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Richa Pyasi
Department of Horticulture, college of Agriculture Gwalior, RVSKVV, Madhya Pradesh, India

Deepa Bhatt
Department of Horticulture, college of Agriculture Gwalior, RVSKVV, Madhya Pradesh, India

Ranvijay Singh
Scientist, KVK Panna, Madhya Pradesh, India

Corresponding Author:
Richa Pyasi
Department of Horticulture, college of Agriculture Gwalior, RVSKVV, Madhya Pradesh, India

Response of potato crop to different combinations of inorganic fertilizers, organic manure and biofertilizers

Richa Pyasi, Deepa Bhatt and Ranvijay Singh

Abstract
The present experiment was conducted at the, Department of Horticulture, College of Agriculture, RVSKVV, Gwalior (M.P.) during the *Rabi* season of two consecutive years 2017-18 and 2018-19. The experiment was comprised of 18 treatment combinations of three levels of inorganic fertilizers *viz*., (100% NPK), (75%NPK) and (50% NPK), two levels of farm yard manure (FYM 20 t/ha) and (FYM10 t/ha), and three levels of biofertilizers (Azotobacter 5 kg/ha), (PSB 5kg/ha) and (Azotobacter 2.5 kg/ha + PSB 2.5kg/ha) tested on potato processing cultivar Kufri Chipsona-1, for yield and economic parameters. The experiment was laid out in Randomized Completely Block Design (RCBD) with three replications. The tubers of uniform size were sown in plots of size 3 x 3 m at a spacing distance of 60 x 20 cm. Observations for yield parameters were grade wise yield of tubers (kg/plot), processing grade tuber yield (T/ha), marketable tuber yield and total yield (T/ha) of potato tubers. The treatment combination $I_3O_2B_3$ (100%NPK+FYM 20 t/ha + PSB2.5kg/ha+ Azotobacter 2.5kg/ha) resulted in maximum number of tubers per plant (12.4), maximum 'A' grade tubers (8.2 kg/plot), maximum 'B' grade tubers (7.5 kg/plot) and maximum average weight of processing (Agrade) tuber per plant (97.0 g) during the pooled mean data, of the experiment.
The treatment combination $I_3O_2B_3$ also resulted in maximum total yield (22.6 t/ha). Whereas minimum total yield (15.6 t/ha) was obtained in treatment $I_1O_1B_2$, during the pooled mean data, of the experiment. The highest gross returns was recorded (Rs.220300.0) and highest benefit cost ratio was recorded (2.56) with treatment $I_3O_2B_3$ (100% NPK+FYM20t/ha+PSB2.5kg/ha+Azotobacter2.5kg/ha). Whereas, the minimum gross returns (Rs.138500.0) and minimum benefit cost ratio was recorded (1.77) with treatment $I_1O_1B_2$ (50% NPK + FYM 10 t/ha + PSB 5kg/ha).

Keywords: Kufri Chipsona-1, NPK, FYM, Azotobacter, PSB

Introduction
The present cultivated potato is an autotetraploid and belongs to the species *tuberosum* L. (2n=4x=48) which includes two subspecies *viz*., ssp. *tuberosum* adapted to long day conditions and ssp. *andigena* adapted to short day conditions (Pandey and Luthra, 2010) [8]. The current global production of potato is around 376.8 million tonnes and China is the biggest producer globally, India ranks 2nd in area and production of potato in the world after China (FAO STAT, 2018). In India potato is grown in an area of around 2.17 Million hactare with total production of about 46.54 million tonnes and the productivity is 21.5 tonnes/ha (Horticultural Statistics at a Glance, 2017) [4].
It became necessity of the time to incorporate combined use inorganic and organic fertilizers to obtain sustainability in the yields along with inoculation of biofertilizers which not only fix and mobilise the available elements to soluble forms for plants but improve the soil quality also. Therefore the present experiment was carried out to study the response of potato crop to different combinations of inorganic fertilizers, organic manure and biofertilizers.

