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THE RESIDUAL EFFECT OF RICE N-BIOFERTILIZATION AS POTENTIAL ECONOMIC FOR MINERAL NITROGENOUS FERTILIZATION OF WHEAT CROP.

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ABSTRACT

This study was conducted during winter seasons of (2009-2010) and (2010-2011) at Meet Louza Village, Mansoura Province, Dakahlia Governorate, Egypt on a silty clay soil to find out the residual effect rice N-biofertilization on the next wheat crop (*Triticum aestivum* L. c.v. sakha 93). Biofertilization 8 treatments involving inoculums of Azolla (Azl), Azospirillum (Azs), Azotobacter (Azt), and Cyanobacreria (Cyn) as well as mixtures (Azl + Azs), (Azl + Azt), (Azs + Azt) and (Cyn + Azt) which take the same location with the same layout of the experimental field for the previous crop (rice), soil N- fertilization (4 treatments of control, 12.5 %, 18.75 and 25 % of N-recommended level 75 kg N fed^{-1} as urea) were tasted in a split plot design with three replicates.

The most important finding could be summarized as follows:

- Treatment of 25 % N-level led to highest increases for plant height, grain yield, chlorophyll (a) and (b) content and the highest values were (101.27cm, 1.57 Mg fed^{-1}, 13.55 mg g^{-1} f.w and 8.95 mg g^{-1} f.w) for the previous parameters, respectively. Although, the highest straw yield, N, P, K, Fe, Mn and Zn uptake by grains of (1.31 Mg fed^{-1}, 26.17, 4.27, 4.67 kg fed^{-1}, 106.23, 47.91 and 48.33 g fed^{-1}), were recorded at 18.75 % N-level, respectively. The highest mean value of caroteniods (2.75 mg g^{-1} f.w). achieved at, control treatment.
- Inoculation of (Azl) gave maximum plant height and Mn-uptake of ((98.16 cm and 47.47 g fed^{-1}), respectively. The highest grain, straw yields, caroteniods, N, K, Fe and Zn uptake were due to (Azs) Inoculation which were (1.84, 1.40 Mg fed^{-1}, 3.48 mg g^{-1}f.w, 27.13, 5.21 kg fed^{-1}, 18.87 and 49.65 g fed^{-1}) respectively, the highest P-uptake of (4.32 kg fed^{-1}) occurred with (Azt). While (Azs+Azt) revealed the highest values (15.05 and 10.25 mg g^{-1}f.w) for chlorophyll (a) and (b) content, respectively.
- The combination of 25 % N-level with (Azl, Azs, Cyn, Azs +Azt, Azs and Cyn + Azt) inoculations, gave superiority plant height (106.38 cm), grain yield (1.95 Mg fed^{-1}, chlorophyll (a), (b) (15.52, 13.39 mg g^{-1} f.w), Fe and Mn uptake of (137.32 and 55.49 g fed^{-1}), respectively. The superiority average values of straw yield (1.53 Mg fed^{-1}), N and Zn uptake (32.01 kg $fed^{-1}$and 57.01 g fed^{-1}), release from organic and inorganic (30.25ppm), N-uptake % (67.92%) and N-recovery % (61.66%) occurred with combination of (18.75%N-level + (Azl+Azs)), but 18.75 % N-level combined with (Azl) and (Azs) respectively gave highest P-uptake of (4.90kg fed^{-1}) and K-uptake of (5.88 kg fed^{-1}). The uppermost caroteniods (3.71 mg g^{-1}f.w) occurred with the combination of (12.5% N-level + Azs) and The superiority net return (3060 £.L. fed^{-1}.) of wheat crop, was given by combination of (25 % N-level + Azs).

Keywords: N-fertilization, residual effect of rice N-biofertilization, and wheat plant.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important winter cereal crops in Egypt. Fertilization of wheat is an important limiting factor affecting wheat production. Nitrogen is well known to be one of the most major elements for plant nutrition and development since, it plays an important role in proteins, enzymes synthesis and is frequently the major limiting nutrient in most agricultural soils Daughtry *et al.* (2000).

Nitrogen concentration in green vegetation is related to chlorophyll content, and therefore indirectly to one of the basic plant physiological processes:i.e. photosynthesis. Amaliotis *et al.*, (2004), Cabrera, (2004) and Biljana and Stojanovic(2005). Gholve *et al.*, (2003) reported that in terms of the residual effect of nutrient management in rice (cv. Pawana) on yield of succeeding wheat crops (cv. HD 2189), (50 % recommended rate of N + 10 t Gliricidia green manure /ha)for rice recorded the maximum wheat yield. Parihar (2004) under field experiment studied the effect of N-levels (80 and 120 Kg N ha^{-1}) on wheat which grown after rice and showed that grain and straw yield increased significantly with the application of 120 Kg N ha^{-1}.In addition, 120 Kg N ha^{-1} registered significantly higher NPK uptake by crop compared to 80 Kg ha^{-1}.

Aishwath *et al.* (2003) reported that biofertilizers (Azotobacter and Azospirillum seed inoculation) increased wheat chlorophyll content, and Azotobacter was more effective than Azospirillum in the enhancement of wheat chlorophyll content. El-Naggar *et al.*, (2005) pointed out that the biofertilizer Azospirillum proved to be superior than Cyanobacteria one to increase, significant wheat (grain and straw) yield. Azospirillum still better than Cyanobacteria in improving N-uptake, N-use efficiency, % biomass N recoverd and available soil N, for wheat. Also increasing N-rates resulted in significant increases in (grain and straw) yield, N-uptake and available soil N after harvest, whereas, biomass-N recovered % and N- use efficiency tended to be reduced with increasing N-rates.

