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Response of various doses of organic manures and inorganic fertilizers on plant growth and tuber yield of sweet potato (*Ipomoea batatas*) cv. Bhu Krishna

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Abstract
Sweet potato ranked seventh most important food crop of the world after wheat, rice, maize, potato, barely and cassava. China tops the rank in Sweet Potato production in the world. In India, it is cultivated in almost all the states but major contribution comes from four states namely Odisha, Kerala, West Bengal and Uttar Pradesh. Sweet Potato cv. BHU-Krishna is the popular variety of Odisha. It is purple fleshed biofortified cultivar with an average yield of 18 t/ha with high anthocyanin content. This cultivar is not grown in Prayagraj agroclimatic condition. So, to study the **"**Response of various doses of organic manures and inorganic fertilizers on plant growth and tuber yield of Sweet Potato (*Ipomoea batatas*) cv. Bhu Krishna"; a field experiment was conducted on the Horticulture research farm of the Department of Horticulture, SHUATS, Prayagraj during year 2021. The experiment comprised of 9 treatments of different combinations of inorganic fertilizers and organic manures replicated thrice in a Randomized Block Design. The main objective of the experiment was to evaluate the to find out the best treatment combination for better growth and yield of Sweet Potato (*Ipomoea batatas*) cv. Bhu Krishna and to work out the economics of the treatments in the Prayagraj agroclimatic zone. The inorganic fertilizers in the experiment include Urea, SSP & MOP whereas the organic fertilizers Farmyard manure, Vermicompost & Poultry manure in different combinations. From the present investigation it may be concluded that the effect of T9 i.e., 50% RDF+20% FYM+20% poultry manure+10% vermicompost (65.2kg urea+125kg ssp+51.7kg mop/ha+2t fym+1t poultry manure+0.5t vermicompost/ha) was found significantly highest for vegetative and yield parameters *viz*., vine length i.e., (154.09) cm, number of leaves per plant (170.00), number of vines per plant (10.40), highest internodal length (cm) (4.69), number of tubers per plant (3.35), tuber length (cm) (15.42), highest tuber diameter (cm) (7.24), weight of tuber (g) (96.34), Tuber yield per plant (kg) (0.323) & Tuber yield (155.47 q ha-1). These practices may be passed on to the farmers for obtaining higher returns in this Agro- climatic zone with the B:C ratio of 4.38.

Keywords: Economics, farmyard manure, MOP, poultry manure, SSP sweet potato, urea, vermicompost

Introduction
Sweet potato (*Ipomoea batatas* Lam.) is an important tuber crop grown in the tropics, sub-tropics and warm temperate regions of the world for its edible storage roots. It is a herbaceous and perennial vine cultivated as an annual. It belongs to family Convolvulaceae and originated from Central America Shubha *et al.*, (2018) [9].

Among different tuber crops, sweet potato [*Ipomoea batatas* (L.) Lam] is an important tuber crop belongs to family Convolvulaceae. It is a natural hexaploid (2n=6x=90), having basic chromosome number x=15. It is also known as a famine relief crop as it had played a pivotal role in averting the Bengal famine of 1942. It is vegetatively propagated by vine cuttings taken from freshly harvested vines grown in secondary nursery (Selvakumar, 2014). Asia is the largest producer of sweet potato having 92% of production and 80% of area in the world. China and India are the leading sweet potato growing countries in the world. Uttar Pradesh, Bihar, Tamil Nadu, Odisha, Kerala, Karnataka, West Bengal, Madhya Pradesh, Assam, Maharashtra and Gujarat are the leading states of sweet potato cultivation Sheth *et al.*, (2017) [7, 8].

The sweet starchy edible tuberous roots have economic values that contain about 27% carbohydrate and high concentration of Vitamin A, Vitamin C, calcium and iron. Sometimes, young leaves and shoots are also eaten as greens (Abidin, 2004) [1]. It is a rich source of carotene, ascorbic acid, thiamine, riboflavin, protein and energy. Because of the high nutritional and economic value, it is necessary to improve yield and its related traits that can be achieved through balance availability of all the nutrients in the crop.

