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Growth and yield of potato (*solanum tuberosum* linn.) Crop to certain fertilizers and growth regulators under sandy-clay loam of Madhya Pradesh

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Abstract

Potato had tallest plants (71.6 cm, P>5) under interaction between F_2 and bio-fertilizers Azotobacter *(B_1). Seed size tubers (25-75g) gave maximum yield 236.6g/plant (P>5) at G_1. Tuber yield under $F_2B_1G_2$ was profitable to have monetary gain to the rank of Rs 297254/- per hectare.*

Keywords: Potato, tuber yield, NPK, Bio-fertilizers, Growth regulators

Introduction

The potato is the world's most important food crop next to the cereals. It originated in the Andes highlands, probably in Peru or Bolivia where several wild species of *solanum* are found. In 17th century, the crop was introduced in India by Portuguese explorers. Now a days, India stands at 3rd rank in respect of potato production in the world.

Seed tubers are commonly used for vegetatively propagating the potato crop because it rapidly gives out sprouts for a fast growth of the plant. The Indian farmers use different chemical fertilizers along with animal compost for production of the tuber. The nitrogen (ammonium sulphate), phosphorus (P_2O_5) and potash (K_2O) are the chemical fertilizers applied in various proportions to secure higher yields. But the use of chemical fertilizers alone causes disruption in the soil nutrient balance.

As per estimates of *Singh* ***et al.*** (2003), potato, a heavy soil surface feeder crop, removes 0.42 kg nitrogen, 0.18 kg phosphorus and 0.60 kg potash from the top soil for yielding one quintal of tubers. Tuber production in potato increases on increasing NPK fertilizer. *Kurlekar and Pawar* (1978) found that application of 180 kg N + 100 kg P_2O_5 + 100 kg K_2O/ha gave the highest tuber yield of 26.46 tons/ha as against 16.93 tons/ha of control without NPK fertilizer. *Sharma* and *Singh* (1988) recorded increase in plant height, tuber number and tuber weight per hill on application of 120:180:60 kg NPK/ha in sandy-loam acidic soil of Shillong.

Azotobacters, the free- living aerobic nitrogen fixing bacteria, on their application are able to save additions of nitrogenous fertilizers by 10-20 percent. *Pseudomonas striata,* the phosphate solubilizing bacterium (PSB) caused higher tuber yield in potato over control (*Singh*, 1999**).** *Singh and Sharma* (2002) found significantly higher seed yield and large size tubers/ha on application of PSB.

Bio-fertilizers and growth regulators are also applied to boost potato tuber production. The present piece of work deals with soil application of NPK under field conditions, presowing seed treatment with bio-fertilizers and foliar spray of growth regulators on plant growth and tuber yield of potato.

Materials and Methods

The experiment was conducted at the Horticulture Nursery, College of Agriculture, Gwalior ($26^0 13^1$N latitude and $78^0 14^1$E longitude, lying at height of 211.5m) during 2008-09. The climate of Gwalior is sub-tropical with hot and dry summers. The experimental farm had sandy- clay loam soil with organic carbon 0.55%, available nitrogen 185.5 kg/ha, available phosphorus 24.2 kg/ha, available potash 333.2 kg/ha and pH 7.8.

The main plot soil was treated with 50% dose (F_1) of NPK and 100% recommended dose (F_2) of NPK (150:80:100 kg/ha). Ammonium sulphate (N), single super phosphate (P) and muriate of potash (K) were applied in furrows with half dose of N and full dose of P and K one day before planting of tubers and the remaining half dose of N was given at the time of earthing up of the potato crop. The seed tubers of variety Kufri Pukhraj were taken from Central Potato Research Station, Gwalior (MP).

The potato seeds were treated with liquid bio-fertilizer, azotobacter (3 kg/ha-B_1) and PSB (3kg/ha-B_2) for 15 minutes and then dried under shade for one hour for better coating. The coated seeds were planted

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in the field at spacing of 50 x 20 cm. The control plants for the bio-fertilizers served as B_3.

Plant growth promoter, gibberellic acid (GA_3)-100 ppm (G_1) and growth retardant, ethrel (ethaphon) -250 ppm (G_2) were sprayed at 25 and 50 days after planting and the results were compared with control (B_3).

The growth parameters, number of stems/hill and plant height were recorded at 75 days after planting. Three grades of tuber i.e. < 25 g, 25-75g and >75 g were considered for working out tuber number/plant and weight (g)/plant. The various data recorded from 10 plants tagged randomly in the experimental plot analyzed by applying Anova (*Fisher,* 1958).

Results and Discussion

Stem number/hill and plant height

The growth promoter and retardant and bio-fertilizers had no significant effect on the stem number/hill, except to the fertility levels with significantly higher number/hill that was found to the rank of $F_2>F_1$. F_2 dose i.e. 100% recommended dose of NPK had 9.04 percent increase in stem number over F_1 i.e. 50% dose of NPK (Table 1).

