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INTERCROPPING OF WHEAT WITH FABA BEAN PLANTS AS AFFECTED BY BIOFERTILIZATION

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ABSTRACT

Two field experiments were conducted at the Sakha Agricultural Research Station in seasons 2002 and 2003 to study the role of inoculation with a mixture contains *Rhizobium leguminosarum biovar viceae* + *Bacillus megatherium* (for faba bean) and *Azotobacter* spp. + *B. megatherium* (for wheat) as well as addition of farmyard manure; FYM (5.0 tons/fed) at different levels of nitrogen (15 0, 40 0 and 70 kg N/fed) on some yield and chemical components and some seeds technological characteristics under intercropping sercumistances.

Results show that intercropping system decreased straw and seed yield of both crops and achieved lower values in comparison with their corresponding controls (pure stands). Since, in the intercropping system, the plots are cultivated with a mixture of two plant crops by a ratio of 50:50%. As a general, inoculation in combination with the two N-fertilizer levels (15 and 40 kg N/fed.) relatively increased straw seed yields of both crops as compared with uninoculated control. The increase were mostly significant. On the other hand, inoculation, intercropping and/or addition of farmyard manure increased nodules dry weight (g/3 plants) of faba bean. There were no significant effects between the different treatments and control for germination %, seed moisture %, radical and shoot lengths of either wheat grains or faba bean seeds. Weight of 100 seeds of both wheat and faba bean were significantly increased. Also, microbial inoculation in the intercropping system led to an increase in volume and density of wheat grains and faba bean seeds. The results of some treatments were significant. Also, microbial inoculation and intercropping significantly increased crude protein of wheat grains, while faba bean seeds showed inconsistent pattern. Regarding percentage of ether extract constituents (E.E) and ash%, there were no significant variations for either wheat grains or faba bean seeds Although,there is no unique trend due to inoculation,intereropping and FYM on total carbohydrate% of wheat grains as they achieved less values than tradition control ,carbohydrate % of faba bean seeds is significantly increase .Intercropping and FYM increased land equivalent ratio (LER) The application of FYM strengthed the positive effect of microbial inoculation.

It could be concluded that microbial inoculation of both intercropped crops achieved the highest net return when 40 kg N/fed. was applied (at first season) and 15 kg N/fed. and FYM (at second seasons) and their corresponding net return values reached 1783 and 1401(L.E./fed.) respectively.

Keywords: Intercropping - *Rhizobium* - *Azotobacter* - *B. megatherium* - Farmyard manure

INTRODUCTION

Sustainable agriculture seeks at least in principles to use nature as the model for designing agricultural system. By understanding principles we

can use them to reduce costs and increase profitability while at the same time sustaining our land resource base.

Among the nature resources, soil is infinite, not elastic and non-renewable asset. In Egypt, in dwindling per-capita availability of land decreased because of population escalation and is likely to reduce further. So, the pressure on agricultural lands is increasing and attempts to maximize yield under traditional agriculture on small holding may not be enough to ensure food security (FAO, 1997).

Scientific management of these invaluable resources has assumed a greater significance over time. One of these approaches is cropping intensity which take several forms such as intercropping.

Intercropping offers farmers the opportunity to engage nature's principle of diversity of their farms. Farmers have generally regarded intercropping as a technique that reduces risks in crop production, if one member of intercrop fails, the other survives and compensates in yield to some extent allowing the farmers an acceptable harvest. Intercropping of legume with non-legume was found to be attractive and can be more productive than growing pure stands. In this respect Abbas *et al.* (1999) reported that intercropping of elephant grass on leucaena plant increased yield of elephant grass. Also, Cowell *et al.* (1989) found that intercropping increased land equivalency.

Due to the over use of agricultural lands, the soil fertility is diminished gradually. Application of organic wastes and biofertilizer are considered the main sources to meet the nutrient requirements of crops. Furthermore, knowing the deleterious effects of using only the chemical fertilizer, use the microorganisms which can either fix atmospheric nitrogen or solubilize phosphates or stimulate of growth promoting substances will be environmentally benign approach for nutrient management and ecosystem function (Dobereiner and Pedrosa, 1987; Alagawadi and Gaur, 1988; Dashti *et al.*, 1997; Nour El-Dein, 1997 and Zein *et al.*, 2000).

The present work was carried out to deal with major aspects, the first, intercropping system of wheat with faba bean (the two important strategic crops of human feeding in Egypt). The second application of biofertiizer using *Rhizobium, Azotobacter* and *B. megatherium* in combination with different levels of N-fertilization. The third, addition of organic fertilizer in a form of farmyard manure (FYM). This study aimed to clarify the pattern of nodulation, seed yield, yield component and seed and grain quality as well as to find out the best combination that can achieve the maximum yield of both wheat and faba bean crops.

MATERIALS AND METHODS

Two field experiments were conducted in seasons 2002 and 2003 at the Sakha Agricultural Research Station, Kafr El-Sheikh.

Inoculants:

The inoculants contained *Rhizobium leguminosarum* biovar *viceae* + *B. megatherium* for faba bean, *Azotobacter* spp.+*B. megatherium* for wheat. *Azotobacter* and *Rhizobium* were obtained from the Microbiology Lab., at Sakha experimental station and the *B. megatherium* was kindly provided by the Microbiology Lab. ARC, Giza. They were used as peat-based inoculants. Microbial densities of the inoculant were 2 x 10^8 CFU/g of inoculum for the rhizobia, 3.5 x 10^8 CFU/g for the *Azotobacter* spp.

