IMPROVEMENT OF THE PRODUCTIVITY OF COTTON BY PHOSPHATE SOLUBILIZING BACTERIAL INOCULANTS

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Abstract

Field experiments were carried out on calcareous Calcisol soil for evaluating the effects of phosphor solubilising bacterial (PSB) inoculants combined with phosphorit on cotton growth and yield. The experimental treatments were untreated control (NoPoKo), standard treatment ($N_{200}P_{140}K_{60}$), and phosphorit combined with bacterial inocula ($N_{200}P_{140+PSB}K_{60}$). Stimulatory effects of treatments on growth, yield, N, P –uptake of cotton, soil P content and soil microbial population were recorded. The results revealed that PSB combined with phosphorit significantly increased dry matter accumulation, yield of cotton and were superior over the other treatments. The phosphorus content was significantly increased in cotton plants inoculated with PSB combined with phosphorit with respect to the uninoculated plants growing in the control soil and also along with fertiliser. Standard treatment without bacterial inoculation has resulted very low P uptake in plants. This result suggests that PSB are able to mobilise more P to the plants and improve plant growth.

Introduction

Phosphorus is a important element for growth development and yield of cotton. Phosphorus deficiencies are common nutritional problems in cotton production in Uzbekistan. Application of phosphorites along with phosphate solubilising bacteria (PSB) to such soils improved P uptake by plants and yields indicating that the PSB are able to solubilise phosphates and to mobilise phosphorus in crop plants (1). In this respect, biofertilisation technology has taken a part to minimise production costs and at the same time, avoid the environmental hazards (2). Phosphorus application and bacterial inoculation affect yield of soybean through their effects on phosphorus use efficiency (3). Also they are successful applied in the cultivation of barley and chick pea plants (4).

In this study, the effect of new biopreparation based on PSB on plant growth, nutrient uptake, and yield of cotton and soil productivity were investigated.

Material and Methods

The field trials was conducted at the experimental farm of Institute of organic and inorganic chemistry, Uzbekistan. The soil chemical and physical characterisation has given in Table 1.

Table 1. Soil chemical properties, and soil particle distribution at 0-30 cm soil layer

Type	C_{tot}	$N_{tot.}$	$P_{tot.}$	K	Mg	pH	soil particle size, mm		
	---------mg · (100g) $^{-1}$----------								
							2 – 0.2 %	0.2 – 0.02 %	< 0.02 %
Calcisol	200	6	3.0	12.0	6.0	7.8	2.2	54.5	43.3

Recommended rates of phosphorus (140kg P h^{-1}, as phosphorit and superphosphate), nitrogen (200 kg N $ha^{-1,}$ as ammonium sulphate) and potassium (60 kg K $h^{-1,}$ as potassium sulphate) were applied. Treatments were: plants without treatments 1. (NoPoKo), 2. ($NP_{superphosphate}K$), ($NP_{phosphorit}K$), ($NP_{phosphorit+PSB}K$). These treatments were distributed in a randomised complate block design with four replications. The plot size was 5 m by 3 m. Cotton seeds were obtained from the University of Agriculture, Tashkent. *Rhizobium meliloti* URM1 used as phosphore soulubilisng bacterial inoculant, which combined with phosphorits (inoculum density 10^9cellsg^1). Plants were harvested at tillering, flowering and maturity stages. Dry matter accumulation, N, P

uptake efficiency in plants and in the soil, yield have been determined. Also the effect of treatments on soil microbial population (oligotrophic, ammonifying and mineral assimilating bacteria) were investigated. Plate dilution method was used for determination of numerous microorganisms using agar medium. In order to count the number of microorganisms, 10 g of soil was shaken with 90 ml of sterile water. From this suspension the serial dilution (1:10) was prepared and plate counts were performed in triplet and incubating until growth occurred (usually 3-7 days). CFU of ammonifying were enumerated on glycerine peptone agar. Oligotrophic bacteria on soil agar containing 900 ml water, 100 g soil, 18 g agar L^{-1}. Mineral assimilating bacteria in Nutrient broth agar NA. Microbial density was expressed as colony forming units (CFU). The obtained results were statistically analysed using ANOVA of mean effects.

Results

The results of our experiments showed, that PSB combined with phosphorit have a significant effect on dry matter accumulation in leaves, shoot and root (Table 2). Compared to the control and fertiliser used along, the PSB combined with phosphorit was superior over the other treatments. Higher effect was found in maturity stage. In tillering stage of cotton, bacterial inoculation did not effect significantly.