Materials and Methods
The experiment was conducted at the, Horticulture research area, Department of Horticulture, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) during the *Rabi* season of two consecutive years 2017-18 and 2018-19. The Experimental site College of Agriculture, Gwalior is situated at 26o 13 N latitude and 78o 14‟ E longitudes at an altitude of 211.5 m from mean sea level in central part of Madhya pradesh and it has a semi-arid subtropical climate. The soil of the experimental field was clay in texture with uniform topography. The experiment was comprised of 18 treatment combinations of three levels of inorganic fertilizers *viz*., (100% NPK), (75%NPK) and (50% NPK), two levels of farm yard manure (FYM 20 t/ha) and (FYM10 t/ha), and three levels of biofertilizers (Azotobacter 5

kg/ha), (PSB 5kg/ha) and (Azotobacter2.5kg/ha+PSB 2.5kg/ha) tested on potato processing cultivar Kufri Chipsona-1, for yield and economic parameters. The experiment was laid out in Randomized Completely Block Design (RCBD) with three replications. Nitrogen was given in the form of urea. Phophorus and potassium were applied through single super phosphate and muriate of potash, respectively. Pre-planting seed treatment was done with Mancozeb 0.2% solution. The tubers of uniform size were sown in plots of size 3 x 3 m at a spacing distance of 60 x 20 cm. The observations for plant growth parameters like plant height, number of shoots per plant, leaf area (cm2), diameter of stem (cm), were recorded on five randomly selected plants from each plot of each replication separately. Similarly, observations for yield parameters were taken at the time of harvest to obtain the *viz*., grade wise yield of tubers(kg/plot), Marketable tuber yield and Total yield (T/ha) of potato tubers. The grade wise yield of tubers was obtained by sorting out total yield into four grades. The grading was done based on weight basis *viz*., A (>75 g), B (50-75 g), C (25-50g), tubers of each grade were weighed separately and graded yield was expressed in kilograms (kg/plot) and total yield (T/ha) was obtained as a sum total of all tuber yield obtained from each treatment and each replication at the time of harvest. The data recorded under the study were subjected to statistical analysis as per standard procedure as suggested by Panse and Sukhatme (1985) [12].

Results and Discussion

Growth parameters

Significant results were obtained due to the combined effects of inorganic fertilizers, organic manure and biofertilizers at different growth stages for plant,(Table-1) where maximum height of the plant, leaf area, shoots per plant was observed under the treatment combination $I_3O_2B_2$ (100%NPK+ FYM20t/ha + PSB 5kg/ha) whereas minimum plant growth at different stages was seen in treatment $I_1O_1B_1$ (50% NPK+FYM10t/ha +Azotobacter 5kg/ha). This may be due to fact that at higher dose of NPK, FYM and biofertilizers, the plant height and number of leaves per plant also got increased which may have resulted in increase in leaf area per plant. These results are in agreement with results seen by Jaipaul (2011) [5, 10], Sharma *et al.* (2011) [5, 10], Dhakal *et al.* (2011) [2] and Marthha *et al*. (2017) [11].