Azotobacter was isolated from rhizosphere of maize plants and cultured using Vancura and Mucura (1960) medium: Sucrose, 30.0 g; K_2HPO_4, 0.16 g; NaCl, 0.2 g; $MgSo_4$-$7H_2O$, 0.2 g; $CaCo_3$, 2.0 g; Fe_2 $(SO_4)_3$, 0.005g; $NaMo_4$, 0.005; $NaBO_3$, 0.005g and distilled water, 1 L. The medium was autoclaved at 121°C for 15 minutes. The obtained isolate was subjected to morphological, cultural and biochemical characteristics according to the method of Breed *et al.* (1974).

Rhizobium was cultured using yeast mannitol medium (Somasegaran and Hoben, 1985): Mannitol, 10.0 g; K_2H PO_4, 0.2 g; $MgSo_4$-$7HG_2O$, 0.2 g; NaCl, 0.1 g; yeast extract, 0.5g and distilled water, 1 L. pH was adjusted to 7 and medium was autoclaved at 121°C for 15 minutes.

B. megatherium was cultured using nutrient broth medium: beaf extract, 3 g; peptone, 10 g and distilled water ,1L.

Plant Species:

Grains of wheat (Sakha 93) and seeds of faba bean (Giza blanka), were kindly provided by Agronomy Research Institute, Sakha Agricultural Research Station, Sakha.

Experimental procedure:

Intercropped plots (2.0 m x 2.0 m) were sown with both wheat grains in lines in one side of the ridge at 30 kg and faba bean seeds (25 kg/f.) on hills of the other side of ridges at 15 cm distance. Control plots for either wheat or faba bean were carried out by planting both ridges with either wheat grains (60 kg/fed.) or faba bean seeds (50 kg/fed.). Distance between each ridge was 70 cm. The sowing dates of the two seasons were 2nd of December, 2002 and 27th of November 2003.

A factorial plot design with four replicates was applied. Every crop of wheat and faba bean or their intercropping treatment received the following 6 treatments as follow (18 treatment):

1. Un-inoclated (unino) + 70 kg N/f. (traditional)
2. Un-inocualted (unino) + 70 kg N/f. + FYM.
3. Inoculated + 40 kg N/fed.
4. Inoculated + 40 kg N/fed. + FYM
5. Inoculated + 15 kg N/fed.
6. Inoculated + 15 kg N/fed. + FYM

Fertilization:

Nitrogenous fertilizer was added as urea at 70 (kg N/fed.) for non-inoculated treatments and 40 and 15 kg N/fed. for inoculated ones. Inoculated experimental plots received phosphorus as calcium superphosphate at level of 15 kg P_2O_5 fed.$^{-1}$ But un-inoculated treatments received 30 kg P_2O_5/fed. All experimental plots fertilized with the same level of K as K_2SO_4 (15 kg K_2O/fed.). Representative soil samples were collected before sowing to estimate some chemical and physical characteristics of experimental soil. Chemical and physical properties of soil as well as farmyard manure chemical compositions were analyzed according to the methods described by Black (1965) and tabulated in Table (1).

Plant sampling:

Plant samples were collected after 60 days from planting for estimation of nodules dry weight (g/3 plants) and other samples were colleced at harvest for estimation of yield components and chemical determinations. Nodules were detached from washed roots and dried in oven at 70°C till their weight became stable. Grains and straw yields were assessed and calculated to be at 15% moisture content. Seed index (100-seeds weight, g), volume of 100 seeds (cm^3) and seeds density (g/cm^3) were also estimated.

Table (1): Some initial physicochemical characteristics of the experimental soil and farmyard manure.

Experimental soil

EC (dSm^{-1})	Soluble cation meq/L.				Soluble anions meq/L.				SAR	pH	OM %	Texture clay %	$CaCO_3$ %
	Na	K	Ca	Mg	CO_3	HCO^-_3	Cl^-	SO^-_4					
4.53	25.00	1.10	15.80	8.10	1.20	5.20	19.20	24.40	7.24	8.3	1.95	57.8	2.38

Farmyard manure

E.C (dSm^{-1}) 1: 10	pH 1: 10	CEC meq/ kg	OM %	N %	P %	K %	C %	C/N %	Fe	Mn	Zn	Cu
									ppm			
2.89	7.56	43.6	36.64	1.29	0.114	0.486	21.3	16.5	248	61 30	63.4	5.05

Seed vigor:

Germination was carried out under optimum conditions according to international rules (I.S.T.A. 1993). Radical, shoot length and seedling dry weight were also measured according to the procedures reported in seed vigor testing hand book (A.O.S.A., 1991).

Chemical analysis:

Samples of faba bean seeds and grains of wheat were collected randomizly from each treatment then ground to fine powder to pass through 2 mm seive and stored for the following chemical analysis: Crude protein (CP); ether extract (EE); ash, crude fiber (CF) and total carbohydrate were determined according to the procedures outlined in A.O.A.C. (1990). Trace elements, Mn, Zn, Fe and Cu were determined according to the method of Black (1965) using atomic absorption spectrophotometer (Perkin-Elmer instrument Model 2380 AL).

Land equivalent ratio (LER) calculation:

It was calculated according to Willey (1965) by the following equation:

$$LER = \frac{Y_f}{Y_{sf}} + \frac{Y_w}{Y_{sw}}$$

Where:

Y_f = seeds yield of intercropped faba bean.
Y_{sf} = seeds yield of pure stand of faba bean.
Y_w = seeds yield of intercropped wheat.
Y_{sw} = seeds yield of pure stand of wheat.

Statistical analysis:

Analysis of variance (ANOVA) was calculated by the method reported by Steel and Torrie (1980), using IRRISTAT software version 3/93 (Biometric Unit). Multiple range test were used to compare means at 0.05 level of probability (Duncan, 1955).

