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Response of Wheat (*triticumastivum* L.)to Bio fertilization and NPK fertilizers with and without Chicken manure

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Abstract

Wheat is the most important crop in Egypt and the imports are large to fill the gap between production and consumption. Biofertilization is highly needed to help increasing the local production.N_2 fixers *Azospirillum+Azotobacter*bacteria, P-dissolver *Bacillus megaterium* bacteria and K-dissolver ***B. circulans*** bacteria were assessed for wheat growth and nutrient uptake in 3 pot experiments (one for each nutrient) in absence or presence of nutrient-rich chicken manure (CM) applied at 10 g kg^{-1}.Increases in plant growth (45-day growth) of up to 50% occurred particularly in presence of CM. Sources of rock phosphate P and rock (feldspar) K were used to provide available P and K with the help of the biofertilizers and along with the organic manure. Soluble sources of N (ammonium sulphate), P (Ca-superphosphate) and K (K-sulphate) were included for comparisons. Practical implications indicate a strong proofs that using biofertilizers can contribute to sustainability in boosting wheat production.

Key words: Wheat, biofertilization and NPK fertilization.

Introduction

Wheat is the most important cereal crops in the world and in Egypt, it the local production is not sufficient to supply demand the country which leads to importing large quantities to make for the gap. The 2016-year production of wheat in Egypt was about 9 million Mg (1 Mg"megagram" = 10^6 g) and the import was 12 million Mg **(FAO, 2017).** Efforts in reclaiming new arable lands involve cultivation of wheat in such lands. Since the crop needs a fertile soil to grow on to givereasonable production in low fertility lands by adding materials such as manures and biofertilizerswhich may help increasing the fertility of soils(**Mohammadi and Sohrabi (2012):Abdel-Salam et al., 2012 and Abdel-Salam, 2014**). Organic manuresare materials of organic nature, animal or plant residues which when well decomposed are of benefit for plant growth and production. Investigation of different organic manures showed that poultry manure was of considerable contents of N, P,K compared with different sources (**Rowell and Hadad, 2017**).

Inocula of microorganisms beneficial for soil fertility can be used as biofertilizers. The most used biofertilizers belong to three main groups:the N_2-fixing, the phosphate solubilising (P- solubilising) and the K-solubilising groups (**Abdel-Salam, 2014)**.The N_2-fixing microorganisms fixatmospheric N_2 and transform it into amines and other organic N substances ready for plant use (an operation called "N_2-fixation").The N_2-fixers include symbiotics, such as the *Rhizobia*species, and free-living ones such as *Azospirillum*and *Azotobacter* species (**Dhanasekar and Dhandapani, 2012).**OtherN_2 fixing cyanobacteriainclude *Aulosira, Tolypothrix, Scytonema, Nostoc, Anabaena* and *Plectonema*.Inocula of N_2fixersare used as biofertilizers**(Roy and Srivastava, 2013).**Many N_2fixers can provide plants with growth-promoting substances and vitamins **(Venkataramanand Neelakantan, 1967).**On the other hand, **t**he P-dissolving and K-dissolving microorganisms causes olubilization of insoluble P (of phosphate rocks or other insoluble P-forms) or insoluble K (of feldspar rocks, or other insoluble or fixed-K) releasing them to plants for uptake**.**Total P in soilis mainly in insoluble forms, and even if soils are supplied with soluble phosphate, a majority of this P is quickly transformed into insoluble P,but can be dissolved by microorganisms**(Seshardi, 2000).** Most microorganisms have enzymatic systems that catalyzes hydrolysis of `myo-inositol hexa-kisphosphate` (phytic acid) (**Greaves et al., 1963).** Bacteria have phytase and nuclease, to mineralize glycerophosphate as well as lecithin **(Atlas and Bartha 1998 and Madigan et al., 2000).**The most used P-dissolving bacteria (PDB) is an inoculum of *Bacillus megaterium* , marketed under different commercial brand names including the biofertilizer brand of PHSPHORIN© manufacture by the Egyptian Ministry of Agriculture.