Hammouda *et al.*, (2001) demonstrated that results of the residual improving effect of such biofertilizers (Blue green algi , Azotobacter chroococcum and Azospirillum brasilense) on untreated wheat crop reveal a similar trend to that observed in case of rice crop and indicated that triple inoculation with (BGA + Azot + Azos) still achieved the highest values of yield, yield components and their nitrogen content of wheat plants. Also, they reported that beneficial effect of different biofertilizers in combination with 30 Kg fed^{-1} when applied to rice crop and their residual effect on untreated wheat crop could arranged in descending order as follows: Triple inoculation> BGA > Azospirillum >Azotobacter. Singh (2004) stated that subsequent crop of rapeseed (after rice harvesting), the treatments containing Azolla were found better in yield and the highest was recorded with higher dose of N (80 Kg N ha^{-1}) in integration with Azolla.

The objectives of the present study are to investigate the residual effect of the different N-biofertilizers which were applied with the previous crop (rice) on the next wheat crop, reducing the application of the soil N-fertilization rates and minimizing the induced environmental pollution.

MATERIALS AND METHODS

Two field experiments were conducted in the Meet louza village, Mansoura province, Dakahlia Governorate, Egypt (+7 m altitude, 30^0 11^- latitude and 28^0 26^- longitude), during winter seasons of (2009- 2010) and (2010-2011) to study the residual effect of the different biofertilization treatments with the previous crop (rice) on wheat crop (*Triticum aestivum*, L., c.v. sakha93) growth and its production. The seeds of wheat at the rate of 70 kg seed fed^{-1} were spread in the same location with the same layout of the experimental rice field trial, biofertilizer inoculation without addition over all the growing seasons of wheat. Wheat seeds were sowing handly in 11^{th} and 13^{th} of November in the two seasons respectively, plot area, 12 m^2. Representative soil samples were collected from the surface layer (0-30 cm) of the experimental plots and analyzed for some physical and chemical properties as shown in Table 1, according to Black *et al.* (1965) and Page (1982).

Thirty two treatment were arranged in split-block design with 3 replicates which were the simple possible combination between 4 levels of N-fertilization and 8 treatments of bio-fertilization.

- N-fertilization levels were located as a main plots, and represented as 0, 12.5, 18.75 and 25 % from the recommended dose by the Ministry of Agric. and soil Recl. For wheat plants (75 kg N fed^{-1}) i.e. 9.38, 14.06 and 18.75 kg N fed^{-1} for the treatments of 12.5, 18.75 and 25 %, respectively.
- Eight treatments of bio-fertilization were adopted as a sub-plots as follows; Azolla (Azl), Azospirillum (Azs), Azotobacter (Azt), and Cyanobacreria (Cyn) as well as mixtures (Azl + Azs), (Azl + Azt), (Azs + Azt) and (Cyn + Azt).

Urea (46.5% N) was used as a source of nitrogen fertilization. The 1^{st} addition 2/3 the dose was added after 21 days from planting, and the other 1/3 15 days later. Common agricultural practices known for rice and wheat commercial production were applied as prevailing in the area of the experiment. biofertilizers inoculation as the residual effect namely; i.e. Azolla (A.Pinnata) inoculum, Azospirillum bacteria (using biofertilizer with a trade name of "SERIALINE" inoculum), Cyanobacteria (blue-green algi inoculum), Azotobacter bacteria (using biofertilizer with a trade name of "AZOTOBACTRINE" inoculum). which take the same location with the same layout of the experimental field for the previous crop (rice). Total experimental plots were under foliar spraying of urea at 20 g/L (i.e: 2 % N) (4.00 kg N/200L fed^{-1}, as urea) plus yeast 16 g L^{-1} (3.2 kg/200 L fed^{-1}). The foliar spraying was repeated 3 times; i.e. 45, 60 and 75 days after planting.

Table 1: Some physical and chemical properties of the studied soil before cultivation for the two seasons.

Soil characteristics	1st (2009-2010)	2nd (2010-2011)
Sand%	11.28	10.18
Silt%	42.98	43.62
Clay%	45.74	46.20
Texture Class	Silty clay	Silty clay
***pH**	8.50	8.25
****EC, dS m^{-1}**	0.54	0.47
$CaCO_3$ %	2.25	2.22
OM%	2.01	2.34
Soluble Cations (meq.L^{-1})		
Ca^{++}	1.77	1.40
Mg^{++}	1.00	0.90
Na^{+}	2.30	2.00
K^{+}	0.37	0.40
Soluble Anions (meq.L^{-1})		
$CO3^{--}$	n.d_	n.d_
$HCO3^{-}$	0.60	0.40
Cl^{-}	2.90	2.60
SO_4^{--}	1.94	1.70
*****Available nutrients (mg kg^{-1} soil)**		
Nitrogen (N)	48.00	44.00
Phosphorus (P)	10.50	9.86
Potassium (K)	314	290
Iron (Fe)	4.74	4.56
Zinc (Zn)	0.98	0.79
Manganese (Mn)	3.79	3.48

***pH: soil past. **Ec: 1:5 soil : water extract.**
*****Extracts for available nutrients are: KCL (for N), Na-bicarbonate (for P), NH_4 OAC (for K) and DTPA (for Fe, Zn and Mn).**