RESULTS AND DISCUSSION

Nodulation pattern of faba bean plants:

Data presented in Table (2) indicated that intercropping mostly increased dry weight of nodules (g/3 plants). The increases at 15 kg N/fed. were significant. It was also noted that, all inoculated treatments increased it over control. The increases were mostly significant. The treatments of (inoculated + 40 kg N/fed. + FYM, pure stand) and (inoculated + 15 kg N/fed. + FYM, intercropped) attained the highest values (4.20 and 4.11 g/3 plants). Many reports indicated that inoculation of legumes with rhizobia enhanced nodulation process (Rasal and Patil, 1989; Monib *et al.*, 1999 and Badr El-Dein *et al.*, 2001). On the other hand, reports on the effect of intercropping on nodulation were contradicting, whereas Abbas *et al.*, 1999 found that nodulation status of legume crop (leucaena) was not affected by intercropping with elephant grass. But, Patra and Poi (1998) found that when legume (pea) was intercropped with cereals (wheat), legume crop was poorly nodulated and less nitrogen fixation took place, and they related this to shading effect caused by wheat.

In the present study, the positive response of intercropping wheat with faba bean on faba bean nodules dry weight could be attributed to the difference in root shape of each intercropped crops whereas wheat plants have fibrous roots which occupate the upper surface layer of soil, but faba bean have tap roots that extended deeply in soil, the matter which causes less competition between both crops on nutrients and water uptake. In the same time, shoot systems of the two crops were approximately similar and consequently wheat plants did not shad faba bean, so that nodulation process succeeded under these conditions. So far, nodulation was further

strengthened by the application of FYM at the two levels of N-fertilization and these may be attributed to the better environmental condition in plant rhizosphere beside its role in increasing the level of supply in available form of the nutritional elements required at trace levels both by the plant and by the nodule system.

Table (2): Nodules dry weight (g/3 plants) of faba bean intercropped on wheat plants as affected by microbial inoculation and/or farmyard manure addition.

Treatments	Dry weight of nodules (g/3 plants)	
	Faba bean pure stand	Faba bean intercropped
Un-inoculated + 70 kg N/fed.	1.53	1.52
Un-inoculated + 70 kg N/fed. + FYM	0.90	1.55
Inoculated + 40 kg N/fed.	2.29	3.80
Inoculated + 40 kg N/fed. + FYM	4.20	3.31
Inoculated + 15 kg N/fed.	1.56	3.55
Inoculated + 15 kg N/fed. + FYM	2.19	4.11
L.S.D.	1.82	

N: Nitrogen FYM: Farmyard manure

Seed yield and yield components of wheat and faba bean:

1.Straw yield:

It is worthy to mention that intercropped plots was planted with wheat and faba bean with ratio of 50: 50%, so that yield of wheat represented 50% of the plot area and yield of faba bean represented 50% of its pure stand area. While yield of pure stands (wheat or faba bean) represent the all area of the plot. Therefore yield of one crop in intercropped treatments will be lower than its corresponding control (one crop). Data of Table (3) indicated that intercropping decreased straw yield of wheat and faba bean plants lower than their corresponding control (pure stand of wheat or pure stand of faba bean). For example, treatment of (uninoculated + 70 kg N/fed. pure stand of wheat) gave 6.7 tons/fed. compared to 4.03 tons/fed. for (uninoculated + 70 kg N/fed., intercropped) in the first season. Also, faba bean straw yield evaluated 2.81 and 1.32 ton/fed. due to treatment of (uninoculated + 70 kg N/fed., faba bean) and uninoculated + 70 kg N/fed., intercropped) respectively. Results of the second season gave a similar trend. Inoculation and farmyard manure addition did not give consistent influence.

2.Grains yield of wheat and seeds yield of faba bean:

Data of Table (4) represent grains yields of wheat and seeds yield of faba bean. Intercropping decreased grains yield of wheat and seeds yield of faba bean lower than their corresponding pure stand crop (control.), this influence is due to the aforementioned reason. The decreases ranged from 17.1 to 47.1% for wheat, and from 17.7 to 52.3% for faba bean. While, microbial inoculation caused increases in yield of both crops. It is noted that this positive influence of inoculation is more obvious in case of intercropped

treatments, this may be due to the effect of N_2-fixing and phosphate-dissolving microorganisms presents in the used inoculum and their role in availability of N and P through N_2-fixation and solubility of soil phosphates, in addition, these microorganisms release growth phytohormones which make the plant more healthy, due to increasing the absorbing capacity of root system. These sercumestances may decrease competition between intercropped plants.

Table (3): Straw yields of intercropped wheat on faba bean plants as affected by microbial inoculation and/or farmyard manure addition (tons/fed.).

Treatments	Wheat				Faba bean			
	2002		2003		2002		2003	
	Pure stand	Inter-cropped	Pure stand	Inter-cropped	Pure stand	Inter-cropped	Pure stand	Inter-cropped
Un-inoculated + 70 kg N/fed.	6.70	4.03	5.51	3.19	2.81	1.32	2.84	1.63
Un-inoculated + 70 kg N/fed. + FYM	6.16	4.03	5.15	3.01	2.51	1.42	2.43	1.42
Inoculated + 40 kg N/fed.	9.47	5.38	5.15	3.73	2.84	1.07	2 78	1.51
Inoculated + 40 kg N/fed. + FYM	9.59	4.39	5.51	3.55	3 55	1 60	2.34	1.28
Inoculated + 15 kg N/fed	9.11	5.68	5 32	3.19	2 96	1.36	2.43	1.36
Inoculated + 15 kg N/fed. + FYM	8.93	4.62	5.50	3.19	2.88	1.33	3.29	1.69
L.S.D.	0.59		0.48		0.32		0.47	

N: Nitrogen FYM: Farmyard manure

Table (4): Grains yield and seeds yields of intercropped wheat on faba bean plants, as affected by microbial inoculation and/or farmyard manure addition (tons/fed.).