Foliar application of plant growth regulators had significant effect on plant height, the mean maximum of 64.4cm height was recorded with 100 ppm GA_3 which was found significantly higher to 250 ppm ethrel at 75 days after plantation. Significantly higher stem heights were recorded under interactions of fertility levels (F_1 & F_2) and bio-fertilizers (B_1& B_2). Of the bio-fertilizer treatments, *Azotobacter* (B_1) with F_1 (B_1 F_1) and PSB (B_2) with F_1 (B_2 F_1) had significantly higher stem lengths, 60.6 cm (P>5) and 59.1 cm (P>5) respectively. 100 percent dose of NPK (F_2) along with B_1 produced significantly tallest plants (71.6 cm, P>5) over 50% dose of NPK (60.6 cm).

NPK at F_2 had significantly highest stem number (4.82/hill) and tallest plants (66.4 cm) over its F_1 dose. The higher number of stem/hill and plant height at F_2 may be due to higher rate of cell division and cell elongation in the meristematic region. This resulted in the higher length of plant in the potato. These results are in the conformity with the findings of *Shah et al.* (1996) and *Barche et al.* (2000).

Inoculation of seed tubers with *Azotobacter* and PSB resulted in increased plant height upto 14.6 and 10.1% respectively at 75 days after planting over the control. *Chettri et al.* (2003) and *Yadav et al.* (2003) also found increase in plant height due to inoculation of seed tubers with bio-fertilizers.

GA_3 100 ppm (G_1) resulted in significantly tallest plants due to its effect on stem elongation of potato. *Birbal et al.* (2003) also reported increase in plant

Table 1: Effect of fertility levels, bio-fertilizers and growth regulators on plant emergence stem number per hill and plant height of potato.

Treatments		Emergence (%)	Stem number/hill (per tuber)	Plant height (cm) at 75 days after planting	
1. Fertility levels	F_1	92.01	4.42	58.47	
	F_2	92.29	4.82	66.45	
SE(m)		0.21	0.06	0.32	
CD (P=0.05)		NS	0.39	1.93	
2. Bio-fertilizers	B_1	92.25	4.68	66.14	
	B_2	92.19	4.63	63.56	
	B_3	92.00	4.54	57.68	
SE(m)		0.42	0.04	0.22	
CD (P=0.05)		NS	NS	0.72	
3. Plant growth regulators	G_1	92.25	4.63	64.41	
	G_2	91.90	4.65	62.21	
	G_3	92.32	4.57	60.77	
SE(m)		0.45	0.05	0.61	
CD (P=0.05)		NS	NS	1.77	
4. Interactive effect of bio-fertilizers and fertility levels on plant height (cm) at 75 days after planting					
Bio-fertilizers				Fertility levels	
				F1	F2
	B_1	-	-	60.68	71.60
	B_2	-	-	59.13	67.99
	B_3	-	-	5.59	59.76
SE(m)		-	-	0.31	0.40
CD (P=0.05)		-	-	1.02	2.02

F_1 = 50% NPK, F_2 = 100% NPK, B_1= Azotobacter, B_2 = PSB, B_3 = control,
G_1 = 100 ppm, G_2 = Ethrel (250 ppm), G_3 = control

height due to GA_3 treatments.

Tuber number/plant

Tuber number of the lowest (<25 g) and medium (25-75g) categories did not differ significantly at different fertility levels. However, tubers with >75 g size were found to differ significantly. Seed tubers inoculated with *Azotobacter* had significant increase in number of small size tuber/plant than PSB and control. PSB-treated seeds had plants that also produced lesser number of small size tubers than control (Table 2). The other two categories of tubers gave significantly higher tuber numbers at B_1 and B_2 over control.

Foliar spray of GA_3 100 ppm (G_1) significantly reduced number of small size tubers/plants as compared to ethrel 250 ppm (G_2) and control. Ethrel 250 ppm also had significantly lower number of small size tuber than the control. 25-75 g category tubers had highest number, 4.58 tubers (P>5) at G_1 and 4.23 tubers/plant (P>5) at G_2 over control (3.72 tubers/ plant). The large size tubers also had significantly higher number 1.65 (P>5) at G_1 and 1.56 (P>5) at G_2 over 1.37 of the control (Table 2).

Interaction of the growth regulators and the fertility levels also had significantly higher number of tubers, 4.52 (P>5) at G_1F_1 and 3.84 (P>5) at G_2F_1 over 3.80 of the control. The number further increased significantly at G_1F_2 (4.64 tubers, P>5) and at G_2F_2 (4.63 tubers, P>5) over 3.64 of the control plants.