Total K in soil is mainly in non-soluble forms (**Sharpley, 1989)** .From a total K content of about 1800 to 9000 mg kg^{-1} in Qalubiasoils, only about 2 to 15 % of such contents are available (**Abdel-Salam 2001**). Potassium dissolvingbacteria (KDB) include *Bacillus, Pseudomonas* and *Clostridium* bacteria.The most used of them are *Bacillus circulans,* under different commercial names**(Lian et al. 2008, Mohammadi ,K. and Sohrabi,Y. 2012 and Parmar and Sindhu 2013).**The present work aims at assessing three kinds of bacterial inoculai.e. N_2-fixers, P-dissolvers and K-dissolvers as providers of nutrients (biofertilizers) for wheatin presence and absence of organic chicken manure which is one of the few organic manures most rich in plant nutrients (**Singh et al. 1996, andRowell and Hadad, 2017**).

Materials and methods:

Three pot experiments were conducted on wheat (*Triticumaestivum*, cv. Giza 168) grown on aheavy clay soil (Table 1). Each was in a randomized complete block design, factorial with two factors in 3 replicates. Experiments 1,2 and 3 relate to N, P and K fertilization respectively. Factors and treatments are as follows for each experiment: E**xperiment 1(N-experiment): Factor 1 N**-fertilization 3 treatments of N0, N1 and N2 i.e. non-fertilized, mineral-N-fertilized and bio-fertilized with *Azotobacter+ Azospirillum* respectively. **Factor 2:** Organicmanuring; i.e.non-manured (O_0) and chicken-manured (O_1).E**xperiment2(P-experiment): Factor 1 P-fertilization:**5 treatments of P_0, P_1,P_2, P3 and P4 i.e. non-P-fertilized, PDB-biofertilized (*B. megaterium*), super-phosphate-P, rock-P and PDB+rock-Prespectively.**Factor2**: Organic manuring: as with experiment1. E**xperiment 3 (K-experiment): Factor 1:K-fertilization 5 treatments of** K0, K1,K2, K3 and K4 i.e. non-K-fertilized , KDB-biofertilized (***Bacillus circulans***) , Sulphate-K, rock-K and KDB+rock-K respectively.**Factor 2:**Organicmanuring: as with experiment 1.Mineral soluble fertilizers were ammoniumsulphate (205 g N kg^{-1}),ordinary calcium superphosphate (68 g P kg^{-1}), and potassium sulphate (400 g K kg^{-1}). In experiment 1, N was at 100 mg Nkg^{-1} (in 3 equal splits, on days 10, 20 and 30 after seeding). In Experiment 2 mineral super phosphate P was at 30 mg P kg^{-1}, while rock P was at 60 mg P kg^{-1}. **In experiment 3**,sulphate K was 200 mg K kg^{-1}while rock K was at 400 mg K kg^{-1}. Rock nutrients (rock phosphate-P and feldspar-K) as well as soluble P and K were applied during soil preparation. The rock ones were at rates double those of their soluble forms in view of the insolubility nature of the former sources. Organic manure was added to soil at 10g kg^{-1}during soil preparation. Each pot was seeded with 12 seeds, thinned to 9 plants after emergence. Plants were allowed to grow for 45 days after which they were removed, weighed and oven dried then weighed. All pots of experiment 1 were given P and K, all pots in experiment 2 were given N and K given, and all pots of experiment 3 were given N and P. This was done to allow for exhibiting the response of the nutrient under study in every experiment under no stress of lack of other macro nutrients. Analysis of rockphosphate, superphosphate and feldspars are given in Table 2 .