At booting stage; 90 day after sowing the plants were randomly taken from each plot, then average plant height (cm) was determined, the pigments of chlorophyll and carotenoids were estimated according to the methods of Metzner and Singer (1965) and Dubios *et al.*, (1956), respectively. At harvesting stage; 150 days after sowing the plants of 1/2 m^2 were randomly taken from each experimental plot; separated into straw and grain. Then yield of straw and grain were calculated (Mg fed^{-1}) Since (megagrame "Mg"=1000kg). Representative samples of grain was taken oven dried at 70^0C tell constant weight, wet digested according to (Peterburgski, 1968) for determination of N, P, K as described by Pregl (1945), Jakson (1967) and Black *et al.* (1965), respectively as well as Fe, Zn and Mn according to Chapman and Pratt (1961). Calculators parameter; nitrogen recovery %, was calculated as follows;

$$\text{N-recovery \%} = \text{N1} - \text{N0} \times 100/\text{N-added}$$

where N1= Total N-uptake for the treatment kg N fed^{-1} and N0= Total N-uptake for the control kg N fed^{-1}, the residual effect of nitrogen uptake was calculated according to Abd El-Hameed (1998) and economic evaluation, based on yield as an average for two seasons was calculated according to

Ezzat and Abd El-Hameed (2010). Statistical Analysis of the mean values of two seasons were done according to the methods described by Waller and Duncan (1969).

RESULTS AND DISCUSSION

Plant height, photosynthetic pigments at booting stage and Yield at harvest stage of wheat crop:

Effect of nitrogen fertilization levels:

Data presented in Table 2, demonstrate that nitrogen fertilization levels significant affected the plant height, grain, straw yield and photosynthetic pigments content wheat crop. Increasly N-levels addition, in general, significantly increased plant height, grain, straw yield and chlorophyll (a) and chlorophyll (b) content in wheat crop. The highest N-levels addition, i.e. 25 % of recommended dose came in the first rank in this respect. Treatment of 25 % N-level was the most superior one for enhancing plant height, grain yield, chlorophyll a and chlorophyll b content since the highest mean values for average two seasons were (101.27cm- 1.57 Mg fed^{-1}- 13.55 mg g^{-1} f.w and 8.95 mg g^{-1} f.w) for the previous characters respectively. It is seen also, from the same data, that straw yield gave higher mean values under 18.75 % N-level, i.e. 1.31 ton fed^{-1}. The increase in the yield of wheat crop due to raising the nitrogen dose can be attributed to the beneficial effects of nitrogen on stimulating the meristematic activity for producing more tissues and organs since nitrogen is a constituent of protein, nuclic acids and many important substances of plant cell. Moreover, nitrogen is highly effective on vegetative growth and yield through its effects on vital prosses, i.e. chlorophyll, enzymes, photosynthesis and endogenous hormones synthesis, which consequently affect plant growth and yield (Marschner, 1995). These results of increasing in the previous parameters with high doses of N application were confirmed with the findings of Parihar (2004) and Ali *et al.*, (2008) who reported that increasing nitrogen rates from 100 to 125 Kg N fed^{-1}. increased the grain and straw yield by 16.9 % and 1.9 %, respectively. with the exception of the carotenoids decreased by increasing N-levels where the highest mean values 2.75 mg g^{-1} f.w. achieved at, i.e. control treatment. Carotenoids decreasing with increasing N-fertilization may be attributed to biosynthesis of carotenoids in plant is a genetic characteristic, but environmental condition also have an essential role Biljana and Stojanovic (2005).

Residual effect of N-biofertilizer inoculations:

Data in Table 2, show that residual effect of N-biofertilizer inoculations had significant effect on plant height, grain, straw yield and photosynthetic pigments content for wheat crop. Results in Table 2, showed that the residual effect of N-biofertilizer inoculation with Azolla attained the superior effect on plant height compared to other biofertilizer treatments, the highest mean values of plant height was 98.16 cm.

Table 2: Effect of nitrogen fertilization levels, N-biofertilizer inoculations and their combinations on grain yield (Mg. fed^{-1}), straw yield (Mg. fed^{-1}) at harvesting stage, plant height (cm), chlorophyll (a), chlorophyll (b) and carotenoids (mg.g^{-1} f.w) at booting stage of wheat crop as average two seasons.