Table 1: Effect of NPK, FYM and biofertilizers on growth of potato

Treatment Symbol	Treatments	Plant height (cm)	Leaf area (cm^2)	Shoots per plant	Diameter of stem	Daystuber initiation.	Days to haulm cutting	Days to harvest
		90 DAS	90 DAS	90 DAS	90 DAS			
$I_1O_1B_1$	50% NPK + FYM 10 t/ha + Azotobacter 5kg/ha	55.35	398.99	4.32	3.65	35.18	106.78	119.00
$I_1O_1B_2$	50% NPK + FYM 10 t/ha + PSB 5kg/ha	57.08	407.78	4.61	3.71	33.80	107.32	118.00
$I_1O_1B_3$	50%NPK+FYM 10t/ha+Azotobacter 2.5kg/ha +PSB 2.5kg/ha	58.80	405.77	4.79	3.92	34.33	106.25	118.50
$I_1O_2B_1$	50%NPK +FYM 20 t/ha + Azotobacter 5 kg/ha	56.02	408.43	4.82	3.98	31.70	106.65	118.33
$I_1O_2B_2$	50%NPK + FYM 20 t/ha + PSB 5 kg/ha	58.87	410.25	5.08	3.85	32.37	106.22	118.17
$I_1O_2B_3$	50%NPK+FYM20t/ha+Azotobacter2.5kg/ha+PSB 2.5kg/ha	57.50	402.13	4.92	4.03	35.33	106.28	118.67
$I_2O_1B_1$	75%NPK + FYM 10t/ha + Azotobacter 5kg/ha	58.82	399.03	5.14	4.05	33.85	106.72	119.17
$I_2O_1B_2$	75%NPK + FYM 10 t/ha + PSB 5kg/ha	58.33	418.85	5.31	4.12	33.28	107.62	118.83
$I_2O_1B_3$	75%NPK + FYM 10 t/ha+Azotobacter2.5kg/ha +PSB2.5kg/ha	58.73	417.87	5.21	4.06	31.75	105.35	119.17
$I_2O_2B_1$	75%NPK+ FYM 20 t/ha + Azotobacter 5kg/ha	59.05	414.93	5.45	4.06	31.75	106.27	117.67
$I_2O_2B_2$	75%NPK + FYM 20 t/ha + PSB 5kg/ha	59.92	415.53	5.37	4.01	32.35	105.53	118.00
$I_2O_2B_3$	75%NPK + FYM 20 t/ha + Azotobacter 2.5kg/ha+ PSB 2.5kg/ha	58.76	417.80	5.39	4.12	32.50	105.68	118.50
$I_3O_1B_1$	100% NPK + FYM 10t/ha +Azotobacter 5kg/ha	58.68	424.15	5.78	4.13	31.92	105.65	118.50
$I_3O_1B_2$	100%NPK + FYM 10t/ha +PSB 5kg/ha	58.62	411.00	5.04	4.22	31.88	106.70	118.17
$I_3O_1B_3$	100%NPK + FYM 10t/ha + Azotobacter2.5kg/ha +PSB2.5kg/ha	58.80	415.38	4.89	4.31	31.30	105.74	118.50
$I_3O_2B_1$	100%NPK + FYM 20 t/ha +Azotobacter 5kg/ha	58.82	417.22	5.08	4.22	32.82	104.59	116.83
$I_3O_2B_2$	100%NPK + FYM 20 t/ha + PSB 5kg/ha	59.46	420.63	5.71	4.18	33.33	105.55	117.00
$I_3O_2B_3$	100%NPK + FYM 20 t/ha + PSB 2.5kg/ha+ Azotobacter 2.5kg/ha	59.02	421.27	5.46	4.36	32.33	105.45	118.00
SEm+-		1.606	9.896	0.182	0.126	1.129	0.470	0.915
CD		4.530	27.91	0.514	0.356	3.186	1.326	2.850

Yield attributes

Significant results were obtained for number of tubers per plant (Table-2), where treatment $I_3O_2B_3$ (100% NPK+FYM20t/ha+PSB2.5kg/ha+Azotobacter 2.5kg/ha) resulted in highest number of tubers per plant (12.4) and minimum number of tubers per plant (7.6) were obtained in $I_1O_1B_1$ (50% NPK+FYM 10 t/ha + Azotobacter 5kg/ha). Simmillar findings were also reported by Jatav *et al.* (2017) [6]. This may be due to fact that higher levels of NPK, FYM and biofertilizers helped in increased absorption of nutrients which would have increased photosynthetic activity and quick availability of nutrients leading to increased number of tubers. The highest graded tuber yield of ('A' and 'B grade tubers) was observed under the treatment $I_3O_2B_3$. Whereas, minimum tuber yield of ('A', B grade tubers) was seen in treatment $I_1O_1B_2$ (50% NPK + FYM 10 t/ha + PSB 5kg/ha).The reason behind formation of bigger tubers may be due to more luxuriant growth, large leaf area more foliage and plant growth, may have caused higher supply of photosynthates got assimilated in the tubers, which would have induced big size tubers. These results are in close conformity with results obtained by Sandhu *et al.* (2010) [9] who obtained higher number of processing quality tubers in their experiment on varietal trial in Kufri Chipsona-1. Kumar *et al.* (2017) [17] recorded highest yield of 6.85 kg per plot of 'B' grade tuber (50-75 g) and highest yield of 10.24 kg per plot of 'A' grade