Table 1. Main properties of soil of the experiment

Property	Value	Property			Value
Particle size distribution		Soluble ions (mmolcL^{-1})			
Sand %	26.3	Ca^{2+}			5.5
Silt %	17.0	Mg^{2+}			4.8
Clay %	56.7	Na^{+}			9.2
Texture class	heavy Clay*	K^{+}			0.5
Moisture parameters		Cl^{-}			8.3
		SO_4^{2-}			6.2
Saturation percent (%)	67.8	HCO_3^{-}			5.5
Field capacity (% w/w)	43.0	CO_3^{2-}			0.0
Wilting point (% w/w)	24.2	Available nutrients** (mg kg^{-1})			
Available water(% w/w)	18.8	N	25	Fe	0.8
Organic matter content		P	14	Mn	0.6
Organic matter (g kg^{-1})	13.1	K	180	Zn	0.7
Chemical Properties				Cu	0.2
$CaCO_3$ (g kg^{-1})	1.5				
pH(1:2.5 w:v soil water)	7.3				
EC dSm^{-1} (in paste extract)	2.0				
CEC (cation Exchangeable Capacity) cmolc kg^{-1} soil	30.4				

* According to the International Soil Texture Triangle (Moeys, 2016).
** Extracts are: KCl (for N); NH4HCO3-DTPA (for P and K). DTPA for micronutrients.

Table 2. Nutrients (total)in mineral P and K materials and manure used in the experiment

Source	Total P ($g\ kg^{-1}$)	Total micronutrients ($mg\ kg^{-1}$) Fe	Mn	Zn	Cu
Super phosphate	TotalP67	28	150	195	7
Rock phosphate	Total P 125	4200	261	810	14
Feldspar	Total K120	165	40	7	6
Contents of main constituents of the chicken manure $g\ kg^{-1}$					
Ash $g\ kg^{-1}$	Organic matter	Total N	Total P	Total K	Soluble N
23	83.1	42	21	32	10

The soil was taken from an arable field in Moshtohor ,Qalubiya, sieved through 8-mm sieve (to keep aggregates of the soil and allow for sufficient aeration for plant roots; no stones were in the soil) .Soils and plants were analyzed according to method cited by**Black et al. (1965) for soils and chapman and Pratt (1961)** for plants and soil **.**

Results and discussion:

For each experiment the results will be confined to the response in terms of plant growth weight (shoots+roots) and the uptake on the nutrient relating the experiment. N uptake and protein contents will be included in experiment 1 in view of the importance of protein for plant quality.

Experiment 1. TheN-experiment:

The N fertilization treatments were N_0, N_1andN_2:non-fertilized and, N- mineral-fertilized and N-bio-fertilized with *Azotobacter*+ *Azospirillum*respectively while the organic manured were O_0 and O_1: non-manured and chicken manured respectively.

Plantgrowth weight (Table 3):

Application of fertilizers with of N without the organic manure increase the growth of wheat plant. The lowest weight was that which received neither manure nor N fertilization, giving 7.55 g pot^{-1}. All other treatments which received either manure of N fertilization of both gave increases of 8.3% (by manure alone) to 96.8% (by manure +bio-fertilization) indicating a considerable positive response***Azotobacter*/*Azospirillum***(**Zambre et al., 1984**) especially when combined with the chicken manure which is notably high in N nutrient (**Rowell and Hadad,2017)**.The main effect of N treatments shows a pattern of N_2> N_1> N_0 (average increase of 84.4 and 49.9 % by N_3 and N_2 respectively).The main effect was an average increase of 13.7%. High response to N occurredparticularly under no manuringwith littledifference between the mineral N and the biological N sources. The effect of manuring occurred was particularly significant under mineral N.

Table 3. Response of wheat to N-biofertilizer,N-mineral fertilizer and organic manuring:Dry weight of roots+shoots of “45-day growth”. (g pot^{-1})

Organic manuring (O)	N fertilization (N) N_0	N_1	N_2	mean
O_0	7.55	10.26	14.05	**10.62**
O_1	8.18	13.24	14.86	**12.08**
mean	**7.84**	**11.75**	**14.46**	
$LSD_{0.05}$= O: 1.3	**; N: 1.7**	**; ON:2.3**		

Notes: O_0 and O_1 are non-manured andmanured with chicken manure respectively….. N_0, N_1 and N_2 are non-fertilized , N-mineral-fertilized andbio-fertilized with *Azotobacter*+ *Azospirillum* respectively.