No single source is capable to supply the required quantity of plant nutrients. Due to continuous application of inorganic fertilizers in the soil, had negative effect on soil and also productivity of the crop (Lal and Kang, 1982) [4].

The calorific yield per unit area of these crops is also high because they are efficient converters of atmospheric carbon dioxide into carbohydrates. Among the tuber crops sweet potato (*Ipomoea batatas* L.) is the seventh most important food crop in the world. It is grown in many tropical and subtropical regions. Among the world's major food crops, sweet potato produces the highest amount of edible energy per hectare per day Allolli *et al*., (2011) [2].

Organic matter serves as a reservoir for plant nutrients and prevents depletion of nutrients essential to plant growth. Organic manure also produces an ecosystem that promotes beneficial soil species, i.e. earthworms. Organic matter undergoes mineralization with the release of large quantities of nitrogen, phosphorus, sulphur and minimal amounts of micronutrients.

Farmyard manure is rich in nutrients and increases soil fertility. It refers to the decomposed mixture of dung and urine and farm animals along with litter and left-over material from roughages or fodder fed to the cattle. Well decomposed farmyard manure includes 0.5 percent N, 0.2 percent P2O5 and 0.5 percent K2O. Recommended dose of Farmyard manure for cultivating sweet potato is approx. 10tonnes/ha

The application of vermicompost in crop production is an important feature of organic farming. Vermicompost can be used as important manure in the cultivation of crops and as biofertilizer in preservation of soil health. Vermicompost is a rich organic nutritious fertilizer that is rich in humus, micronutrients, and beneficial soil microbes- nitrogen fixing and phosphorus solubilizing bacteria and actinomycetes and growth hormones "auxins", "gibberellins" and "cytokinin's". Vermicompost contains several nutrient elements such as N- 1.9 percent, C:N- 13.6 percent, P- 2 percent, K- 0.8 percent, Zn- 100ppm and Mn- 500ppm.

Allolli *et al.*, (2011) [2] reported that the effect of organic manures in combination with inorganic fertilizers on the productivity and economic feasibility in sweet potato. Pooled data of 2 years revealed that, among organics, application of FYM at 10 t ha^{-1} + NPK at 50:25:50 kg ha^{-1} recorded significantly higher tuber yield $plot^{-1}$ and 24.16 kg and 33.55 t ha^{-1} respectively, and was at par with FYM at 20 t ha^{-1}. While significantly the lowest yield 21.34 t ha^{-1} was noticed in sweet potato due to T4 - PM at 5 t ha^{-1}.

Yeng *et al.*, (2012) [13] conducted research on growth and yield of sweet potato (*Ipomoea batatas* L.) as influenced by integrated application of chicken manure and inorganic fertilizer and concluded that organic and inorganic input combinations for soil mineral supplementation in sweet potato production is a better option than either of organic or inorganic input applied singly. A combination of 150 kg inorganic fertilizer +1.5 t cattle manure/ha is preferred for higher sweet potato growth and marketable and total fresh root yield in the Guinea Savanna zone, while 100 kg inorganic fertilizer + 3.0 t cattle manure /ha may be preferred for forest-transition zone or similar representative environments. These combinations produced sweet potato growth and yields either higher or comparable to inorganic fertilizer only as well as increased the soil nutrients and physical properties, thus may limit total dependence on inorganic fertilizers for sustainable sweet potato production.

Materials and Methods

The current research was conducted at the Research Farm Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Science (SHUATS) Allahabad, during the rabi season of 2020-2021. The experimental field lies about 8 kilometres from Allahabad city, on the left side of the Allahabad-Rewa Road, near the Yamuna River.

Prayagraj lies in Uttar Pradesh's subtropical zone, which enjoys scorching summers and mild winters. The peak temperature in the area is between 46°C to 48°C, with temperatures rarely falling below 4°C or 5°C. The relative humidity varies between 20% to 94%. The average annual rainfall in this area is 1013.4 mm.