Treat. \ Char.		Plant height (cm)	grain yield (Mg. fed^{-1})	Straw yield (Mg. fed^{-1})	Chlorophyll a (mg.g^{-1} f.w)	Chlorophyll b (mg.g^{-1} f.w)	Carotenoids (mg.g^{-1} f.w)
A:- Mineral fertilization							
Control		77.21	1.33	1.09	11.77	5.83	2.75
12.5%		95.02	1.39	1.22	12.82	7.12	2.51
18.75%		96.26	1.53	1.31	13.34	7.81	2.30
25%		101.27	1.57	1.30	13.55	8.95	2.10
L.S.D at 5%		**2.98**	**0.05**	**0.04**	**0.43**	**0.23**	**0.09**
B:- Biofertilization							
Azl.		98.16	1.68	1.25	11.90	5.96	2.76
Azs.		92.07	1.84	1.40	10.08	4.94	3.48
Cyn.		93.23	1.21	1.19	14.27	8.41	1.69
Azt.		90.18	1.19	1.20	14.93	9.39	1.60
Azl. + Azs.		96.23	1.58	1.30	10.15	5.39	3.19
Azl. + Azt.		92.60	1.44	1.20	11.61	5.99	3.03
Azs. + Azt.		89.85	1.44	1.16	15.05	10.25	1.59
Cyn. + Azt.		87.20	1.29	1.17	14.97	9.08	1.99
L.S.D at 5%		**1.24**	**0.02**	**0.01**	**0.12**	**0.06**	**0.02**
A × B:- Mineral fertilization × Biofertilization							
Control	**Azl.**	77.20	1.42	1.06	10.28	5.33	3.27
	Azs.	80.17	1.74	1.31	9.11	4.46	3.34
	Cyn.	76.47	1.11	1.08	12.08	4.93	2.47
	Azt.	76.21	1.10	1.06	14.39	7.60	1.97
	Azl. + Azs.	82.67	1.50	1.09	10.12	5.23	3.27
	Azl. + Azt.	76.14	1.26	1.03	9.72	4.75	3.47
	Azs. + Azt.	74.80	1.29	1.06	14.43	7.43	2.04
	Cyn. + Azt.	74.02	1.26	1.06	14.09	6.92	2.16
12.5%	**Azl.**	103.49	1.56	1.26	11.90	6.06	2.92
	Azs.	93.28	1.82	1.42	10.70	5.47	3.71
	Cyn.	91.74	1.21	1.26	14.40	7.65	1.92
	Azt.	93.64	1.09	1.26	14.83	9.11	1.50
	Azl. + Azs.	100.42	1.56	1.24	9.87	5.12	3.22
	Azl. + Azt.	101.25	1.30	1.16	10.68	6.48	2.73
	Azs. + Azt.	90.62	1.39	1.10	15.18	10.31	1.64
	Cyn. + Azt.	85.72	1.23	1.09	14.99	6.76	2.47
18.75%	**Azl.**	105.56	1.81	1.31	12.93	6.27	2.55
	Azs.	97.41	1.86	1.47	10.29	4.73	3.51
	Cyn.	100.74	1.30	1.18	15.08	9.73	1.28
	Azt.	93.64	1.25	1.30	15.27	10.46	1.83
	Azl. + Azs.	98.60	1.69	1.53	10.18	5.14	3.34
	Azl. + Azt.	95.87	1.54	1.31	12.50	5.62	3.12
	Azs. + Azt.	90.75	1.55	1.22	15.14	9.89	1.23
	Cyn. + Azt.	87.55	1.29	1.21	15.31	10.65	1.56
25%	**Azl.**	106.38	1.93	1.37	12.50	6.17	2.33
	Azs.	97.42	1.95	1.42	10.22	5.09	3.34
	Cyn.	103.98	1.24	1.23	15.52	11.35	1.08
	Azt.	97.23	1.32	1.19	15.22	10.42	1.10
	Azl. + Azs.	103.25	1.57	1.35	10.43	6.08	2.95
	Azl. + Azt.	97.14	1.66	1.29	13.55	7.12	2.81
	Azs. + Azt.	103.21	1.54	1.27	15.46	13.39	1.43
	Cyn. + Azt.	101.52	1.38	1.33	15.50	11.96	1.78
L.S.D at 5%		**2.49**	**0.04**	**0.02**	**0.23**	**0.13**	**0.04**

∗Azl: Azolla **∗ Azs: Azospirillum**

∗Cyn: Cyanobacteria **∗ Azt: Azotobacter**

The residual effect of N-biofertilizer by inoculation of Azospirillum reported a highest effect on grain, straw yield and carotenoids and gave the highest mean values (1.84, 1.40 Mg fed^{-1}. and 3.48 mg g^{-1} f.w), respectively. While Azospirillum + Azotobacter inoculations revealed the highest average values for chlorophyll (a) and (b) content (15.05 and 10.25 mg g^{-1}f.w). Similar trend were confirmed by Aishwath *et al.*, (2003) and El-Naggar *et al.*, (2005).

Effect of combination of nitrogen fertilization levels and residual effect of N-biofertilizer inoculations:

Regarding the effect of combination of nitrogen fertilization levels with the residual effect of N-biofertilizer inoculations on plant height, grain, straw yield and photosynthetic pigments content. Data in Table 2, show significantly increased by the combinations for the previous parameters. The uppermost of combination was at 25 % N-level when the residual effect of (Azolla, Azospirillum, Cyanobacteria) and (Azsopirillum + Azotobacter) for parameters; plant height (106.38 cm), grain yield (1.95 Mg fed^{-1}) chlorophyll (a) (15.52 mg g^{-1} f.w) and chlorophyll (b) (13.39 mg g^{-1} f.w), respectively. Exception, the uppermost average of straw yield 1.53 Mg fed^{-1}. was resultant from the residual effect of (Azolla + Azsospirillum) combined with 18.75 % N-level. But, the heighest mean value of carotenoids content (3.71 mg g^{-1} f.w) was achieved at 12.5 % N-level combined with the residual effect of (Azospirillum) inoculation. Results could be confirmed with those reported by Aishwath *et al.*, (2003) and Singh (2004).

Macro and micronutrients content in wheat grain at harvest time.

Effect of nitrogen fertilization levels:

Concerning the effect of nitrogen fertilization levels, data given in Table 3, reflected a significant influence for the N-levels applied on content of nutrients in grain. The highest uptake of N, P, K, Fe, Mn and Zn by grains (26.17, 4.27, 4.67 kg fed^{-1}, 106.23, 47.91 and 48.33 g fed^{-1}) were recorded at 18.75 % N-level, respectively. These positive effect of N fertilization levels on nutrients uptake in grain may be due to the effect of nitrogen fertilizer on improving root growth, hence increasing the absorbing area of root and in addition to the increase of root size in the presence of nitrogen fertilizer. These data are in a good harmony with those revealed by Parihar (2004).

