمح + 40٪ فول بلدي، 100٪ قمح + 20٪ برسيم فحل ، و 100٪ قمح + 30٪ برسيم فحل ، 100٪ قمح + 40٪ برسيم فحل) في القطع الشقية بالإضافة إلى الزراعة المستقلة لكل من القمح والبرسيم والفول. تأثر معنويا كل من محتويات التربة من النتروجين، الفوسفور، البوتاسيوم والمواد العضوية وكذلك انتاجية الفول البلدي وجودته وذلك بزيادة معدل التسميد النتروجيني ونظم التحميل وتفاعلها فيما عدا محصول البرسيم الفحل وجودته لم تتأثر بكل من مستويات التسميد ونظم التحميل . تم الحصول علي أعلي قيمة لمحتويات التربة عند اضافة 90 كجم نتروجين/فدان مع 100 % قمح+40 % فول بلدي مقارنة بالمعاملات الأخرى .تأثر معنويا بزيادة معدل التسميد النتروجيني ونظم التحميل وتفاعلها كلا من الخصائص البيولوجية للتربة ومحصول القمح ومكوناته وكذلك جودته. أدّت زيادة التسميد المعدني من 60 - 75 كجم نتروجين للفدان الى زيادة كل الصفات تحت الدراسة . فيما عدا طول السنبلة ووزن ال1000 حبة .أدّت زيادة معدل التسميد النتروجيني(90كجم نتروجين) الي ادني قيم البيولوجية للتربة ومحصول القمح ومكوناته وكذلك جودته. تم استخدام البيانات المتحصل عليها في دراسة العلاقة بين نتروجين التربة وميكروبات التربة وكذلك المحصول ومكوناته باستخدام معامل الارتباط البسيط . كان معدل كفاءة استغلال الارض أكبر من واحد مما يدل علي زيادة كفاءة التحميل. تم الحصول علي أكبر قيمة لمعدل استغلال الارض عند أضافة 75 كجم نتروجين للفدان مع 100 % قمح + 20 % فول بلدي . كان القمح أكثر قدرة علي المنافسة (سائد) من الفول والبرسيم الفحل (المسود) . تحقق أعلى عائد للمزارع عند اضافة 75 كجم نتروجين مع 100% قمح + 20% فول بلدى أو برسيم فحل وهذه الزيادة 2554, 2488 جنيه / فدان علي التوالي مقارنة بالزراعة المنفردة .

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