Tuber yield (g/plant)

NPK at F_2 had lowest yield i.e. 22.1 g/plant of small size tubers as compared to 31.1 g/plant of G_1. The other two categories of tubers, on the other hand, showed significantl increase of tuber yield at F_2 (Table 3).

The bio-fertilizers (B_1 & B_2) caused significant reductions in yield of small size tubers whereas the medium and large size tubers as well showed significant increase in their yield over the control. The growth regulators also showed similar performance of the three category tubers. The medium size tubers were most productive with highest yield, 236.6 g/plant (P>5) at G_1 and 217.8 g/plant (P>5) at G_2 over 187.5 g/plant of the control (Table 3). Interaction between the bio-fertilizers and the fertility levels were recorded to be unprofitable with significantly lower tuber yield/plant.

Azotobacter and PSB individually might have increased N and P availability in soil and thereby enhanced nutrient uptake and consequently the yield as *Azotobacter* functions for nitrogen fixation, ammonium excretion and production of plant growth promoting substances. PSB solubilizes phosphorus from soil and makes it available to plants. *Singh* (2002a) has also recorded significant increase in yield of seed size tubers due to inoculation with PSB. *Singh* (2001) and *Singh* (2002 b) recorded significant increase in yield of large size tubers due to bio-fertilizers.

Table 2: Effect of fertility levels, bio-fertilizers and growth regulators on potato tuber/plant.

Treatments		Tuber number per plant (grade wise)		
		< 25 g	25-75 g	>75 g
1. Fertility level	F_1	1.42	4.05	1.43
	F_2	1.30	4.31	1.63
SE(m)		0.03	0.08	0.01
CD (P=0.05)		NS	NS	0.07
2. Bio-fertilizers	B_1	1.18	4.49	1.67
	B_2	1.36	4.43	1.55
	B_3	1.53	3.62	1.36
SE(m)		0.03	0.10	0.03
CD (P=0.05)		0.08	0.31	0.10
3. Plant growth regulators	G_1	1.15	4.58	1.65
	G_2	1.35	4.23	1.56
	G_3	1.57	3.72	1.37
SE(m)		0.03	0.11	0.03
CD (P=0.05)		0.09	0.31	0.08
4. Interactive effect of growth regulators and fertility levels on 25-75g tubers				
Growth regulators			Fertility levels	
			F1 F2	
	G_1	-	4.52 4.64	-
	G_2	-	3.84 4.63	-
	G_3	-	3.80 3.64	-
SE(m)		-	0.15 0.15	-
CD (P=0.05)		-	0.44 0.58	-

Table 3: Effect of fertility levels, bio-fertilizers and plant growth regulators on tuber yield (g/plant).

Treatments		Tuber yield (g)/plant (grade wise) < 25 g	25-75 g	>75 g
1. Fertility level	F_1	31.11	204.30	133.41
	F_2	22.15	223.79	141.05
SE(m)		0.11	0.05	0.69
CD (P=0.05)		0.67	0.28	4.19
2. Bio-fertilizers	B_1	23.43	223.29	149.84
	B_2	26.61	219.35	135.71
	B_3	29.84	189.50	126.14
SE(m)		0.22	1.08	0.71
CD (P=0.05)		0.72	3.53	2.33
3. Plant growth regulators	G_1	21.99	236.67	150.08
	G_2	28.01	219.89	140.50
	G_3	29.88	187.57	121.10
SE(m)		0.28	1.08	0.91
CD (P=0.05)		0.82	3.14	2.66
4. Interaction between bio-fertilizers and fertility levels on tuber yield/plant <25g				
Bio-fertilizers		Fertility levels F1 / F2		
	B_1	27.34 / 19.52	-	-
	B_2	31.17 / 22.05	-	-
	B_3	34.82 / 24.87	-	-
SE(m)		0.31 / 0.28	-	-
CD (P=0.05)		1.01 / 1.03	-	-

Mult-factor interactions of the fertility levels, bio-fertilizers and growth regulators were also conducted and net monetary gain was calculated per hectare basis. A minimum of Rs 162742/ha was found under $F_2B_3G_3$ which reached to maximum level of Rs 297254/ha in $F_2B_1G_2$ followed by Rs 272262/ha under $F_2B_2G_1$ and Rs 269619/ha in $F_1B_2G_1$.

The above experimental findings indicate that values for most of the vegetative traits remained no-significant, except to plant height that showed significant increase at all the treatments. F_2B_1 interaction had tallest stem (71.6 cm, P>5) over 59.7 cm of the control. Major share in the tuber yield was attained by 25-75 g category tubers at G_1 and G_2, contributing upto 236.67 and 219.89 g/plant respectively over 187.57 g/plant of the control (Table 3).

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