Table 2. The effect of Posphate solubilising bacteria (PSB) *Rizobium meliloti* URM1 combined with phosphorite on dry matter of cotton (field experiments, g.plant $^{-1}$)

Treatments	Tillering		Flowering			Maturity		
	leaves	stem	leaves	Stem	bud	leaves	stem	bud case
NoPoKo	8.1	7.0	46.5	10.5	15.5	54.6	39.5	35.3
$NP_{superp}K$	9.5	6.3	47.0	18.7	17.1	53.0	42.1	36.0
$NP_{phosphorite}K$	8.9	6.0	46.9	18.0	18.4	57.4	51.0	38.3
$NP_{PSB}K$	14.6	8.7	47.0	18.9	23.4	89.1	64.8	49.5

In field experiments all treatments increased yield of cotton in comparison to control plants (Fig 1). Higher yield obtained after treatment with PSB *Rhizobium meliloti* URM1. The yield of cotton increased up to 77% (285.7 g^{-1} plant).

Fig.1 The effect of PSB combined with phosphorite on cotton yield in field experiments, g^{-1} plant, (Control plants, 160 g^{-1} plant =100%)

According to the results obtained, PSB was able to mobilise phosphorus efficiency in cotton. The phosphorus content was significantly increased in cotton plants with treatment PSB combined phosphorit (Table 3). The standard treatment with fertiliser along did not effect P uptake in plants.

Table 3. The effect PSB combined with phosphorite on N and P uptake of cotton (field experiments, N and P content in %)

Treatments	Leaves		Stem		Bud case		Cotton fibers	
	N	P	N	P	N	P	N	P
NoPoKo	1.45	0.51	0.68	0.21	0.78	0.19	1.78	0.81
$NP_{superp}K$	1.55	0.75	0.75	0.24	0.83	0.22	1.87	0.84
$NP_{phosphorite}K$	1.2	0.2	0.3	0.1	0.5	0.1	1.6	0.4
$NP_{PSB}K$	1.62	0.8	0.75	0.24	0.83	0.25	1.9	0.89

A positive influence of treatments on soil P content is marked (Table 4). Soil P content in the variant with PSB reaches 6.0 mg $P_2O_5.100^{-1}$ soil. It has been found that application of phosphorit combined with PSB leads to the increase of P content in soil (tillering, flowering and maturity stages of Plants).

Table 4. Phosphorus content in soil as affected by PSB combined with phosphorite (before sowing

1.8 mg P_2O_5 . 100^{-1} soil)

Treatments	Tillering	Flowering	Maturity
NoPoKo	2.4	1.5	2.2
$NP_{superp}K$	2.8	6.0	4.7
$NP_{phosphorite}K$	2.0	1.8	1.9
$NP_{PSB}K$	5.4	6.0	4.0

The all treatments effect on soil microbial population negatively or positively (Table 5). Oligotrophic microorganisms are mineralising organic matters of soil. After treatment with PSB the the number of oligotrophic microorganisms decreased in all plant stages. Ammonifying and mineral ssimilating bacterial population also decreased after this treatment in flowering and maturity stages.

Table 5. The effect of PSB combined with phosphorite on oligotrophic (before sowing 2.5 mln.g^1 soil), ammonifying (before sowing 1.7 mln.g^{-1} soil), and mineral assimilating bacteria (before sowing 15.0 mln.g^{-1} soil)

Treatments	Oligotrophic			Ammonifying			Mineral assimilating		
	Tille-ring	Flowe ring	Matu rity	Tillering	Floweri ng	Maturi ty	Tilleri ng	Flowe ring	Maturity
NoPoKo	62.1	78.6	14.2	1.5	10.3	20.0	144.0	182.0	21.7
$NP_{superp}K$	1.8	59.3	17.2	3.9	1.8	7.5	82.0	123.0	19.6
$NP_{phosphorite}K$	6.8	17.3	80.0	1.9	1.2	1.2	2.3	25.5	16.5
$NP_{PSB}K$	4.4	7.3	13.1	2.4	5.6	2.1	55.0	108.0	12.9

The obtained results suggest that PSB is able to mobilise more P into plants and to leads to promotion of cotton growth and yield.

Discussion

The results have showed that the inoculation of phosphorit with PSB increased dry matter accumulation, N and P uptake, yield of cotton and soil P content. The results of the study agree with studies of (3). According his result, phosphorus uptake efficiency and yield increased with phosphorus application and with inoculation. Inoculated soybeans had greater phosphorus uptake efficiency than uninoculated soybean. Other authors (5) reported, that PSB increased phosphorus accumulation in plants, yield of pea and barley. The bacterial strains were able dissolve hard soluble organophosphates. Inoculation also lead to the increase of N content in the biomass of both plants. In previous works *Bacillus* sp. mobilise phosphate from organic hard soluble phosphoric compounds and increased growth and yield of cotton in Calcisol soil. This results suggest that PSB are able to mobilise more P, where hard soluble phosphates are presented in soil and increased yield and growth.

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