The soil chemical analysis found that the texture was sandy loam, the reaction was acidic (pH 7.20), there was a medium amount of organic carbon (1.62 percent) and potassium (44.8 kg/ha), and there was a low amount of accessible phosphorus (6.72 kg/ha). The soil had a conductivity of 0.56 dS/m and was electrically conductive.

Three replications were used for each of the 9 treatment combinations. Table 1 exhibit the treatment details and treatment combinations, respectively. On the 1ST AUGUST, 2021, sweet potato c.v. Bhu Krishna was physically planted. Crop spacing was kept constant at 60cmx30cm. At basal and at 30 days after planting, the combinations of the aforementioned treatments were applied. The measurements of vine length(cm), no of leaves, internodal length(cm), no of vines per plant along with tuber weight, tuber diameter, tuber length, no of tubers per plant, tuber yield per plant and tuber yield (q/ha) were successfully taken. Also, the benefit cost was successfully calculated.

Table 1: Treatment combination Details

Treatment	Treatment combination
T1	100% RDF 130.4kg Urea+250kg SSP+103.4kg MOP/ha
T2	75%RDF+25% FYM 97.8kg Urea+187.5kg SSP+77.55kg MOP/ha+2.5tons fym/ha
T3	75%RDF+25%vermicompost 97.8kg Urea+187.5kg SSP+77.55kg MOP/ha +1.25tons vermicompost/ha
T4	60% RDF+20%FYM+20%vermicompopst 78.2kg Urea+150kg SSP+62.04kg MOP/ha+2tons fym+1ton vermicompost/ha
T5	50%RDF+50%FYM 65.2kg Urea+125kg SSP+51.7kg MOP/ha+5tons fym/ha
T6	50%RDF+50%vermicompost 65.2kg Urea+125kg SSP+51.7kg MOP/ha +2.5tons vermicompost/ha
T7	50%RDF+25%FYM+25%vermicompost 65.2kg Urea+125kg SSP+51.7kg MOP/ha +2.5tonsfym+1.25tons vermicompost/ha
T8	50%RDF+50%poultry manure 65.2kg Urea+125kg SSP+51.7kg MOP/ha +2.5tons poultry manure/ha
T9	50%RDF+20%FYM+20%poultry manure+10%vermicompost 65.2kg Urea+125kg SSP+51.7kg MOP/ha +2t fym+1t poultry manure+0.5t vermicompost/ha

Results and Discussions

Vine length (cm)

Treatment T9 was found best and recorded significantly highest vine length i.e., (46.43, 85.30, 130.31 and 154.09) cm followed by T8 and T7 whereas treatment T1 recorded significantly the lowest vine length i.e., (30.19, 60.91, 106.97

and 123.13) cm. The effect of vermicompost on plant growth might also attribute to the fact that earthworms mineralized the macro and micronutrients during vermicomposting and made available to crop plant for longer period. The results are in close conformation with findings of Vanmathi and Selvakumari (2012) [11]. The results are depicted in table 2.

No. of leaves

Treatment T9 found best and recorded significantly the highest number of leaves per plant (170.00) followed by T8 and T7 whereas treatment T1 recorded significantly the lowest number of leaves per plant (125.42).

The above result shows that T9 was found significantly highest number of leaves per plant. Various organic sources of nutrients markedly increased number of leaves per plant. This clearly indicates that higher levels of nutrients helped in cell elongation of stem due to development of cell and rapid cell division and cell elongation in meristematic region of plant. Similar findings have also been reported by Sood and Sharma (2001) [10]. The results are depicted in table 3

No. of vines per plant

Treatment T9 found best and recorded significantly the highest number of vines per plant (10.40) followed by T8 and T7, whereas treatment T1 recorded significantly the lowest number of vines per plant (5.73).