(>75 g) tubers with the application of 150, 80, 50 kg NPK/ha. Simmilarly treatment $I_3O_2B_3$ resulted in highest total tuber yield (22.64, t/ha, respectively) which was at par to treatment $I_3O_2B_1$, whereas minimum marketable tuber yield were obtained in treatment $I_1O_1B_2$. Potato is a highly nutrient responsive crop, hence the yield of the crop is mainly governed by the availability of nitrogen, phosphorous and potassium to the crop. In this experiment higher yield was obtained with the application of higher dose of NPK, FYM and bioertilizers which lead to overall increase in number of large, medium and small sized tubers which in turn increased the total yield. Whereas biofertilizers treatment provide better absorption of phosphorus as compared to other treatments. Jaipaul (2011) [5, 10] and Kumar *et al.* (2017) [17] also noticed similar findings in their experiments.

Economics

The highest gross returns (Rs.220300.0) (Table-3) and highest benefit cost ratio (2.56) was recorded with treatment $I_3O_2B_3$ (100%NPK+FYM20t/ha+PSB2.5kg/ha+Azotobacter2.5kg/ha. Whereas, the minimum gross returns (Rs.138500.0) and minimum benefit cost ratio was recorded (1.77) with treatment $I_1O_1B_2$ (50% NPK + FYM10 t/ha + PSB 5kg/ha). These results are in close association with findings of Jaipaul (2011) [5, 10], Sarkar *et al.* (2011) [15] who obtained a highest B:C ratio (1.34) and net profit and in Kufri Chipsona-1' under NPK i.e. 180:66:125 kg/ ha. Narayan *et al.* (2014) [14] noted a benefit cost ratio (1.75) in potato with the application of 75% NPK (120:75:75 kg/ha) + *Azotobacter* and PSB. Whereas, Kumar *et al.* (2015) [17] found maximum B:C ratio (2.16) in potato under high NPK dose.

Table 2: Effect of NPK, FYM and biofertilizers on yield parameters of potato

Treatment Symbol	Treatments	Number of tubers/ plant	'A' grade yield (Kg/plot)	'B' grade yield (Kg/plot)	'C' grade yield (Kg/plot)	Avg. weight of processing grade tubers(g).	Total yield T/ha.
$I_1O_1B_1$	50% NPK + FYM 10 t/ha + Azotobacter 5kg/ha	7.63	4.15	4.26	4.33	80.60	16.07
$I_1O_1B_2$	50% NPK + FYM 10 t/ha + PSB 5kg/ha	8.25	4.07	4.13	4.23	80.71	15.62
$I_1O_1B_3$	50%NPK+FYM 10t/ha+Azotobacter 2.5kg/ha +PSB 2.5kg/ha	7.98	4.26	4.52	4.18	78.01	15.96
$I_1O_2B_1$	50%NPK +FYM 20 t/ha + Azotobacter 5 kg/ha	8.60	4.21	5.14	4.49	82.20	16.80
$I_1O_2B_2$	50%NPK + FYM 20 t/ha + PSB 5 kg/ha	9.13	4.25	4.41	4.04	82.90	15.70
$I_1O_2B_3$	50%NPK+FYM20t/ha+Azotobacter2.5kg/ha+PSB 2.5kg/ha	8.83	4.59	4.87	4.49	83.67	16.87
$I_2O_1B_1$	75%NPK + FYM 10t/ha + Azotobacter 5kg/ha	9.62	4.54	5.26	4.23	82.22	16.84
$I_2O_1B_2$	75%NPK + FYM 10 t/ha + PSB 5kg/ha	10.17	5.23	5.57	4.44	86.28	18.53
$I_2O_1B_3$	75%NPK + FYM 10 t/ha+Azotobacter2.5kg/ha +PSB2.5kg/ha	10.12	5.54	5.54	4.20	83.12	18.16
$I_2O_2B_1$	75%NPK+ FYM 20 t/ha + Azotobacter 5kg/ha	9.98	6.02	4.98	4.28	88.83	18.48
$I_2O_2B_2$	75%NPK + FYM 20 t/ha + PSB 5kg/ha	9.18	5.88	5.30	4.14	88.85	18.16
$I_2O_2B_3$	75%NPK + FYM 20 t/ha + Azotobacter 2.5kg/ha+ PSB 2.5kg/ha	10.42	6.04	6.06	3.92	90.96	19.05
$I_3O_1B_1$	100% NPK + FYM 10t/ha +Azotobacter 5kg/ha	11.53	6.76	6.15	4.17	90.65	19.95
$I_3O_1B_2$	100%NPK + FYM 10t/ha +PSB 5kg/ha	10.95	6.99	6.38	3.95	88.00	20.30
$I_3O_1B_3$	100%NPK + FYM 10t/ha + Azotobacter2.5kg/ha +PSB2.5kg/ha	12.38	7.47	6.17	3.83	89.24	20.17
$I_3O_2B_1$	100%NPK + FYM 20 t/ha +Azotobacter 5kg/ha	10.60	7.30	6.99	3.86	91.9	20.98
$I_3O_2B_2$	100%NPK + FYM 20 t/ha + PSB 5kg/ha	11.95	7.15	6.69	3.79	91.07	21.53
$I_3O_2B_3$	100%NPK + FYM 20 t/ha + PSB 2.5kg/ha+ Azotobacter 2.5kg/ha	12.43	8.23	7.51	3.80	97.00	22.64
SEm+-		0.299	0.197	0.276	0.283	2.716	0.519
CD		0.843	0.591	0.818	0.549	8.118	1.577