Effect of the residual effect of N-biofertilizer inoculations:

As for N, P, K, Fe, Mn and Zn uptake by grains, illustrated data in Table 3, show that the residual effect of N-biofertilizer inoculations reflected significant effect on nutrients uptake in wheat grain. Farah-Ahmed *et al.,* (2008) tested some microbial isolates and found that more than (80%) are able to solubilize of phosphate and all the tested isolates produce ammonia.

Table 3: Effect of nitrogen fertilization levels, N-biofertilizer inoculations and their combinations on N, P and K uptake kg.fed^{-1}, Fe, Mn and Zn uptake g. fed^{-1} in wheat grain as average two seasons.

Treat. / Char.		N uptake kg.fed^{-1}	P uptake kg.fed^{-1}	K uptake kg.fed^{-1}	Fe uptake g.fed^{-1}	Mn uptake g.fed^{-1}	Zn uptake g.fed^{-1}
A:- Mineral fertilization							
Control		22.23	3.68	3.94	89.92	37.09	41.71
12.5%		23.74	3.95	4.36	91.12	44.41	43.70
18.75%		26.17	4.27	4.67	106.23	47.91	48.33
25%		24.86	4.21	4.59	99.98	45.81	45.12
L.S.D $_{at\ 5\%}$		**1.34**	**0.22**	**0.26**	**6.58**	**2.78**	**2.97**
B:- Biofertilization							
Azl.		24.16	4.18	4.36	75.56	47.47	43.80
Azs.		27.13	4.04	5.21	118.87	47.32	49.65
Cyn.		24.72	4.18	4.58	100.27	44.30	43.66
Azt.		23.53	4.32	5.06	114.64	44.64	47.42
Azl. + Azs.		26.46	4.03	4.34	98.55	41.30	46.67
Azl. + Azt.		23.80	3.76	4.25	87.13	40.88	43.82
Azs. + Azt.		21.34	3.63	3.72	92.25	40.01	41.23
Cyn. + Azt.		22.86	4.05	3.59	87.22	44.53	41.44
L.S.D $_{at\ 5\%}$		**0.19**	**0.03**	**0.04**	**1.81**	**0.79**	**0.72**
A × B:- Mineral fertilization × Biofertilization							
Control	**Azl.**	21.00	3.43	4.01	54.57	40.24	38.06
	Azs.	25.29	3.60	4.95	84.87	45.55	46.44
	Cyn.	24.05	4.08	4.35	113.20	38.48	44.08
	Azt.	20.67	3.84	4.43	104.30	33.75	47.56
	Azl. + Azs.	21.93	3.68	3.90	93.35	36.13	40.22
	Azl. + Azt.	21.98	3.55	3.63	90.24	34.14	41.49
	Azs. + Azt.	21.60	3.62	3.43	96.21	35.11	39.59
	Cyn. + Azt.	21.28	3.63	2.80	82.63	33.34	36.19
12.5%	**Azl.**	24.10	4.13	4.26	71.00	46.86	40.27
	Azs.	26.56	3.87	5.15	121.66	47.05	48.57
	Cyn.	25.33	4.26	4.41	98.79	45.98	43.09
	Azt.	22.57	4.62	5.36	111.53	51.63	52.13
	Azl. + Azs.	24.32	3.54	3.80	81.42	42.23	42.25
	Azl. + Azt.	25.46	3.88	3.97	74.94	35.79	42.92
	Azs. + Azt.	20.70	3.45	4.05	86.50	38.22	40.07
	Cyn. + Azt.	20.89	3.79	3.86	83.09	47.51	40.27
18.75%	**Azl.**	23.26	4.90	4.33	95.96	52.83	47.69
	Azs.	29.43	4.51	5.88	131.62	51.71	54.10
	Cyn.	25.49	4.18	4.58	101.77	48.50	44.73
	Azt.	26.79	4.41	5.54	121.05	48.38	47.63
	Azl. + Azs.	32.01	4.60	5.04	123.84	44.58	57.01
	Azl. + Azt.	26.40	3.49	4.63	91.11	51.26	48.45
	Azs. + Azt.	21.04	3.90	3.57	95.53	44.27	44.80
	Cyn. + Azt.	24.93	4.14	3.77	88.98	41.76	42.24
25%	**Azl.**	28.27	4.27	4.84	80.70	49.95	49.16
	Azs.	27.24	4.17	4.89	137.32	44.98	49.50
	Cyn.	24.00	4.21	4.97	87.31	44.24	42.75
	Azt.	24.10	4.41	4.89	121.68	44.79	42.40
	Azl. + Azs.	27.59	4.28	4.65	95.62	42.25	47.20
	Azl. + Azt.	21.37	4.11	4.78	92.22	42.34	42.39
	Azs. + Azt.	22.04	3.57	3.81	90.76	42.43	40.46
	Cyn. + Azt.	24.34	4.64	3.91	94.18	55.49	47.08
L.S.D $_{at\ 5\%}$		**0.38**	**0.07**	**0.07**	**3.63**	**1.57**	**1.44**