The above result shows that T9 was found significantly highest number of vines per plant and this may be attributed to, the increase in number of vines with application of FYM, poultry manure and vermicompost might be due to the fact that organic manure not only provides nutrients to plants but also improve soil physical condition with respect to friability, porosity and develop a balanced nutritional environment in both soil and plant system Marimuthu *et al.* (2002) [5]. The results are depicted in table 3.

Internodal length

Treatment T9 found best and recorded significantly the highest internodal length (cm) (4.69) followed by T8 and T7, whereas treatment T1 recorded significantly the lowest internodal length (cm) (3.05).

The increase in internodal length in T9 might be because of better photosynthetic activity in large photosynthesis area. Since, nitrogen is one of the basic minerals associated with synthesis of protoplasm and in primary synthesis of amino acids, it increases meristematic activity at faster rate under higher dose which causes better plant growth and intermodal length. It is also an established fact that plant supplied with abundant nitrogen and phosphorus would assimilate higher photosynthesis and better translocation resulting higher in vegetative growth. The finding gets full support from the observations Ghosh and Das (1998) [3]. The results are depicted in table 3.

No. of tubers per plant

Treatment T9 found best and recorded significantly the highest number of tubers per plant (3.35) followed by T8 and T7, whereas treatment T1 recorded significantly the lowest number of tuber per plant (2.07)

The above result shows that T9 was found significantly highest which might be due to better utilization of nutrients like nitrogen for reproductive growth rather than for vegetative growth (Gowda *et al*., 1979) [15]. The increase in number of tubers per plant might be due to various plant metabolic processes that resulted in more production of carbohydrates due to higher uptake of nitrogen. The results are depicted in table 4.

Tuber length

Treatment T9 found best and recorded significantly the highest tuber length (cm) (15.42) followed by T8and T7 whereas treatment T1 recorded significantly the lowest tuber length (cm) (11.03).

The above result shows that T9 was found significantly highest which might attribute to the beneficial effect of vermicompost for its ability to provide nutrients throughout its growing season. The availability of balanced C:N ratio might have increased the synthesis of carbohydrates which leads to increases in tuber length of sweet potato. These findings are in accordance with Yadav and Yadav (2010) [16]. The results are depicted in table 4

Tuber diameter

Treatment T9 found best and recorded significantly the highest tuber diameter (cm) (7.24) followed by T8and T7 whereas treatment T1 recorded significantly the lowest tuber diameter (cm) (5.17).

The above result shows that T9 was found significantly highest which might be attributed with poultry manure because of rapid availability and utilization of nitrogen for various internal plant processes for production of carbohydrates. These results are in conformity with findings of Meera bai *et al.*, (2007) [6]. The results are depicted in table 4

Weight of tuber

Treatment T9 found best and recorded significantly the highest weight of tuber (g) (96.34) followed by T8 and T7 whereas treatment T1 recorded significantly the lowest weight of tuber (g) (66.81)

The above result shows that T9 was found significantly highest which may be attributed to organic manure which shows superiority to weight of tubers. This was possible due to the fact that organic manure increased soil organic matter, water holding capacity, nutrient contents, soil aggregation, root system and microbial activity. This is in conformation with Carter *et al*. (2001) [18]. The results are depicted in table 5.

Tuber yield per plant

Treatment T9 found best and recorded significantly the highest Tube yield per plant (kg) (0.323) followed by T8 and T7 whereas treatment T1 recorded significantly the lowest Tuber yield per plant (kg) (0.138).

The above result shows that T9 was found significantly highest which might attribute to the sustained availability of nutrients throughout the growing phase thus increasing yield and also due to enhanced carbohydrate synthesis and effective translocation of photosynthates to sink i.e., tuber. The proportion and activity of beneficial microbes would have been at the higher rate during fermentation and thus helped in synthesis of growth substances, which might have resulted in better yield. These findings are in conformity with results obtained by Velmurugan *et al.*, (2005) [14]. The results are depicted in table 5.

Tuber yield (q/ha)

Treatment T9 found best and recorded significantly the highest Tuber yield (155.47 q ha^{-1}) followed by T8 and T7 whereas treatment T1 recorded significantly the lowest Tuber yield (q ha^{-1}) (76.82).