Treatments	Wheat				Faba bean			
	2002		2003		2002		2003	
	Pure stand	Inter-cropped	Pure stand	Inter-cropped	Pure stand	Inter-cropped	Pure stand	Inter-cropped
Un-inoculated + 70 kg N/fed.	1.72	0.92	1.43	0.86	1.02	0.49	0.96	0.52
Un-inoculated + 70 kg N/fed. + FYM	1.65	0.92	1.44	0.94	0.89	0.68	0.80	0.66
Inoculated + 40 kg N/fed.	2.2	1.44	1.37	1.07	1.09	0.65	1.04	0.61
Inoculated + 40 kg N/fed. + FYM	2.3	1.06	1.40	1.16	1.01	0.69	0.79	0.53
Inoculated + 15 kg N/fed.	2.18	1.33	1.68	0.89	1.08	0.55	0.80	0.47
Inoculated + 15 kg N/fed. + FYM	1.90	1.03	1.44	1.16	1.02	0.52	1.15	0.69
L.S.D.	0.37		0.25		0.11		0.17	

N: Nitrogen FYM: Farmyard manure

In the first season, wheat grains yield achieved 1.72 tons/fed. for treatments of (uninoculated + 70 kg N/fed., wheat pure stand) compared to 2.20 and 2.18 tons./fed. for (inoc. + 40 kg N/fed., solitary wheat) and (inoculated + 15 kg N/fed., pure stand of wheat, respectively with percentages over un-inoculated control by 146.5 and 126.7%, respectively. Also, intercropped treatments attained 0.92 ton/fed., for (uninoculated + 70 kg N/fed., intercropped) compared to 1.44 and 1.33 tons/ed. for (inoculated + 40 kg N/fed. + intercropped) and (inoculated + 15 kg N/fed., intercropped) respectively, with percentages increase over their corresponding inoculated control, representing 156.5 and 144.6% respectively. It is noted that percentages of increases over un-inoculated control for intercropped

treatments were higher than those of pure stand crops. This may be attributed to the above mentioned reasons.

Results of the second season were as similar as first one. Farmyard manure addition did not exhibit consistent trend, this may be due to the relative small applied amount of it (5 tons/fed.).

The high relative response of inoculation and fertilization could be also attributed to the improved uptake of soil nitrogen and improved assimilation of the nitrogen in plants. Although the inoculated treatments received low amounts of N-fertilizers ranged between 15-40 kg N/fed., in the presence of absence of FYM, it exceeded uninoculated ones that received 70 kg N/fed. in the presence or absence of F.Y.M. The average increases of the two experimental seasons of un-inoculated treatments were about 1.56, 0.92, 0.91 and 0.59 tons/fed. of grains yield of wheat, seeds yield of faba bean, and their intercropped treatments of wheat and faba bean respectively, compared to inoculated treatments which calculated 1.8, 1.0, 1.14 and 0.59 tons/fed. t the same order. The same trend was also observed for straw yield. Such results indicated that inoculation with N_2-fixers and phosphate dissolvers can save at least from 30 to 55 kg N/fed. and 15 kg P_2O_5/fed.

Many authors emphasised the positive effect of inoculation with *Azotobacter* spp. and rhizobia on plant yield (Kundu and Sharma (1994); Chauhan *et al.* (1996) and Zein *et al.* (2000). The positive effect of *Azotobacter* and rhizobia may refers to improvement of root development, an increase in the rate of water and mineral uptake by roots, displacement of pathogenic fungi and bacteria, execration of phytohormones and vitamins especially the group B as well as biological N_2-fixation (Abdalla *et al.*, 1985 and Rodelas *et al.*, 1998). Farmyard manure also have a positive response on plants yield (Nour El-Dein, 1997).

Intercropping attained positive results for yield of serial plants whereas, Abu-Taleb *et al.* (1999) indicated that intercropping of chickpea with wheat was beneficial in transferring N_2-fixed to wheat, and this achieved through direct release of N_2-fixed and indirect decomposition of both nodules and fine roots. They also reported that the amount of transferred nitrogen decreased with the increase of applied mineral nitrogen fertilizer.

3.Viability and seed vigor:

Viability and seed vigor data were estimated in second season only (2003). Seed vigor parameters includes germination %, radical and shoot length, seedling dry weight, weight of 100 grains, volume of 100 grains and volume of grains. Data of Table (5 and 6) indicated that inoculation, intercropping and/or farmyard manure addition did not significantly influence germination %, radical length, shoot length or seedling dry weight of wheat and faba bean between different treatments and control. The study of Zein *et al.* (2000) found that neither N-levels nor *Azotobacter* inoculation affected germination %, but they found significant increase in radical and shoot lengths due to inoculation. Also, it is noted that in case of intercropping, weight of 100 seeds in some cases significantly increased over solitary wheat or faba bean. The highest values for wheat and faba bean were

recorded by treatment (inoc. + 40 kg N/fed., intercropped) which attained 4.62 g.

From the above mentioned data the viability and vigor parameters of seeds, it could be concluded that inoculation and/or intercropped treatments did not show negative effect on seed viability and vigor. Moreover, these studied treatments induced increments in some desirable characters such as seed index (weight of 100 seeds) and seeds density (weight of 1000 seeds/volume of them).

Studies of the effect of microbial inoculation on weight of 100 seeds were contradicting, whereas Omar *et al.* (1991) did not found significant differences in this respect, while Eid *et al.* (1986) and Hegazy *et al.* (1992) using faba bean found that inoculation with *Azospirillum* and rhizobia significantly increased weight of 100 seeds. On the other hand, Nour El-Dein *et al.* (2005) found that intercropping of mustard and nosturtium on fenugreek did not reflect significant differences in weight of either 100 seeds of mustard or nosturtium. In this work, inoculation, farmyard manure and intercropping mostly exhibited significant increases than their corresponding controls.

