Effect of Phosphate Solubilization Microorganisms (PSM) and Plant Growth Promoting Rhizobacteria (PGPR) on Yield and Yield Components of Corn (*Zea mays L.)*

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***Abstract*—**In order to study the effect of phosphate solubilization microorganisms (PSM) and plant growth promoting rhizobacteria (PGPR) on yield and yield components of corn *Zea mays* (L. cv. SC604) an experiment was conducted at research farm of Sari Agricultural Sciences and Natural Resources University, Iran during 2007. Experiment laid out as split plot based on randomized complete block design with three replications. Three levels of manures (consisted of 20 $Mg.ha^{-1}$ farmyard manure, 15 $Mg.ha^{-1}$ green manure and check or without any manures) as main plots and eight levels of biofertilizers (consisted of 1-NPK or conventional fertilizer application; 2-NPK+PSM+PGPR; 3 $NP_{50\%}K$+PSM+PGPR; 4-$N_{50\%}PK$+PSM +PGPR; 5-$N_{50\%}P_{50\%}K$+PSM+ PGPR; 6-PK+PGPR; 7-NK+PSM and 8-PSM+PGPR) as sub plots were treatments. Results showed that farmyard manure application increased row number, ear weight, grain number per ear, grain yield, biological yield and harvest index compared to check. Furthermore, using of PSM and PGPR in addition to conventional fertilizer applications (NPK) could improve ear weight, row number and grain number per row and ultimately increased grain yield in green manure and check plots. According to results in all fertilizer treatments application of PSM and PGPR together could reduce P application by 50% without any significant reduction of grain yield. However, this treatment could not compensate 50% reduction of N application.

***Keywords*—**Biofertilizers, corn, PSM, PGPR, grain yield.

I. INTRODUCTION

CORN (*Zea mays*) among the crops, is an important in temperate climatic region, because of the increasing demand for food and livestock feed. Nitrogen and phosphorus are essential nutrients for plant growth and development in corn [10]. Large quantities of chemical fertilizes are used to replenish soil N and P, resulting in high costs and severe environmental contamination [7]. Most of phosphorus in insoluble compounds are unavailable to plant. N2-fixing and P-solubilizing bacteria may be important for plant nutrition by increasing N and P uptake by the plants, and playing a significant role as plant growth promoting rhizobacteria (PGPR) in the biofertilization of crops. Plant growth-promoting rhizohacteria (PGPR) are able exit a beneficial upon plant growth. Nitrogen fixation and P.solubilization [6] production of antibiotic [8] and increased rood dry weight are the principal mechanism for the PGPR. A number of different bacteria promote plant growth, including *Azotobacter sp*., *Azospirillum sp*., *Pseudomones sp*., *Bacillus sp*. *Acetobacter sp* [2]. Economic and environmental benefits can include increased income from high yields, reduced fertilizer costs and reduced emission of the greenhouse gas, N2O as well as reduced leaching of NO3, N to ground water. Plant growth promoting bacteria are important in managing plant growth because of their effects on soil conditions, nutrient availability, growth and yields. However, information is not available on the PGPR in corn systems under field conditions. Therefor, the aim of this studies was to evaluate effect of phosphate solubilization microorganisms (PSM) and plant growth promoting rhizobacteria (PGPR) on yield and yield components of corn *(Zea mays* L.*)*

II. MATERIALS AND METHODS

An experiment was conducted at research farm of Sari Higher Education Agricultural Sciences and Natural Resources University, Iran during 2007. Experiment laid out as split plot based on randomized complete block design with three replications. Three levels of manures (consisted of 20 $Mg.ha^{-1}$ farmyard manure, 15 $Mg.ha^{-1}$ green manure and check or without any manures) as main plots and eight levels of biofertilizers (consisted of 1-NPK or conventional fertilizer application; 2-NPK+PSM+PGPR; 3-$NP_{50\%}K$+PSM+PGPR; 4-$N_{50\%}PK$ +PSM+PGPR; 5-$N_{50\%}P_{50\%}K$+PSM+ PGPR; 6-PK+PGPR; 7-NK+PSM and 8-PSM+PGPR) as sub plots were treatments. Bacterial (consisting of *Azotobacter coroocoocum, Azospirillum brasilens*, *Pseudomonas putida, Bacillus lentus*) were suspended in suspension of sugar in water. This slurry was used to introduce the bacteria as corn seed coatings. After 150 days of growth (maturity) corn plants were carefully removed from field experiments. Biofertilizer plant effects of treatments were evaluated by determining average grain yield and yield components. Data were subjected growth promoting rhizohacteria (PGPR) and phosphate

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solubilization microorganisms (PSM) to ANOVA using the SAS statistical software package (SAS Institute, 2000) and means were compared by Duncan test (P<%5) [11].