The above result shows that T9 was found significantly highest which might attribute to the sustained availability of nutrients throughout the growing phase thus increasing yield and also due to enhanced carbohydrate synthesis and effective translocation of photosynthates to sink i.e., tuber. The proportion and activity of beneficial microbes would have been at the higher rate during fermentation and thus helped in synthesis of growth substances, which might have resulted in better yield. These findings are in conformity with results obtained by Velmurugan *et al.*, (2005) [14]. The results are depicted in table 5.

Table 2: Response of various doses of organic manures and inorganic fertilizers on vine length (cm) of Sweet Potato (*Ipomoea batatas*) cv. Bhu Krishna

Treatment notation	Treatment combination	Vine length (cm)			
		30 DA P	60 DA P	90 DAP	120 DAP
T1	100% RDF 130.4kg Urea +	30.1	60.9	106.	123.
	250kg SSP+103.4kg MOP/ha	9	1	97	13
T2	75%RDF+25% FYM+ 97.8kg Urea+	37.0	72.9	111.	125.
	187.5kg SSP+77.55kg MOP/ha+2.5tons fym/ha	9	7	80	38
T3	75%RDF+25%vermicompost 97.8kg	35.5	77.9	112.	127.
	Urea+187.5kg SSP+77.55kg MOP/ha+	6	2	76	08
	1.25tons vermicompost/ha				
T4	60%RDF+20%FYM+20%vermicompopst	35.3	71.9	116.	129.
	78.2kg Urea+150kg SSP+62.04kg MOP/ha+	3	5	52	81
	2tons fym+1ton vermicompost/ha				
T5	50%RDF+50% FYM 65.2kg Urea+	35.1	73.0	118.	133.
	125kg SSP+51.7kg MOP/ha+5tons fym/ha	0	1	81	75
T6	50% RDF+50% vermicompost 65.2kg	39.6	74.8	120.	136.
	Urea+125kg SSP+51.7kg MOP/ha+2.5tons	9	9	48	81
	vermicompost/ha				
T7	50%RDF+25%FYM+	42.7	78.3	125.	138.
	25% vermicompost 65.2kg Urea+125kg	6	7	25	37
	SSP+51.7kg MOP/ha +2.5tonsfym+1.25tons				
	vermicompost/ha				
T8	50%RDF+50%poultry manure 65.2kg	43.9	84.1	128.	147.
	Urea+125kg SSP+51.7kg MOP/ha +	6	9	96	08
	2.5tons poultry manure/ha				
T9	50%RDF+20%FYM+20%poultrymanure+10%	46.4	85.3	130.	154.
	vermicompost 65.2kg Urea+125kg SSP+51.7kg	3	0	31	09
	MOP/ha+2t fym+1t poultry manure+0.5t				
	vermicompost/ha				
	F-Test	S	S	S	S
	C.D.at 0.5%	3.90	5.47	8.76	8.91
		7	7		
	S. Ed (+)	1.84	2.58	4.13	4.21
		3	3		