Azospirillum biofertilizer single inoculation obtained the superior mean values (27.13, 5.21 Kg fed^{-1}., 18.87 and 49.65 g fed^{-1}.) for N, K, Fe and Zn uptake by wheat grains, respectively. In this context also, the highest mean value of P-uptakeof(4.32 kg fed^{-1}) by grains due to the inoculation of (Azotobacter). Meanwhile, the maximum Mn-uptake was (47.47 g fed^{-1}) occurred with (Azolla) inoculation as a residual effect after rice planting. This effect of residual effect of N-biofertilizer inoculation upon nutrient uptake could be attributed to organic matter, which was produce, by N-biofertilizer inoculation and nutrient element such as N, P, K, Fe, Mn and Zn which releases from histolysis of organic matter. Therefor, soil fertility increase and supplying wheat plants with nutrients which increasing nutrients uptake in wheat plant. These changes have been attributed to inoculation induced enhancement mineral uptake in plants, Variation in improvement of N, P, K, Fe, Mn, and Zn uptake through inoculation in wheat, sorghum, rice and corn proposed that enhancement of mineral uptake by plants results in an increased accumulation of both dry matter and minerals in the stem and leaves of plant. Briefly, inoculation increased both concentration and uptake of N, P, K, Fe, Mn, and Zn and that indicated the beneficial effect of biofertilization (Mervat and Dahdoh; 1997).

Effect of combination of nitrogen fertilization levels and the **residual effect of N-biofertilizer inoculations:**

It is evident from Table 3, that combination of nitrogen fertilization levels with the residual effect of N-biofertilizer inoculations had significant effect on N, P, K, Fe, Mn and Zn uptake as average two seasons. It is worth to mention that highest mean values of N, Zn, P and K uptake were produced when 18.75 % N-level applied integrated with residual effect of (Azolla + Azospirillum) for N-uptake (32.01 kg fed^{-1}) and Zn-uptake (57.01 g fed^{-1}) while, with the residual effect of(Azolla) and (Azospirillum) for P-uptake (4.90 kg fed^{-1}) and K-uptake (5.88 kg fed^{-1}), respectively. Regarding the uptake of Fe and Mn, the highest mean values (137.32 and 55.49 g fed^{-1}) were obtained at 25 % N-level applied, the residual effect of (Azospirillum) and (Cynobacteria + Azotobacter) as residual effect after rice culture for Fe and Mn uptake, respectively. These results could be confirmed with those obtained by Hammouda *et al.*, (2001).

N-recovery % :

Table 4, illustrate mean values of nitrogen uptake by wheat plants from available nitrogen in soil after planting. Available nitrogen estimated for every treatment of wheat crop since, the lowest values of available nitrogen were (36.35 and 13.00 ppm) at no N-fertilization coupled with Azospirillum inoculation as average two seasons before and after planting, respectively. While, the maximum values of available nitrogen (71.93 and 40.52 ppm) in soil as average two seasons occurred with combination of 25 % N-level + Azotobacter inoculation before and after planting, respectively. Data in Table 4, show decreasing of available N during wheat planting under this study, and found that the combination of 18.75 % N-level + (Azolla + Azospirillum) gave the lowest value (14.29 ppm) as average two seasons, in this respect Azolla and Azospirillum proved to be more effective than the other different combinations due to N-uptake percentage of (67.92 %) from available N in soil was highest. In addition, the highest average value available N decreasing (32.61 ppm) in soil during planting was investigated at (18.75 % N-level combined with Azotobacter inoculation. Data in Table 4, reveal that the highest average value of % N-recovery (61.66%) was achieved at combination with (Azolla+ Azospirillum) + 18.75 % N-level of recommended level and biofertilization because the N-uptake from organic and inorganic % was highest 67.92 % than other treatments, while the lowest average value of (19.67 %) occurred with Azotobacter inoculation combined with no nitrogen fertilization under control.

Table 4: Effect of nitrogen fertilization levels, N-biofertilizer inoculations and their combinations on available nitrogen, release from organic & inorganic-N and N-recovery % in wheat crop as average two seasons.

Treat.	Char	Available N ppm in soil			Total N-uptake during planting kg/fed.	Release from organic and inorganic ppm	N-uptake from organic and inorganic %	N-recovery %
		Before planting	After planting	Decreasing during planting				
Control	Azl.	37.8	17.85	19.95	33.66	13.71	40.73	40.73
	Azs.	36.35	13.00	23.35	39.93	16.58	41.52	41.52
	Cyn.	48.60	23.80	24.08	34.79	9.99	28.72	28.72
	Azt.	63.00	36.78	26.22	32.64	6.42	19.67	19.67
	Azl. + Azs.	38.35	16.22	22.13	35.87	13.74	38.30	38.30
	Azl. + Azt.	45.00	19.86	25.14	31.51	6.37	20.22	20.22
	Azs. + Azt.	47.55	25.85	21.70	29.88	8.18	27.38	27.38
	Cyn. + Azt.	48.88	24.85	24.03	30.73	6.70	21.80	21.80
12.5%	Azl.	38.70	21.68	17.02	39.04	22.02	56.40	57.36
	Azs.	39.50	20.50	19.00	44.30	25.30	57.11	46.59
	Cyn.	50.40	27.22	23.18	37.79	14.61	38.66	31.98
	Azt.	58.15	34.73	23.42	36.07	12.65	35.07	36.57
	Azl. + Azs.	40.60	19.73	20.87	41.23	20.36	49.38	57.14
	Azl. + Azt.	44.55	17.64	26.91	36.37	9.46	26.01	51.81
	Azs. + Azt.	58.50	34.22	24.28	34.02	9.74	28.63	44.14
	Cyn. + Azt.	47.70	21.73	25.97	33.69	7.72	22.91	31.56
18.75%	Azl.	40.95	23.93	17.02	41.86	24.84	59.34	58.32
	Azs.	47.25	20.22	27.03	48.15	21.12	43.86	58.46
	Cyn.	53.55	25.85	27.70	39.77	12.07	30.35	35.42
	Azt.	70.65	38.04	32.61	41.00	8.39	20.46	59.46
	Azl. + Azs.	42.30	28.01	14.29	44.54	30.25	67.92	61.66
	Azl. + Azt.	47.25	18.25	29.00	39.63	10.63	26.82	57.75
	Azs. + Azt.	59.85	35.35	24.50	34.58	10.08	29.15	33.43
	Cyn. + Azt.	58.28	31.22	27.06	34.97	7.91	22.62	30.16
25%	Azl.	44.10	25.53	21.57	43.63	22.06	50.56	53.17
	Azs.	50.40	22.19	28.21	48.10	19.89	41.35	43.57
	Cyn.	56.70	28.20	28.50	40.59	12.09	29.79	30.93
	Azt.	71.93	40.52	31.41	40.95	9.54	23.30	44.32
	Azl. + Azs.	47.25	27.20	20.05	47.19	27.14	57.51	60.37
	Azl. + Azt.	53.55	22.72	30.83	40.28	9.45	23.46	46.77
	Azs. + Azt.	63.00	20.57	25.43	35.73	10.30	28.83	31.20
	Cyn. + Azt.	66.15	38.15	28.00	36.13	8.13	22.50	28.20