N uptake (Table 4):

The non-treated plants showed an uptake of 108.3 mg pot^{-1}, while all treated plants exhibited higher uptake surpassing the non-treated by 18.2% by the manured treatment to as high as 322% by the manured bio-fertilized treatment. This indicates a considerable cumulative effect of the chicken manure when combined with the N-biofertilization (**Abd-El-Latifet al., 2001**). The main effect of N treatments shows a pattern of N_2 > N_1>N_0, with average increases of 85.3 and 256.5 % by N_2 and N1, respectively. The main effect of manuringanaverage increase 73.9 % by manuring. The positive effect of N occurred particularly under manuring, more than in absence of manuring. The considerable increase given by manuring was particularly under conditions of no N fertilization. Thus there were interaction effects showing that mineral N was effective only under conditions of manuring; and that manuring was effective where N- fertilization was absent. Augmentation of organic manure to the effect of N-application proved important for maximum benefit of N- fertilization (**Zambre et al 1984 and Ghoneim and El-Araby, 2003)**.

Table 4. Response of wheat to N-biofertilizer, N-mineral fertilizer and organic manuring: N-uptake by roots+shoots of “45-day growth”.(mg pot^{-1})

Organic manuring (O)	N fertilization (N)			mean
	N_0	N_1	N_2	
O_0	108.3	169.2	385.9	**221.1**
O_1	128.0	268.7	456.9	**384.5**
mean	**118.2**	**219.0**	**421.4**	

LSD $_{0.05}$= O: 69.4 ; N: 85.0 ; ON: 100.2

Notes: O_0 and O_1 are non-manured and manured with chicken manure respectively….. N_0, N_1 and N_2 are non-fertilized , N-mineral-fertilized and bio-fertilized with *Azotobacter* + *Azospirillum* respectively

Protein content in plant (Table 5):

The protein content was calculated using the N content multiplied by a factor of 5.7 (**AOAC 2000**).Treatments given N or manure or both showed increased protein contents. The non-fertilized plants showed a content of 82.8 mg protein g^{-1}. All plants given N or manure (singly or combined) showed increases of 9.1%(by the manured) to 114.7 % (by the manured+ biofertilized; a manifestation of the enhancement effect of biofertilization when combined with organic manure. (**Ghoneimand El-Araby, 2003**). The main effect of N treatments shows a pattern similar to that of the N uptake, i.e. $N_2 > N_1 > N_0$, with increases averaging 94.0 and 22.0 % by N_2 and N1 respectively. The superiority of mineral N over the no-N treatment was particularly shown in presence of manure indicating an interaction of manure to the effect of mineral N: i.e. for mineral N to increase the protein, there should be manure application.

The main effect of manuring shows an average 14.4 % increase by manuring .Such pattern of response occurred particularly under conditions of N application (biological or mineral) indicating an interaction caused by N application to the response tomanuring :i.e. in order for manuring to be of significant positive effect , there should be N fertilization (mineral of biological). Augmentation of organic manure to N-application proved important for maximum benefit of N- fertilization (**Singh et al., 1996** and **Ghoneim and El-Araby, 2003**).

Table 5. Response of wheat to N-biofertilizer, N-mineral fertilizer and organic manuring: Protein content (mg g^{1}) in plant (roots+shoots) of “45-day growth”.

Organic manuring(O)	N fertilization (N)			mean
	N_0	N_1	N_2	
O_0	82.8	95.7	159.5	**112.7**
O_1	90.5	117.7	178.1	**128.8**
mean	**46.2**	**56.7**	**118.8**	

LSD $_{0.05}$= O: 8.5 ; N: 9.6 ; ON: 10.0

Notes: O_0 and O_1 are non-manured and manured with chicken manure respectively….. N_0, N_1 and N_2 are non-fertilized , N-mineral-fertilized and bio-fertilized with *Azotobacter*+ *Azospirillum*respectively(protein factor: **N** x**5.8**)

Experiment 2: The P experiment:

The P fertilization treatments were P_0, P_1, P2, P_3 and P_4, i.e.(non-P-fertilized, PDB-biofertilized (*B. megaterium*), super-phosphate-P, rock-P and PDB+rock-P), while the organic manure ones were O_0 and O_1 i.e. non-manured and chicken manured respectively.

