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APPLICATION OF NOVEL MICROBIAL INOCULANTS ENHANCED YIELD OF POTATO (CV. GULMARG SPECIAL) UNDER TEMPERATE FIELD CONDITIONS

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Abstract–This study was undertaken at experimental farm, Division of Basic Sciences & Humanities of Faculty of Agriculture Wadura, Sopore, SKUAST-Kashmir during Kharif season-2019 under RCBD design. The experiment entailed 7 microbial treatments including single inoculation and also combination of two bio-inoculants. The tubers were planted in plots of length 2m and width 2m with spacing of 60× 25 cm. At the time of sowing these bio-inoculants were applied (25 ml/tuber) as liquid medium to the seed (tubers) in the field. The potatoes were harvested when they were fully matured and were of brown colour. The impact of these inoculants as biofertilizers on the overall yield of potato was studied. The application of microbial inoculants viz; *Azotobacter* sp., Phosphorous Solubilizing Bacteria (PSB), Potassium Solubilising Bacteria (KSB), Zinc Solubilising Bacteria (ZnSB), PSB +ZnSB and *Azotobacter* sp. + KSB had a positive impact on yield attributes of Potato tubers under field conditions. The results of the experiment depicted that application of all the microbial inoculants improved yield of potato, maximum tubers per plant (16.28), yield per plant (483.6g), yield per plot (11.75 Kg) and total tuber yield (29.3 t/ha) respectively. Moreover, highest marketable yield was witnessed in *Azotobacter* sp. + KSB (28.31 t ha^{-1}) followed by PSB +ZnSB (25.14 t ha^{-1}). Therefore this study suggested that application of microbial inoculants as an eco-friendly nutrient management tool enhance the yield of potato under temperate field conditions.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is popularly referred to as "the king of vegetables". It is non-woody, dicotyledonous, annual and vegetative propagated plant. Potato plants will attain height of concerning sixty cm relying upon the variability. The leaves of the crop show dying back during maturity, tuber formation and flowering.It may be propagated through seed that's True potato seed (TPS).In general, varieties with white flowers have white skins, whereas as those varieties with coloured flowers show chromatic skin. The potato tuber may be a changed stem developed underground on a specialised structure known as offset. Potatoes are self-fertilizing likewise as cross-pollinated by insects like bumblebees. For long run storage, crop ought to be hold on in well vented dark space at temperatures close to 4 °C (39 °F). For short-run storage, temperatures of concerning 7 to 10 °C (45 to 50 °F) are most popular. When crop is hold on while not cold, period of time is sometimes some weeks. Potato could be an extremely good nutrient crop, simply digestible and wholesome food containing proteins, minerals, vitamins, high levels of carbohydrates, and considerable amounts of vitamins B and C and minerals (Stephen, 1999; Tigoni, 2005; Muthoni, 2009) and high-quality

([1*] M.Sc. Scholar, [2] Assistant Professor) dietary fiber. Potato tuber contains 0.6 % fiber, 1% minerals, 2% macromolecule, 2% sugar, 20 % dry matter consisting of 14 % starch, 80 % water and 0.1 % fat (Watt, 1963). According to Smith, 1968, it's thought of a fashionable supply of some free amino acids. Therefore, potato provides additional nutrition than vegetables and cereals. Keeping into view the arable land and mushrooming population in India, potato could be an alternative.

In India potato is grown in completely divergent situations. Nearly 85 % of the crop is grown as short photoperiod (with about 10-11 hours sunshine) during winter and due to short and mild winter crop duration is also limited to 90-100 days. The mornings usually have fog, which reduces sunshine hours which in turn reduces photosynthetic activity. Increase in area, production and productivity over this period is 550 per cent, 1745 per cent and 178 per cent, respectively. Now India ranks fourth in potato area (1.48 million ha) and third in production (28.47 million tonnes) in the world with an average yield of 183.3q/ha. Generally, potato crop yielding 30 t/ ha removes about 100 kg N/ ha from soil (Pandey *et al*., 2006). Nitrogen and phosphorus are the major nutrients needed in potato cultivation along with potassium.