4.Chemical compositions of seeds:

Data of chemical composition of seeds collected in the second season only (2003). Data presented in Table (7 & 8) indicated that moisture and fatty acids percentages of wheat grains and faba bean seeds mostly did not significantly affect by the studied treatments. Also, data of crude fiber percentage did not exhibit consistent trend and, mostly, there were no significant variations between treatments. Similarly intercropping, inoculation and/or farmyard manure addition had no consistent effect on crude protein, but they attained positive influences when compared to the traditional control (Tr). In general, intercropping decreased ash % of wheat grains and faba bean seeds for example, the treatment (uninoculated + 70 kg N/fed., intercropped) attained 4.27% compared to 4.49% due to treatment (uninoculated + 70 kg N/fed., solitary faba bean), and also, (inoculated + 15 kg N/fed., intercropped) and (inoculated + 15 kg N/fed., solitary faba bean) attained 3.92 and 4.0%, respectively. Inoculation and farmyard manure addition did not attain clear trend in this respect. Total carbohydrates content of wheat grains did not significantly affect by the studied treatments, but the concentrations in faba bean seeds exhibited increases, mostly were significant, due to inoculation; 44.44, 48.66 and 49.15% for treatments (uninoculated + 70 kg N/fed., solitary faba bean), (inoc. + 40 kg N/fed., solitary faba bean) and (inoc. + 15 kg N/fed., solitary faba bean), respectively. Intercropping and farmyard manure addition had no clear influence.

The absence of significant differences in moisture percentages of seeds may attributed to the use of one variety of each crop. Also, harvest was done in the same time for all treatments. While, the presence of significant differences in crude protein in case of wheat grains was similar to studies of Zein *et al.* (2000) on wheat crop as they found that inoculation of wheat with *Azotobacter* increased it. The effect of intercropping may be due to the release of N_2-fixed and growth hormones resulted from rhizobial

inoculation of faba bean (Abu-Taleb *et al.*, 1999). But, the absence of significant responses for inoculation on fatty acids extracted by ethyl ether was not in accordance with that of Zein *et al.* (2000) as they found that fatty acids were increased due to *Azotobacter* inoculation, this contradiction may be due to the difference in crop variety. On the other hand, the effect of inoculation and intercropping on decreasing ash and crude fiber percentages may be attributed to the increase of protein percentage as well as weight and density of seeds. While, the influence of these aforementioned treatments on the decrease of total carbohydrates percentage in case of wheat seeds may caused by increase of physiological performance of the plant leading to increase of anabolism of proteins from carbohydrates through different physiological pathways in the plant cells.

5. L.E.R. and economic evaluation:

Data of Table (9) indicated (L.E.R and economic evaluation of both crops. Intercropping consistently increased LER value. The highest value (1.49) was resulted from the application of the treatment (inoculated + 40 kg N/fed. + FM, intercropped). In addition, inoculation mostly increased it, for example (uninoculated + 70 kg N/fed., intercropped) treatment gave LER value (1.01) compared to 1.16 and 1.12 for inoculated treatments (inoculated + 40 kg N/fed., intercropped) and (inoculated + 15 kg N/fed., intercropped) respectively.

Our study covered here shed light on the technical feasibility of growing this intercropping system in agricultural policy and evaluate their profitability. Costs and gross returns are calculate and presented in Table (9). Intercropping generally increased net return (L.E./fed.) especially when compared to solitary faba bean, the highest values obtained by the treatments of (inoculated + 40 kg N/fed., intercropped) at first season (1783 L.E./fed.) and (inoculated + 15 kg N/fed. + FM, intercropped) at second season which gave 1401 L.E./fed. Farmyard manure generally decreased net return (L.E./fed.) in spite of its positive effect on seeds yield. The reason may be attributed to the high cost of applied farmyard manure compared to the resulted increase in crops yield. Furthermore, microbial inoculation had a vital role in increasing net return (L.E./fed.) of both crops, for example the un-inoculated treatment (uninoculated + 70 kg N/fed., intercropped) attained 775; 722 L.E./fed. at the first and second seasons, respectively compared to 1783; 1212 and 1552 and 733 L.E./fed. at the same order for the inoculated, treatments of (ino . + 40 kg N/fed., intercropped) and (in. + 15 kg N/fed., intercropped), respectively.

Finally, we could recommended the treatments inoculated + 40 kg N/fed., intercropped) and (inoc. + 15 kg N/fed. + FYM, intercropped) for their highest yields and net return (L.E/fed.) as well as the lowest use of chemical fertilizers which will be safely for environment and man.

Table (5): Viability and seed vigor of grains of wheat intercropped on faba bean plants as affected by inoculation and/or farmyard manure addition.

Treatments	Germination (%)		Radical length (cm)		Shoot length (cm)		Seedling dry weight (g)	
	Pure stands	Inter-cropping	Pure stands	Inter-cropping	Pure stands	Inter-cropping	Pure stands	Inter-cropping
Un-inoculated + 70 kg N/fed.	54.67 ab	58.0 ab	13.71ab	13.36 abc	11.86 ab	14.28 a	0.067 b	0.080 b
Un-inoculated + 70 kg N/fed. + FYM	43.33 bc	70.0 a	13.17 a-d	14.41 a	8.77 b	14.62 a	0.097 b	0.080 b
Inoculated + 40 kg N/fed.	60.67 ab	72.67 a	12.16 a-d	11.28 bcd	10.27 ab	10.45 ab	0.093 b	0.110 b
Inoculated + 40 kg N/fed. + FYM	67.33 a	40.0 bc	13.03 a-d	10.49 d	10.59 ab	8.17 b	0 062 b	0.067 b
Inoculated + 15 kg N/fed.	55.67 ab	64.0 ab	10.73 cd	11.10 bcd	10.24 ab	11.13 ab	0.067 b	0.063 b
Inoculated + 15 kg N/fed. + FYM	72.0 a	75.33 a	11.71 a-d	11.62 a-d	11 19 ab	11.17 ab	0 093 b	0.084 b

Table (5): Cont.