Growth weight (Table 6):

The non-treated plants showed the lowest weight of 12.87 g pot^{-1}while all plants which received fertilizers gave increases ranging from 5.4% (by manure alone)to 45.8% (by superphosphate + manure) and as high as 49.7% (bymanure+PDB+Rock-P) indicating high efficiency of combining the PDB withchicken manureto boost dissolution of P in rock phosphate (**Elsebaay, and Elkotkat, 2011 and Abdel-Salam et al., 2016).** The main effect of P-fertilization shows the pattern P4> P_2> P_3> P1>P_0 indicating efficient use of P-biofertilizer combined with mineral P, particularly rock P. In studies elsewhere on PDB B. *megaterium* combinedwith chicken manure (**Dawa et al.,2013 andRowell and Hadad,2017)** on tomato and wheat, increases of up to 50% increase in plant growthwere obtained.On maize, field experiment studies (**Abdel-Salam et al. 2016)** increases exceeded 100% by applying PDB (*B.megaterium*)+farmyardmanure + rock P. Growth promoting substances includingindole-acetic acid (IAA) and siderophoresare producedby B. *megaterium*(**Madiganet al 2000** and **Mehta et al 2010)**

Table 6. Response of wheat to P-biofertilizer, P-mineral fertilizer and organic chicken manure: Plant weight (roots+shoots) of "45-day growth".(g pot[1])

Organic manuring (O)	Bio-Mineral P-fertilization (P)					mean
	P_0	P_1	P_2	P_3	P_4	
O_0	12.87	13.72	15.56	15.30	16.63	**14.75**
O_1	13.56	16.10	18.77	15.39	19.26	**16.62**
mean	**13.22**	**14.91**	**17.17**	**15.35**	**17.95**	
LSD 0.05 = O: 0.89 P:1.41 OP: 1.99						

Notes: O_0 and O_1 are non-manured and manured with chicken manure respectively….. P_0, P_1,P_2, P_3 and P_4 are non-P-fertilized , PDB-biofertilized (*B. megaterium*) , super-phosphate-P, rock-P and PDB+ rock- Prespectively

The PDB in the current study was notable in its efficiency where there was chicken manure, thusexhibiting an interaction caused by manure boosting the positive response to P-biofertilization. The main effect of manure showsan average of 12.7% increase; the effect was particularly in presence of Super-P alone(20.6%), PDB(17.3%), or PDB+rock P (15.8%).

P uptake in whole plant (Table 7):

Untreated plants showed an uptake of 35.64 mg pot^{-1}. All other treatments showed increases ranging from 39.4% (by the biofertilized treatment) to 249.4% (by manure + PDB+Rock-P. The main effect of P-fertilization shows a pattern resembling the one of yield i.e. P_4> P_2> P_3> P1>P_0 confirming the positive response of combining P-biofertilization with rock P boosted by chicken manure. The main effect of manure shows an average 47.6% increase. The positive effect of manure was most apparent in presence PDB (64.9%), rock P (39.9%) or rock P+ biofertilizer (49.3%).Increased P uptake caused by *B. megaterium* with or without organic manures or rock P were reported by researchers on a number of crops including wheat (**Laheurte and Berthelin1988, Ghoneimand El-Araby, 2003**, **Dawa et al 2013, Abdel-Salam et al., 2016and Rowell and Hadad,2017**).