El-Naggar *et al.*, (2005) reported that Azospirillum still uppermost than Cyanobacteria in improving N-uptake, N-use efficiency, % biomass N recoverd and available soil N, for wheat**.**

Economic evaluation of wheat crop.

The data recorded in Table 5, show that the highest net return (£.L.3060 fed^{-1}.) was obtained from wheat receiving 25 % N-level + single inoculation of Azospirillum, in comparison with other treatments.

Table 5: Estimate of additional net return of treatment.

Wheat		Average grain yield (Mg. fed^{-1})	Average straw yield (Mg. fed^{-1})	Total costs (£.L.fed^{-1})	Additional cost (£.L.fed^{-1})	Gross return (£.L.fed^{-1})	Net return (£.L.fed^{-1})	Order
Control	Azl.	1.38	1.07	2440	160	4000	1560	18
	Azs.	1.72	1.32	2440	160	4977	2537	5
	Cyn.	1.05	1.12	2440	160	3227	787	32
	Azt.	1.09	1.01	2440	160	3258	18	31
	Azl. + Azs.	1.48	1.06	2440	160	4237	1797	14
	Azl. + Azt.	4.23	1.01	2440	160	3599	1159	27
	Azs. + Azt.	1.27	1.05	2440	160	3720	1280	25
	Cyn. + Azt.	1.23	1.05	2440	160	3623	1183	26
12.5%	Azl.	1.41	1.27	2470	190	4193	1723	15
	Azs.	1.72	1.44	2470	190	5049	2579	4
	Cyn.	1.16	1.29	2470	190	3597	1127	28
	Azt.	1.09	1.23	2470	190	3390	920	30
	Azl. + Azs.	1.54	1.22	2470	190	4479	2009	12
	Azl. + Azt.	1.28	1.16	2470	190	3811	1314	24
	Azs. + Azt.	1.31	1.09	2470	190	3842	1372	22
	Cyn. + Azt.	1.31	1.08	2470	190	3836	1366	23
18.75%	Azl.	1.72	1.33	2485	205	4983	2498	7
	Azs.	1.90	1.48	2485	205	5511	3026	2
	Cyn.	1.38	1.20	2485	205	4078	1593	17
	Azt.	1.31	1.20	2485	205	3908	1423	21
	Azl. + Azs.	1.69	1.51	2485	205	5018	2533	6
	Azl. + Azt.	1.57	1.31	2485	205	4606	2121	9
	Azs. + Azt.	1.56	1.21	2485	205	4522	2037	11
	Cyn. + Azt.	1.32	1.17	2485	205	3914	1429	20
25%	Azl.	1.91	1.40	2500	220	5488	2988	3
	Azs.	1.93	1.44	2500	220	5560	3060	1
	Cyn.	1.11	1.25	2500	220	3451	951	29
	Azt.	1.32	1.22	2500	220	3944	1444	19
	Azl. + Azs.	1.57	1.33	2500	220	461	2118	10
	Azl. + Azt.	1.64	1.29	2500	220	4765	2265	8
	Azs. + Azt.	1.48	1.19	2500	220	4315	1815	13
	Cyn. + Azt.	1.37	1.31	2500	220	4120	1620	16

*** Grain and straw yield as average two seasons.**

***Total costs include leasehold, labor, PK fertilizers, seeds and other cultural practice which equal nearly £.L. 2280, plus additional cost.**

***Additional cost was calculated according to the following price; price of urea fertilizer £.L.1.50 /kg , yeast £.L.10/ kg and finally, price of produce grain yield £.L.2433.33/ton and straw yield £.L.600/ton.**

Thus, this treatment proved to be economical for wheat production. As a support for the present results El Kholi (1998) said that The intensive use of inorganic fertilizers; the progressive rise in their cost and their low efficiency have comprised expensive charges for the agricultural products, particularly in the developing countries. Thus, attempts have been undertaken to find out a partial substitution for the usually applied chemical fertilizers by using biofertilizers.