India has created a quantum jump in vegetable production ranging from 28.36 mt (1969-1971) to 136.88mt (2009-2010) whereas in geographical region the realm below vegetable cultivation has exaggerated from 10.27 thousand hectares in 1981 to 30.25 thousand hectares in 2007 with a concomitant increase in production from about 2.0 lakh tonnes to 7.70 lakh tonnes great deal in creating a trial forward at the necessity of 225 million a lot of vegetables by 2025, the production and productivity have to be compelled to be exaggerated to satisfy the dietary demand of 300q/capita/day. The rise in production is to be achieved vertically without destructing the fragile and sensitive environmental balance. Though these fertilizers contribute greatly in fulfilling the nutrient demand of vegetable crops however their regular, excessive and unbalanced use could cause health and ecological hazards, depletion of physico-chemical properties of the soil and ultimately poor crop yields. The issues of nutrient drain from the soil becomes thus acute that it is on the most side the ability of any single plant food to just accept the challenge of applicable nutrient provided. Thus there is a requirement to place confidence in alternate sources of safe plant food which can enhance crop yields whereas not having adverse effects on soil properties.

The indiscriminate use of inorganic fertilizers is neither environmentally safe nor economically possible. There's a précising demand for bio-inoculants for quality potato production. Bio-inoculants are price effective eco-friendly, cheaper and renewable sources of plant nutrients and play a significant role in maintaining future soil fertility. The aim of bio-inoculation is to accelerate the microbial processes that augment the supply of nutrients which be simply assimilated by plant and to extend the quantity of helpful microorganisms in soil. Application of microbial inoculants in the soil reduces the chances of pollution in the productive soil ecosystems. Therefore, it is important to boost the microbial growth in unproductive agricultural soils for availability of nutrients for the crop through artificial microbial inoculations.

MATERIALS AND METHODS

The present study was undertaken during Kharif season-2019. The potato tubers were evaluated for their yield performance at experimental farm, Division of Basic Sciences & Humanities of Faculty of Agriculture Wadura, Sopore, SKUAST-Kashmir. The faculty is located in the North of Kashmir about 15 kms from Sopore town. The location is 1524 metres above mean sea level and situated at 34.28° N of latitude and 74.55°E longitude. The climate in Kashmir is temperate, characterized by mild summers.

Experimental material

The variety used in investigation was Gulmarg Special of potato and different bio-inoculants,that were acquired from Division of Horticulture and Bio-fertilizer Laboratory (Basic Sciences), Wadura respectively. The experiment entailed 7 treatments including single inoculation and also combination of two bio-inoculants.

Sowing and after care

The tubers were planted in plots of length 2m and width 2m with spacing of 60× 25 cm. At the time of sowing these bio-inoculants were applied (25 ml/ tuber) as liquid medium to the seed (tubers) in the field. Gap filling was done after seven days of transplanting. The experimental plot was kept weed free by hand weeding whenever necessary. Additionally, the water requirements were also fulfilled by manually applying water to each

Plate 1. Microbial inoculation of Potato tubers before sowing

treatment separately.

Harvesting: The potatoes were harvested when they were fully matured and were of brown colour.

Tubers per plant: After harvesting of the crop number of tubers per plants were counted manually.

Yield per plant(g): Yield per plant was calculated by weighing yield of individual plant on digital weighing machine.

Yield per plot (kg): Yield per plot was calculated by summation of yield of all plants present in that plot.

Total tuber yield (t ha^{-1}): It was estimated by adding yield of all plots and multiplied with 10000 m^2.

Marketable tuber yield (t ha^{-1}): Marketable tuber yield was calculated on the basis of size (grading) of the tubers.

Unmarketable tuber yield (t ha^{-1}): Unmarketable tuber yield was also calculated on the basis of size (grading) of tuber.

Statistical Analysis: Data generated was subjected to statistical analysis using OP Stat software developed by Haryana Agriculture University-Punjab-India.