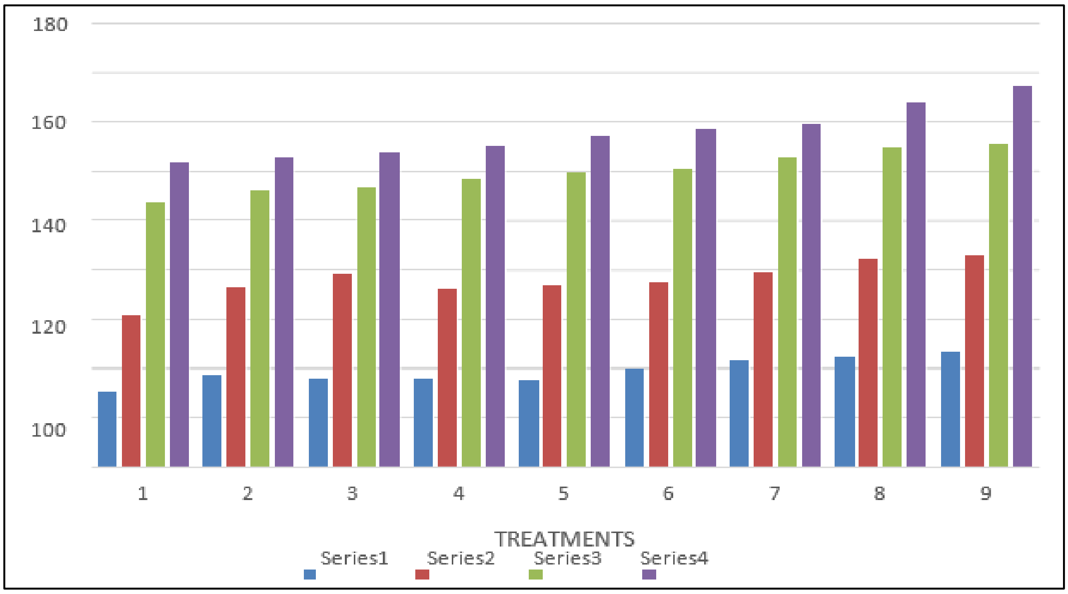

Fig 1: Response of various doses of organic manures and inorganic fertilizers on vine length (cm) of Sweet Potato (*Ipomoea batatas*) cv. Bhu Krishna

Table 3: Response of various doses of organic manures and inorganic fertilizers on number of leaves/plant, number of vines/plant and internodal length (cm) of Sweet Potato (*Ipomoea batatas)* cv. Bhu Krishna

Treatment	Number of leaves / plants	Number of vines/ plants	Internodal length (cm)
T1	125.42	5.73	3.05
T2	129.65	6.44	3.12
T3	133.15	6.45	3.16
T4	135.87	7.76	3.24
T5	145.74	7.23	3.45
T6	149.53	8.26	3.63
T7	156.94	9.59	4.42
T8	166.48	10.09	4.59
T9	170.00	10.40	4.69
F-Test	**S**	**S**	**S**
C.D.at 0.5%	9.55	0.617	0.337
S. Ed (+)	4.51	0.291	0.159

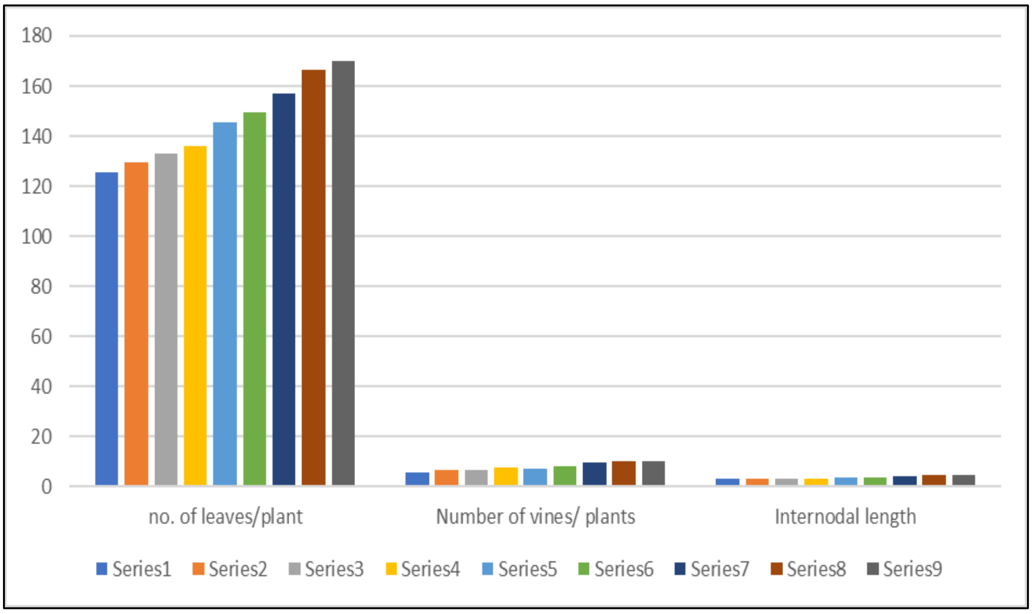

Fig 2: Response of various doses of organic manures and inorganic fertilizers on number of leaves/plant, number of vines/plant and internodal length (cm) of Sweet Potato (*Ipomoea batatas)* cv. Bhu Krishna