Treatments	Weight of 100 seeds (g)		Volume of 100 grams (cm^3)		Density of grains (g/cm^3)	
	Pure stands	Inter-cropping	Pure stands	Inter-cropping	Pure stands	Inter-cropping
Un-inoculated + 70 kg N/fed.	3.78 e	3.82 de	7.90 b	8.13 b	0.473 cde	0.463 de
Un-inoculated + 70 kg N/fed. + FYM	3.43 f	4.11 b	7.83 b	8.30 b	0 433 f	0.490 bc
Inoculated + 40 kg N/fed.	4.05 bc	4.62 a	8.23 b	8.70 b	0.487 bc	0.523 a
Inoculated + 40 kg N/fed. + FYM	3.85 cde	4.11 b	7.90 b	8.10 b	0.483 bc	0.503 ab
Inoculated + 15 kg N/fed.	4.02 bcd	3.67 e	8.17 b	8.07 b	0.487 bc	0.450 ef
Inoculated + 15 kg N/fed. + FYM	3 68 e	4 10 b	7.97 b	8.23 b	0 450 ef	0.493 bc

N: Nitrogen FYM: Farmyard manure

Table (6): Seeds vigor and viability of faba bean intercropped with wheat plants as affected by inoculation and/or farmyard manure addition.

Treatments	Germination (%)		Radical length (cm)		Shoot length (cm)		Seedling dry weight (g)	
	Pure stands	Inter-cropping	Pure stands	Inter-cropping	Pure stands	Inter-cropping	Pure stands	Inter-cropping
Un-inoculated + 70 kg N/fed.	100.0 a	100.0 a	13.36 ab	12.72 ab	8.48 a	8.62 a	3.56 bc	3 49 bc
Un-inoculated + 70 kg N/fed. + FYM	100.0 a	100.0 a	16.30 a	12.77 ab	12.10 a	9.27 a	3.81 bc	8.46 c
Inoculated + 40 kg N/fed.	99.69 a	100.0 a	15.03 ab	13.55 ab	11.22 a	9.08 a	3.75 bc	3.85 bc
Inoculated + 40 kg N/fed. + FYM	98.33 a	91.67 b	14.17 ab	11.85 b	10.71 a	7.90 a	3.43 c	3.59 bc
Inoculated + 15 kg N/fed.	100.0 a	99.33 a	16.53 a	14.71 ab	8.73 a	10.18 a	4.48 ab	4.44 abc
Inoculated + 15 kg N/fed. + FYM	96.67 a	90.0 b	11.57 b	11.95 ab	8.76 a	10.13 a	5.10 a	4.25 abc

Table (6): Cont.

Treatments	Weight of 100 seeds (g)		Volume of 100 grams (cm^3)		Density of grains (g/cm^3)	
	Pure stands	Inter-cropping	Pure stands	Inter-cropping	Pure stands	Inter-cropping
Un-inoculated + 70 kg N/fed.	77.76 de	77.71 de	70.83 b	70.03 b	1.10 c	1.11 c
Un-inoculated + 70 kg N/fed. + FYM	75.04 e	81.31 bcd	68.33 b	71.33 b	1.10 c	1.14 c
Inoculated + 40 kg N/fed.	87.33 a	85.65 ab	75.0 a	70.0 b	1.17 abc	1.22 ab
Inoculated + 40 kg N/fed. + FYM	82.99 abc	84.77 ab	75.0 a	74.67a	1.11 c	1.19 c
Inoculated + 15 kg N/fed.	76.96 de	85.52 ab	60.0 d	75.0 a	1.28 c	1.13 c
Inoculated + 15 kg N/fed. + FYM	79.71 cd	83.77 abc	61.64 d	65.0 c	1.3 a	1.29 a

N: Nitrogen FYM: Farmyard manure

Table (7): Chemical compositions of grains of wheat intercropped on faba bean plants as affected by inoculation and/or farmyard manure.

Treatments	Moisture (%)		Crude protein		Ether extracted (FA %)	
	Pure stands	Inter-cropping	Pure stands	Inter-cropping	Pure stands	Inter-cropping
Un-inoculated + 70 kg N/fed.	13.65 bc	13.68 abc	11.61 f	12.60 de	1.92 a	2.25 a
Un-inoculated + 70 kg N/fed. + FYM	13.81 abc	14.45 a	12.64 de	13.14 cd	2.13 a	2.01 a
Inoculated + 40 kg N/fed.	13.74 abc	113.51 bc	13.79 bc	12.07 ef	2.0 a	2.0 a
Inoculated + 40 kg N/fed. + FYM	13.77 abc	14.30 ab	10.56 gh	14.56 a	2.0 a	1.73 a
Inoculated + 15 kg N/fed.	13.96 abc	13.28 c	13.89 bc	14.51 ab	2.11 a	1.72 a
Inoculated + 15 kg N/fed. + FYM	13.52 bc	13.66 abc	9.61 h	11.07 fg	1.82 a	1.73 a

Table (7): Cont.