Table 3: Effect of NPK, FYM and biofertilizers on economics of potato production.

Treatment Symbol	Treatments	Marketable tuber yield (t/ha)	Gross returns Rs/ha	Net returns Rs/ha	B: C ratio
$I_1O_1B_1$	50% NPK + FYM 10 t/ha + Azotobacter 5kg/ha	14.21	141200	62133	1.78
$I_1O_1B_2$	50% NPK + FYM 10 t/ha + PSB 5kg/ha	13.73	137300	58233	1.73
$I_1O_1B_3$	50%NPK+FYM 10t/ha+Azotobacter 2.5kg/ha +PSB 2.5kg/ha	13.69	136900	57833	1.75
$I_1O_2B_1$	50%NPK +FYM 20 t/ha + Azotobacter 5 kg/ha	15.04	150400	69331	1.85
$I_1O_2B_2$	50%NPK + FYM 20 t/ha + PSB 5 kg/ha	14.28	142800	61731	1.76
$I_1O_2B_3$	50%NPK+FYM20t/ha+Azotobacter2.5kg/ha+PSB 2.5kg/ha	14.4	144000	62931	1.78
$I_2O_1B_1$	75%NPK + FYM 10t/ha + Azotobacter 5kg/ha	15.7	157000	75472	1.92
$I_2O_1B_2$	75%NPK + FYM 10 t/ha + PSB 5kg/ha	16.6	166100	84572	2.04
$I_2O_1B_3$	75%NPK + FYM 10 t/ha+Azotobacter2.5kg/ha +PSB2.5kg/ha	15.4	154000	72472	1.90
$I_2O_2B_1$	75%NPK+ FYM 20 t/ha + Azotobacter 5kg/ha	16.62	166200	82672	1.98
$I_2O_2B_2$	75%NPK + FYM 20 t/ha + PSB 5kg/ha	16.07	160700	77172	1.92
$I_2O_2B_3$	75%NPK + FYM 20 t/ha + Azotobacter 2.5kg/ha+ PSB 2.5kg/ha	17.37	173700	90172	2.08
$I_3O_1B_1$	100% NPK + FYM 10t/ha +Azotobacter 5kg/ha	18.08	180800	96812	2.15
$I_3O_1B_2$	100%NPK + FYM 10t/ha +PSB 5kg/ha	18.49	184900	100912	2.20
$I_3O_1B_3$	100%NPK + FYM 10t/ha + Azotobacter2.5kg/ha +PSB2.5kg/ha	18.42	184200	100212	2.19
$I_3O_2B_1$	100%NPK + FYM 20 t/ha +Azotobacter 5kg/ha	19.52	195200	109212	2.27
$I_3O_2B_2$	100%NPK + FYM 20 t/ha + PSB 5kg/ha	20.12	201200	115212	2.33
$I_3O_2B_3$	100%NPK + FYM 20 t/ha + PSB 2.5kg/ha+ Azotobacter 2.5kg/ha	21.31	213100	127112	2.47

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