Table 7. Response of wheat to P-biofertilizer, P-mineral fertilizer and organic chicken manure: P uptake in (roots+shoots) of "45-day growth".(mg pot[1])

Organic fertilization (O)	Bio-Mineral P-fertilization (P)					mean
	P_0	P_1	P_2	P_3	P_4	
O_0	35.64	49.69	77.66	60.89	83.43	**61.46**
O_1	64.78	81.93	97.07	85.16	124.52	**90.69**
Mean	**50.21**	**65.81**	**87.37**	**73.03**	**103.98**	
LSD $_{0.05}$= O:15.71 ; P: 18.40 ; OP:21.01						

Notes: O_0 and O_1 are non-manured and manured with chicken manure respectively….. P_0, P_1,P_2, P_3 and P_4 are non-P-fertilized , PDB-biofertilized (*B. megaterium*) , super-phosphate-P, rock-P and PDB+rock- Prespectively

Experiment 3. The K-experiment:

K fertilized treatments were $K_{0,}$ K1, K2,K_3 and K4i.e.Non-K-fertilized, KDB-biofertilized (***Bacillus circulans***), Sulphate-K, rock-K and KDB+rock-K. The organic manure ones were none-manures (O_0) and manured (O_1).

Plant dry weight (Table 8):

Untreated plants gave 11.62 g pot^{-1}the ones receiving fertilizers or manure or both showed increases of 13.2 % (by the manured) to 51.3% (by the manured+rock-K).Thus the KDB biofertilizer was effective in solubilizing the rock-K. The main effect of fertilization showed K_4> K_2> K_3> K_1>K_0 indicating highpositive response to K-biofertilizer combined with rock K .In other studies on bio-fertilization of tomatoes and other vegetables, increases were enhanced when in presence ofchicken manure (**Dawa et al 2013 and Rowell and Hadad,2017).**On sorghum(*Sorghumbicolor*) an increase of as high as 66% was obtained upon application of ***Bacillus circulans***in combination with KDB (**Abdel-Salam et al. 2016**) indicating high efficiency of KDB. Other studies (**Gharib et al. 2008**) on response sweet marjoram (Majorana*hortensis*) to ***Bacillus circulans***showed 42% increase in plant growth.Studies on wheat (**Tilak and Reddy 2006**) showed 38 % grain increase by applying *Bacillus circulans*, and 43% by applying *Bacillus cereus.*The main effect of manure shows an increase of 12.4%, and the increase was most pronounced the positive effect of manure was particularly significant in presence of rock K (15.9%).

One of the benefits of the PDB and KDB biofertilizers is that they are reported to produce growth promoting substance such as indole-acetic acid (IAA) and siderophores B. circulans (**Mehta et al., 2010**).

Table 8. Response of wheat to K-biofertilizer, K-mineral fertilizer and organic chicken manure: Plant weight (roots+shoots) of "45-day growth".(g pot[1])

Organic fertilization (O)	Bio-Mineral K-fertilization (K)					mean
	K_0	**K_1**	**K_2**	**K_3**	**K_4**	
O_0	11.62	13.89	15.05	13.68	16.14	**14.08**
O_1	13.15	15.60	16.89	15.86	17.58	**15.82**
Mean	**12.39**	**14.75**	**15.97**	**14.77**	**16.86**	
LSD $_{0.05}$= O: 1.51	**; K: 1.71**		**; OK: 1.92**			

Notes: O_0 and O_1 are non-manured and manured with chicken manure respectively….. K_0, K_1,K_2, K_3 and K_4 are non-K-fertilized , KDB-biofertilized (***Bacillus circulans***) , Sulpaate-K, rock-K and KDB+rock-Krespectively

K uptake in whole plant (Table 9):

The non-fertilized non-manured plants showed222.4 mgK uptake pot^{-1}and the treated onesshowed increases of 39.4 % (K-biofertilized) to 114.5%(biofertilized+rock-K); a pattern rather as the one given by the P-biofertilization experiment. The bacterial inoculation causing dissolution of rock P or rock K , beside their solubilization action , can produce growth promoting substances (**Mehta et al 2010** , **Dawa et al 2013 , Abdel-Salam et al., 2016 and Rowell and Hadad,2017**) .The main effect of K-fertilization shows a pattern resembling the one of yield i.e. $K_4>K_2>K_3>K_1>K_0$elucidating the positive effect of applying K-dissolving biofertilizer combined with rock-K to increase yield and K-uptake .The chicken manure caused an average of 21.9% in K uptake and the positive response was particularly apparent where no fertilizers were added. Increased K uptake caused by *B.* ***circulans***with or without organic manures or rock Kincreased growth, yields and nutrient uptake by many crops (**Ghoneimand El-Araby, 2003**, **Dawa et al 2013, Abdel-Salam et al.,**