Treatments	Ash (%)		Crude fiber (%)		Total carbohydrate %	
	Pure stands	Inter-cropping	Pure stands	Inter-cropping	Pure stands	Inter-cropping
Un-inoculated + 70 kg N/fed.	2.05 ab	1.93 bcd	6.78 a	6.15 abc	65.15 ab	63.18bc
Un-inoculated + 70 kg N/fed. + FYM	1.80 cde	1.77 de	5.43 bc	4.09 d	64.19 ab	64.54 ab
Inoculated + 40 kg N/fed.	2.05 ab	1.60 e	5.99 abc	5.02 cd	61.49 c	65.96 a
Inoculated + 40 kg N/fed. + FYM	1.92 bcd	2.13 ab	5.11 cd	4.15 d	66.72 a	62.86 bc
Inoculated + 15 kg N/fed.	2.04 ab	2.01 abc	6.44 ab	7.10 a	61.19 c	60.73 c
Inoculated + 15 kg N/fed. + FYM	1.68 e	2.22 a	5.21 cd	6.09 abc	66.54 a	65.23 ab

N: Nitrogen FYM: Farmyard manure FA: Faty acids

Table (8): Chemical compositions of faba bean intercropped with wheat plants as affected by inoculation and/or farmyard manure addition.

Treatments	Moisture (%)		Crude protein		Ether extracted (FA %)	
	Pure stands	Inter-cropping	Pure stands	Inter-cropping	Pure stands	Inter-cropping
Un-inoculated + 70 kg N/fed.	12.12 abc	11.65 c	29.64 bc	26.42 de	1.45 b	1.46 b
Un-inoculated + 70 kg N/fed. + FYM	11.84 bc	11.71 c	27.94 cd	29.29 bc	1.88 b	1.57 b
Inoculated + 40 kg N/fed.	12.32 abc	11.91 abc	25 32 e	25.86 e	1.44 b	1.38b
Inoculated + 40 kg N/fed. + FYM	11.83 bc	11.82 bc	26.14 e	25.97 e	1.15 b	0.92 b
Inoculated + 15 kg N/fed.	12.64 ab	12.58 a	24.86 e	30.85 ab	1.65 b	1.46 b
Inoculated + 15 kg N/fed. + FYM	11.75 c	12.30 abc	13.86 a	24.95 e	1.53 b	1.02 b

Table (8): Cont.

Treatments	Ash (%)		Crude fiber (%)		Total carbohydrate %	
	Pure stands	Inter-cropping	Pure stands	Inter-cropping	Pure stands	Inter-cropping
Un-inoculated + 70 kg N/fed.	4.49 a	4.27 b	7.85 a	8.16 a	4.44 c	47.71 c
Un-inoculated + 70 kg N/fed. + FYM	4.57 a	4.23 b	8.36 a	7.92 a	45.09 c	42.41 c
Inoculated + 40 kg N/fed.	4.0 cde	3.85 e	8.31 a	7.70 a	48.66 ab	48.80 ab
Inoculated + 40 kg N/fed. + FYM	4.12 bcd	4.27 b	7.54 a	7.59 a	48.88 ab	48.77 ab
Inoculated + 15 kg N/fed.	4.18 bc	3.89 e	7.57 a	7.33 a	49.15 ab	51.10 a
Inoculated + 15 kg N/fed. + FYM	4.0 cde	3.82 de	8.68 a	7.59 a	48.37 ab	50.24 ab

N: Nitrogen FYM: Farmyard manure FA: Faty acids

Table (9) : L.E.R. values and some economical characteristics of intercropped wheat and faba bean plants , in season 2002 as affected by inoculation and farmyard manure addition.

Treatments	Crop type	L..E.R.	Economic characteristics			
			Un-changed costs* (I.E./fed.)	Changed costs (L.E./fed.)	Total income* (L.E./fed.)	Net return (L.E./fed.)
			Intercropping treatments			
Uninoculated + 70 kg N/fed., intercropped	W + F	1.01	1520	140**	2435	775
Uninoculated + 70 kg N/fed., FM, intercropped	W + F	1.33	1520	215***	2825	1090
Inoc. + 40 kg N/fed., intercropped	W + F	1.16	1520	82**	3385	1783
Inoc. + 40 kg N/fed. + FM, intercropped	W + F	1.14	1520	157***	3039	1677
Inoc. + 15 kg N/fed., intercropped	W + F	1.12	1520	32**	3134	1552
Inoc. + 15 kg N/fed. + FM, intercropped	W + F	1.05	1520	107***	2665	1038
			Sole treatments			
Uninoculated + 70 kg N/fed., sole	W	-	1365	140**	2390	885
Uninoculated + 70 kg N/fed., sole	F	-	1655	140**	2331	536
Uninoculated + 70 kg N/fed. + FM, sole	W	-	1365	215***	2266	686
Uninoculated + 70 kg N/fed. + FM, sole	F	-	1655	215***	2031	161
Inoc. + 40 kg N/fed., sole	W	-	1365	82**	3467	1700
Inoc. + 40 kg N/fed., sole	F	-	1655	82**	2464	652
Inoc. + 40 kg N/fed. + FM, sole	W	-	1365	157***	3259	1737
Inoc. + 40 kg N/fed. + FM, sole	F	-	1655	157***	2375	563
Inoc. + 15 kg N/fed., sole	W	-	1365	32**	2191	794
Inoc. + 15 kg N/fed., sole	F	-	1655	32**	2456	769
Inoc. + 15 kg N/fed. + FM, sole	W	-	1365	107***	2793	1331
Inoc. + 15 kg N/fed. + FM, sole	F	-	1655	107***	2328	641

Table (9)cont: L.E.R. values and some economical characteristics of intercropped wheat and faba bean plants , in season 2002 as affected by inoculation and farmyard manure addition.