RESULTS AND DISCUSSION

Microorganisms constitute an integral and momentous constituent of soil. There is a variety of microorganisms in the soil which play their role in improving the soil health as well as plant growth and yield. The data recorded in (Table 1, Fig. a) shows that application of *Azotobacter sp.* + KSB (16.28) represented a significant increase in tuber per plant over other bio-inoculants followed by *Azotobacter sp.*(16.04) and least tuber per plant was recorded in control plot (10.29). This increase in number of tubers in plant might be due to the higher metabolic activities and nitrogen supplies which were revealed in the form of enhanced growth. These annotations were in conformity with the findings of (Singh and Lallawmkima, 2018) who used chemical fertilizer in combination with PSB, VAM, Fungi, *Azotobacter* and mustard cake which

Plate 3. Harvested Per Plant Potato tubers

Plate 2. Over view of inoculated Potato research trail

results in enhancing number of tubers. The application of potassium has significant role in increasing number of potato tubers per plant (Bhattarai and Swarnima, 2016).

The data contained in (Table 1, Fig. a) reveals a significant increase in yield per plant due to application of various microbial inoculants under field conditions. Moreover, among the inoculants highest number of tuber was exhibited by *Azotobacter* sp.+ KSB (483.6 g/plant) followed by *Azotobacter* sp. (434.4 g/plant). The increase in yield might be attributed to the increased nitrogen content which is responsible for vigorous growth and increased chlorophyll content which in turn increases photosynthetic rate and supply of carbohydrate content to plant. These findings are in good conformity with Rupa *et al*., (2013) who observed that increase in nitrogen content increases the yield in potato crop. Similar observations were reported by Jnawali *et al*., (2015) who observed that N2-fixer diazotroph have several beneficial effects on crop growth and yield Gajbhjiye *et al*., (2003) was also of the opinion that nitrogen leads to enhanced yield of a crop Meena *et al*., (2017) also examined KSB in wheat and concluded that application of KSB on soil plant system can be a valuable tool for increasing crop yield (Khan *et al*., 2017) also observed that yield of pea increases when it is treated with *Azotobacter.* Among different applied treatment combinations, the highest total tuber yield was seen in the treatment combination of *Azotobacter* sp + KSB (29.3) while least value was seen in control plot (20.6) (Table 1, Fig. a). Increase in total tuber yield is due to the adequate supply of potassium in building up the plant tissues, which results in better vegetative growth and hence plays vital role in photosynthesis, carbohydrate transport and other physiological process of the plant. These arguments were in line with the findings of Prajapati, and Modi, (2013) in okra, Zhang and Kong, (2014) in tobacco (Alladi *et al*., 2014) in brinjal and (Joseph *et al*., 2018) in potato (Ramandeep *et al*., 2018) perceived that biofertilizer (*Azotobacter*) have significant effect on tuber yield Similarly, (Zewide *et al*., 2012) observed that application of N and P significantly influences the total tuber yield.

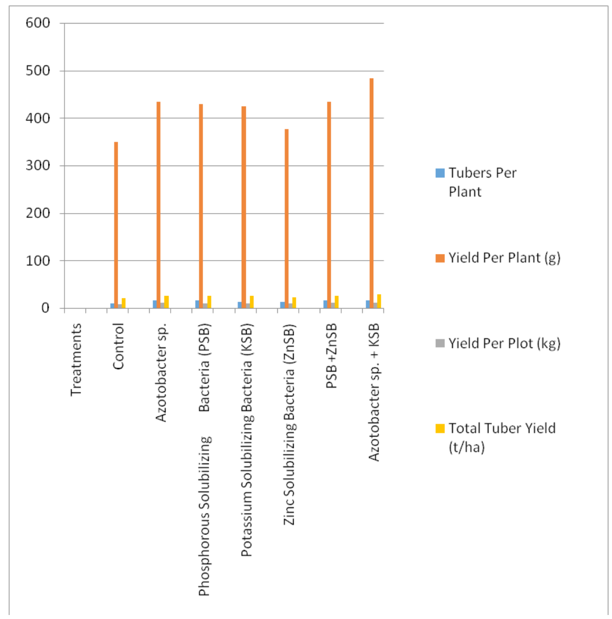

Fig. a. Effect of bio-inoculants on Tubers Per Plant, Yield Per Plant, Yield Per Plot and Total Tuber Yield of potato