III. Results

Results showed that farmyard manure application increased row number, ear weight, grain number per ear, grain yield, biological yield and harvest index compared to check . The data (Table II) indicated that biofertilizer plant growth promoting rhizohacteria (PGPR) and phosphate solubilization (PSM) inoculation significantly increased maize growth, seed corn yield as compared to treatments without inoculation. Probably, plant Growth promoting rhizobacteria by production of growth stimulating phytohormones [10]; mobilization of phosphate [6] siderophore production [8]; antibiotic production [3]; inhibition of plant ethylene synthesis [2]; and induction of plant systemic resistances to pathogens [4], increased the yield. Furthermore, using of PSM and PGPR in addition to conventional fertilizer applications (NPK) could improve ear weight, row number and grain number per row and ultimately increased grain yield in green manure and check plots. According to results in all fertilizer treatments application of PSM and PGPR together could reduce P application by 50% without any significant reduction of grain yield. However, this treatment could not compensate 50% reduction of N application. The production of organic acids and acid phosphates play a major role in the mineralization of organic phosphorus in soil [9], [1]. The harvest index was significantly higher over control in the farmyard manure plot treatments.

IV. Conclusion

Inoculation with rhizobacteria could be efficiently used to improve growth and grain yield of corn, reduced fertilizer costs and reduced emission of the greenhouse gas, N2O as well as reduced leaching of NO3, N to ground water even when optimum levels of N fertilizer were applied.

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TABLE I
SOIL CHEMICAL PROPERTIES, AND SOIL PARTICLE DISTRIBUTION OF THE TOP SOIL LAYER (0-30 CM)

Type	PH	OM (%)	N (mg 100 gr^{-1})	P (mg 100 gr^{-1})	K (mg 100 gr^{-1})	Soil particle size (mm)		
						2.0–0.2	0.2–0.02	<0.02
silty loam	7.5	3.48	193	12.3	367.3	47.3	42.1	10.6

TABLE II
THE EFFECT OF PGPR AND PSM AND FERTILIZER APPLICATION ON YIELD AND YIELD COMPONENTS OF CORN (*ZEA MAYS* L.)

Treatments	Number of row	Number of grin in row	Number of grin in ear	Weight of 100 grin (mg)	Weight of ear (ton.h)	Grain yield (ton.h)	Biological yield (ton.h)	Harvest Index (%)
Manure								
Farmyard manure	18.5a	34.3a	626.1a	21.0a	11.6a	9.12a	16.58a	54.7a
Green manure	18.1ab	31.8b	603a	20.2a	a 11.1	8.71ab	16.07ab	54.0ab
Control	17.7b	31.0b	554.1b	20.7a	10.3b	8.06b	15.09b	53.1b
Cument manure								
NPK	18.3abc	32.8bc	607.0c	21.9a	11.5b	9.13b	16.56b	54.9a
$NPK+P_{g+}P_s$	17.7ab	35.7a	699.8a	21.9a	12.8a	10.19a	18.258a	55.72a
$NP_{50}K+P_{g+}P_s$	19.3a	35.1ab	680.3ab	21.9a	12.9a	10.27a	18.26a	56.28a
$N_{50}PK+P_{g+}P_s$	17.6bc	32.2c	569.5c	21.0ab	10.6b	8.29c	15.55b	53.16b
$N_{50}P_{50}K+P_{g+}P_s$	18.2bc	31.6c	577.7c	21.4bc	10.6b	8.20c	15.44b	52.94b
$PK+P_g$	17.8bc	28.9d	518.0d	20.1bc	9.4c	7.25d	13.97c	51.61b
$NK+P_s$	18.5ab	33.4abc	622.4abc	20.0bc	11.1b	8.72bc	15.88b	54.78b
$P_{g+}P_s$	17.4c	29.3d	510.1d	19.8c	9.1c	6.99d	13.39c	52.16b
significant								
A	*	*	**	NS	*	*	*	NS
B	**	**	**	**	**	**	**	**
A × B	*	NS	*	NS	*	*	*	*
CV	5.58	7.39	8.83	5.04	9.32	9.40	8.35	2.84

Levels of significant:* P< %5, ** P<%1