Treatments	Crop type	L..E.R.	Economic characteristics			
			Un-changed costs * (l.E./fed.)	Changed costs (L.E./fed.)	Total income* (L.E./fed.)	Net return (L.E./fed.)
			Intercropping treatments			
Uninoculated + 70 kg N/fed., intercropped	W + F	1.14	1520	140**	2382	722
Uninoculated + 70 kg N/fed., FM, intercropped	W + F	1.47	1520	215***	2703	968
Inoc. + 40 kg N/fed., intercropped	W + F	1.37	1520	82**	2814	1212
Inoc. + 40 kg N/fed. + FM, intercropped	W + F	1.49	1520	157***	2703	1026
Inoc. + 15 kg N/fed., intercropped	W + F	1.12	1520	32**	2285	733
Inoc. + 15 kg N/fed. + FM, intercropped	W + F	1.40	1520	107***	3028	1401
			Sole treatments			
Uninoculated + 70 kg N/fed., sole	W	-	1365	140**	1981	476
Uninoculated + 70 kg N/fed., sole	F	-	1655	140**	2204	409
Uninoculated + 70 kg N/fed. + FM, sole	W	-	1365	215***	1955	375
Uninoculated + 70 kg N/fed. + FM, sole	F	-	1655	215***	1843	27
Inoc. + 40 kg N/fed., sole	W	-	1365	82**	1885	438
Inoc. + 40 kg N/fed., sole	F	-	1655	82**	2358	621
Inoc. + 40 kg N/fed. + FM, sole	W	-	1365	157***	1951	429
Inoc. + 40 kg N/fed. + FM, sole	F	-	1655	157***	1814	2
Inoc. + 15 kg N/fed., sole	W	-	1365	32**	2212	815
Inoc. + 15 kg N/fed., sole	F	-	1655	32**	1846	159
Inoc. + 15 kg N/fed. + FM, sole	W	-	1365	107***	1950	478
Inoc. + 15 kg N/fed. + FM, sole	F	-	1655	107***	2629	867

Uninoculated = un-inoculated Inoculated = inoculated N = nitrogen. Tr = traditional; control W = wheat FM = Farmyard manure

* Un-changed costs, (L.E), which include: land rent (1000), seeds (W, 70 and F, 200), irrigation (25), P and K fertilizers (60, biofertilizer (2), workers labor (W, 10 and F, 150), tillage (100), herbicides and pesticides (W, 0.0 and F, 20), harvest (100).

** Changed costs of nitrogenous fertilizers (2 L.E/unit of nitrogen).

*** Changed costs of nitrogenous fertilizers + costs of farmyard manure (15 L.E./ton).

Total income includes charge of seeds + hay by L.E.: wheat grains (1000), wheat hay (100) faba bean seeds (2000) and faba bean hay (100).

LER = land equivalent ratio

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تأثير التسميد العضوى ـ الحيوى على محصول القمح المحمل على الفول البلدى

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أجريت تجربتين حقليتين بمحطة البحوث الزراعية بسخا موسمى ٢٠٠٢م ، ٢٠٠٣م لدراسة دور التقليح بخليط ميكروبى يحتوى على الريزوبيا والباسلس ميجاثيريم للفول البلدى وبالأزوتوباكتر والباسلس ميجاثيريم للقمح بالإضافة إلى إضافة السماد البلدى (٥ طن/فدان) ومستويات مختلفة من التسميد النيتروجينى (١٥ ، ٤٠ ، ٧٠ كجم نيتروجين/فدان) وذلك على مكونات الإنتاج وبعض الخصائص التكنولوجية لبذور الفول وحبوب القمح تحت ظروف التحميل.

أظهرت النتائج أن التحميل قلل من إنتاجية كل القش والبذور من الفول البلدى والقمح المحمل عليه فى كلا موسمى الدراسة والسبب فى ذلك يرجع الى أن احواض المعاملات المحملة بها فول وقمح بنسبة ٥٠: ٥٠% بينما المعاملات المفردة بها قمح اوفول بنسبة ١٠٠%. من ناحية أخرى فقد زاد التلقيح والتحميل و/أو السماد البلدى من الوزن الجاف للعقد الجذرية للفول البلدى (جرام/٣ نباتات). لم يوجد تأثيرا معنويا بين معاملة الكنترول وباقى المعاملات على نسبة الإنبات ونسبة الرطوبة للبذور وطول الجذير والريشه لكل من بذور الفول وحبوب القمح وزادات المعاملات معنويا من وزن ١٠٠ بذرة لكل من الفول والقمح. أيضا فإن حجم وكثافة حبوب القمح وكثافة بذور الفول أظهرت زيادات كانت أحيانا معنوية.

زاد التلقيح الميكروبى والتحميل من البروتين الخام لحبوب القمح ، بينما لم يوجد اتجاه ثابت لبذور الفول. لم تؤثر المعاملات المستخدمة معنويا على نسبة مستخلصات الإيثر (E.E.) أو نسبة الرماد فى بذور الفول البلدى أو حبوب القمح. على الرغم من عدم وجود تأثير ثابت للتحميل او التلقيح او اضافة السماد العضورى فقد قللت كل المعاملات من نسبة الكربوهيدرات الكلية لحبوب القمح فى حين زادت منها فى بذور الفول البلدى.

زاد كل من التحميل واضافة السماد البلدى من معدل الكفاءة الارضية ، فى حين لم يعطى التلقيح الميكروبى تأثيرا ايجابيا الا فى حالة وجود السماد البلدى. غالبا ما حقق التحميل والتلقيح زيادات فى معدل الدخل الصافى (بالجنية المصرى) بالمقارنة بمعاملات الكنترول المقابلة. لم تؤثر اضافة المادة العضوية على صافى الدخل. اعطت معاملتى (تلقيح + ٤٠ كجم نتروجين/فدان ، تحميل) فى الموسم الاول و (تلقيح + ١٥ كجم نتروجين/فدان + سماد بلدى ، تحميل) اعلى صافى عائد (١٧٨٣ و ١٤٠١ جنيها مصريا) على التوالى.