Due to the application of different bio-inoculants significant variation was observed in marketable tuber yield. Highest marketable tuber yield was recorded in *Azotobacter* sp. + KSB (28.31) while as least value was recorded in control plot (19.27) (Table 2, Fig. b). The increase in vegetative growth, increases the number of tubers per plant which in turn enhances the marketable tuber yield. These

Table 1. Effect of bio-inoculants on Tubers Per Plant, Yield Per Plant, Yield Per Plot and Total Tuber Yieldof potato

S. No	Treatments	Tubers Per Plant	Yield Per Plant (g)	Yield Per Plot (kg)	Total Tuber Yield (t/ha)
1	Control	10.29	349.8	8.26	20.6
2	*Azotobacter* sp.	16.04	434.4	10.50	26.2
3	Phosphorous Solubilizing Bacteria (PSB)	15.50	428.8	10.34	25.8
4	Potassium Solubilizing Bacteria (KSB)	12.89	425.2	10.09	25.2
5	Zinc Solubilizing Bacteria (ZnSB)	12.17	376.2	8.97	22.5
6	PSB +ZnSB	15.49	434.3	10.50	26.2
7	*Azotobacter* sp. + KSB	16.28	483.6	11.75	29.3
	C.D (pd”0.05)	0.212	7.104	0.066	0.114
	SE(m)	0.068	2.280	0.021	0.037

Table 2. Effect of bio-inoculants on Marketable Tuber Yield and Unmarketable Tuber Yield

S. No	Treatments	Marketable Tuber Yield (t/ha)	Unmarketable Tuber Yield (t/ha)
1	Control	19.27	3.38
2	*Azotobacter* sp.	24.14	2.14
3	Phosphorous Solubilizing Bacteria (PSB)	23.62	2.25
4	Potassium Solubilizing Bacteria (KSB)	22.13	3.15
5	Zinc Solubilizing Bacteria (ZnSB)	21.25	1.25
6	PSB +ZnSB	25.14	1.14
7	*Azotobacter* sp. + KSB	28.31	1.05
	C.D (pd”0.05)	0.072	0.071
	SE(m)	0.023	0.023

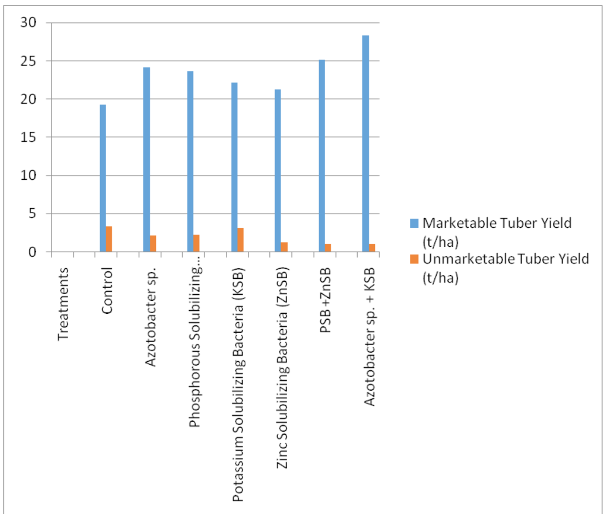

Fig 6. Effect of bio-inoculants on Marketable Tuber Yield and Unmarketable Tuber Yield

results were in line with the findings of (Kolodziejczyk, 2014; Baishya, 2010, Amarananjundeshwara H. 2018), Sarkar, 2011). Similarly (Zewide *et al*., 2012) observed that application of N and P significantly influence the marketable tuber yield.

These are the mean values of three replication.

CONCLUSION

The application of different bio-inoculants significantly increased total tuber yield as well as marketable tuber yield as compared to control. Among all the bio-inoculants *Azotobacter* sp. + KSB increased total tuber yield and proved to be superior as compared to other inoculants and it was followed by PSB + ZnSB and *Azotobacter* sp. Therefore the research findings indicate that microbial inoculation of potato tubers can enhance the yield under temperate field conditions.

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