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التـاثير المتبقـي للتسـميد الحيـوي لـلأرز كبـديل اقتصـادي للتسـميد النيتروجينـي لمحصـول القمح.

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تم اجراء هذة الدراسة بقرية ميت لوزة مركز المنصورة بمحافظة الدقهلية مصر خلال موسمي النمو (٢٠٠٩-٢٠١٠)و (٢٠١٠-٢٠١١) في ارض طينية سلتية لايجاد التاثير المتبقي للتسميد الحيوي للأرز علي المحصـول التـالي (القمـح) وكانـت معـاملات التسـميد الحيـوي تشـمل (الأزولا), (الأزوسـبيريليم), (الأزوتوبـاكتر), (السـيانوباكتيريا) وكـذلك(الأزولا+ الأزوسـبيريليم), (الأزولا+ الأزوتوبـاكتر), (الأزوسبيريليم+ الأزوتوباكتر), (السيانوباكتيريا+ الأزوتوباكتر) والتسميد النيتروجيني الأرضي (بدون تسميد – ١٢.٥ %- ١٨.٧٥ %- ٢٥ % من الجرعة الموصي بها ٧٥ كجم نيتروجين /فدان)في صورة يوريا ٤٦.٥ % .تم إجراء التجربة في قطع منشقة مع ٣ مكررات.وكانت النتائج كالتالي

- المعاملة بمستوي ن ٢٥ % أدت إلي أعلي زيادة في طول النبات, محصول الحبوب ومحتوي كلوروفيل ا وب (١٠١.٢٧ سم ,١.٥٧ ميجاجرم/فدان, ١٣.٥٥ ملجم /جم وزن طـازج و ٨.٩٥ ملجم /جم وزن طـازج) لهـذه الصـفات بالترتيـب, المعاملـة بمسـتوي ن ١٨.٧٥ % أدت إلـي أعلـي محصـول قـش, الممـتص مـن النيتروجين,الفوسفور,البوتاسـيوم,الحديد,المنجنيز,الزنك فـي الحبـوب بالترتيـب (١.٣١ ميجاجرم/فدان,٢٦.١٧, ٤.٢٧,٤.٦٧)كجم/فدان, ١٠٦.٢٣ ,٤٧.٩١ ,٤٨.٣٣ جم/فدان. واعلـي قيمـة للكاروتين ٢.٧٥ ملجم/جم وزن طازج تحققت عند مستوي (بدون تسميد)
- تلقيح الازولا أعطـي أعلـي قيم ل طـول النبـات و المنجنيـز الممـتص ٩٨.١٦ سم و ٤٧.٤٧ جم /فدان وأعلـي محصـول للحبـوب , القش,الكـاروتين,الممتص مـن النيتروجين,البوتاسـيم,الحديد والزنـك بسـبب التلقيح ب الأزوسـبيريليم (١.٨٤, ١.٤٠ ميجاجرم/فـدان, ٣.٤٨ ملجـم /جـم وزن طـازج و ٢٧.١٣, ٥.٢١ كجم/فدان, ١٨.٨٧, ٤٩.٦٥ جم/فدان) بالترتيب. أعلي ممتص من الفوسفور (٤.٣٢ كجم/فدان) ظهر عند التلقيح ب الأزوتوباكتر بينما المعاملة ب (الأزوسبيريليم+ الأزوتوباكتر) أظهرت أعلي القيم (١٥.٠٥و ١٠٢٥ ملجم /جم وزن طازج) لكلوروفيل أ و ب.
- المعاملـة بـالخليط ن ٢٥ % + الازولا او الأزوسـبيريليم أوالسـيانوباكتريا أو (الأزوسـبيريليم + الازوتوباكتريا) أو الأزوسبيريليم أو (السيانوباكتريا+ الازوتوباكتريا) أعطي أعلي القيم ل طول النبات (١٠٦.٣٨ سم) محصول الحبوب (١.٩٥ ميجاجرم/فدان) كلوروفيل أ وب (١٥.٥٢, ١٣.٣٩ ملجم /جم وزن طازج) ,الممتص من الحديد والمنجنيز (١٣٧.٣٢ و ٥٥.٤٩ جم/فدان) بالترتيب. أما خليط مستوي ن ١٨.٧٥ % + (الازولا+ الأزوسبيريليم) أعطي أعلي القيم ل محصول القش (١.٥٣ ميجاجرم/فدان), الممتص من النيتروجين,الزنك (٣٢.٠١ كجم/فدان, ٥٧.٠١ جم/فدان),الميسر مـن النيتـروجين المضـاف (٣٠.٢٥ جـزء فـي المليـون, % للنيتـروجين الممـتص (٦٧.٩٢ %), % الإسـتفادة مـن النيتـروجين (٦١.٦٦%). ولكـن خلـيط مسـتوي ن ١٨.٧٥ % مـع الازولا أو الأزوسـبيريليم أعطـي أعلـي قـيم للفوسفور,البوتاسيوم الممتص بالترتيب (٤.٩٠ , ٥.٨٨ كجم/فدان.اعلي قيم للكاروتين ٣.٧١ ملجم /جم وزن طـازج تحصـل عليـة مـن خليط (ن ١٢.٥ % + الأزوسبيريليم). وأعلـي صـافي ربـح لمحصـول القمح ٣٠٦٠ جنية /فدان من خليط (ن ٢٥ % + الأزوسبيريليم).

قام بتحكيم البحث

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