Table 9. Response of wheat to K-biofertilizer, K-mineral fertilizer and organic chicken manure: K uptake in (roots+shoots) of "45-day growth".(mg pot[1])

Organic manuring (O)	Bio-Mineral K-fertilization (K)					mean
	K_0	**K_1**	**K_2**	**K_3**	**K_4**	
O_0	222.4	310.5	391.3	314.6	402.1	**328.2**
O_1	332.4	384.4	432.2	374.7	477.1	**400.2**
mean	**277.4**	**347.5**	**411.8**	**344.7**	**439.6**	
LSD 0.05 = O: 18.5	**K :23.2**	**OP: 35.2**				

Notes: O_0 and O_1 are non-manured and manured with chicken manure respectively….. K_0, K_1,K_2, K_3 and K_4 are non-K-fertilized , KDB-biofertilized (***Bacillus circulans***) , Sulpaate-K, rock-K and KDB+rock-Krespectively

2016and Rowell and Hadad,2017)

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Conclusion and practical implications:

Biofertilizers providing plant with N, P and K macronutrients in forms of bacterial inoculants can be utilized in practical agriculture in order to enrich soils with available nutrients for wheat.For obtaining the highest positive effect of the biofertilizers, sources of rich organic manure (such as chicken manure "CM") along withsources of the non-available (or difficultly available) macronutrients must be provided. Increases can rise up to as high as 50% in plant growth. The N_2 fixing bacteria of Azotobacter+ *Azospirillum*,the P-dissolvingB. *megaterium*and the K-dissolving B. *circulans* can be used in this concern. Using CM and rock P or rock K can provide sources of low cost P and K nutrients.

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إستجابة القمح للتسميد الحيوى وأسمدة النيتروجين والفوسفور والبوتاسيوم مع أو بدون سماد مخلفات الدواجن

ياسمين نبيل يونس، على أحمد عبدالسلام، وسام رشاد زهرة، محمد على عبدالسلام

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ويعتبر القمح أهم المحاصيل في مصر، والواردات كبيرة لسد الفجوة بين الإنتاج والاستهلاك. لابد من وجود التسميد الحيوى بدرجة عالية للمساعدة فى زيادة الانتاج المحلى. البكتريا المثبتة للنيتروجين مثل الازوسبيريللم والازوتوباكتر والبكتريا المذيبة للفوسفات مثل الباسيللس ميجاتيريم والبكتريا المذيبة للبوتاسيوم الباسيلس سيركيولنس تم تقييمها لنمو وتغذية وامتصاص القمح فى ثلاث تجارب أصص (تجربة لكل عنصر على حدة) فى وجود أو غياب سماد الدواجن الذى تم إضافته بمعدل 10جم/كجم. حدثت زيادة جزئية فى نمو نباتات القمح (45 يوم) تصل الى اكثر من 50% فى وجود سماد الدواجن. استخدم الصخر الفوسفاتى والفلسبارات للامداد بعنصرى الفوسفور والبوتاسيوم لمساعدة الكائنات الحية الدقيقة جنباً الى جنب مع السماد العضوى. تضمنت المقارنة المصادر السمادية الذائبة مثل النيتروجين (سلفات الامونيوم)، الفوسفور (سوبر فوسفات الكالسيوم) ، والبوتاسيوم (سلفات البوتاسيوم). وتشير الآثار العلمية الى وجود ادلة قوية على ان استخدام الاسمدة الحيوية يسهم فى تعزيز انتاج القمح.