Table 4: Response of various doses of organic manures and inorganic fertilizers on number of tubers/plant, tuber length (cm) and tuber diameter (cm) of Sweet Potato (*Ipomoea batatas)* cv. Bhu Krishna

Treatment	Number of Tubers/ plants	Tuber length (cm)	Tuber diameter (cm)
T1	2.07	11.03	5.17
T2	2.14	11.59	5.66
T3	2.31	12.34	5.44
T4	2.40	13.06	6.19
T5	2.50	13.48	6.37
T6	2.86	13.50	5.60
T7	3.12	14.47	6.36
T8	3.24	15.34	6.66
T9	3.35	15.42	7.24
F-Test	**S**	**S**	**S**
C.D.at 0.5%	0.241	0.404	0.350
S. Ed (+)	0.114	0.190	0.165

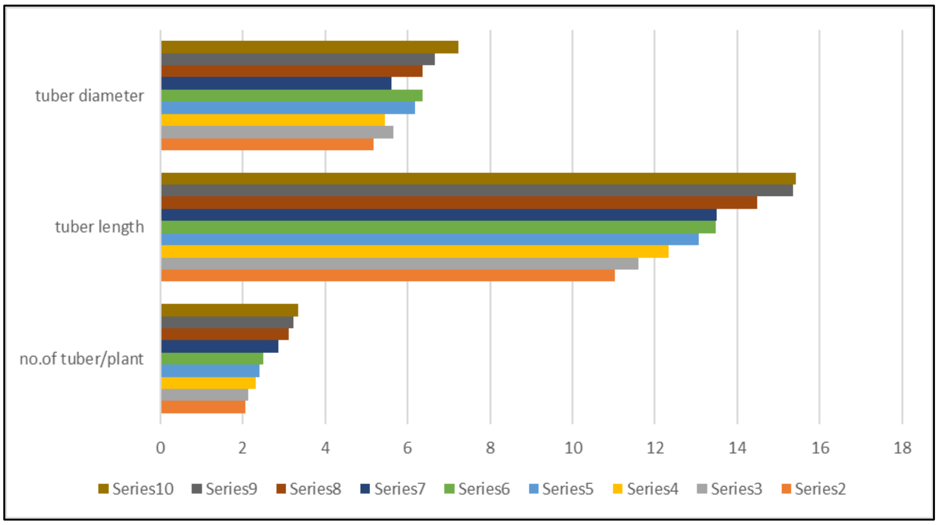

Fig 3: Response of various doses of organic manures and inorganic fertilizers on number of tubers/plant, tuber length (cm) and tuber diameter (cm) of Sweet Potato (*Ipomoea batatas*) cv. Bhu Krishna

Table 5: Response of various doses of organic manures and inorganic fertilizers on weight of tuber (g), tuber yield/plant and tuber yield (q/ha) of Sweet Potato (*Ipomoea batatas*) cv. Bhu Krishna

Treatment	Weight of tuber (g)	Tuber yield per plant (kg)	Tuber yield (q ha-1)
T1	66.81	0.138	76.82
T2	71.49	0.153	85.08
T3	84.37	0.195	98.64
T4	84.53	0.203	106.87
T5	86.74	0.217	113.88
T6	88.01	0.252	123.31
T7	91.67	0.286	142.72
T8	93.37	0.303	143.51
T9	96.34	0.323	155.47
F-Test	S	S	S
C.D.at 0.5%	4.545	0.025	4.83
S. Ed (+)	2.144	0.012	2.28

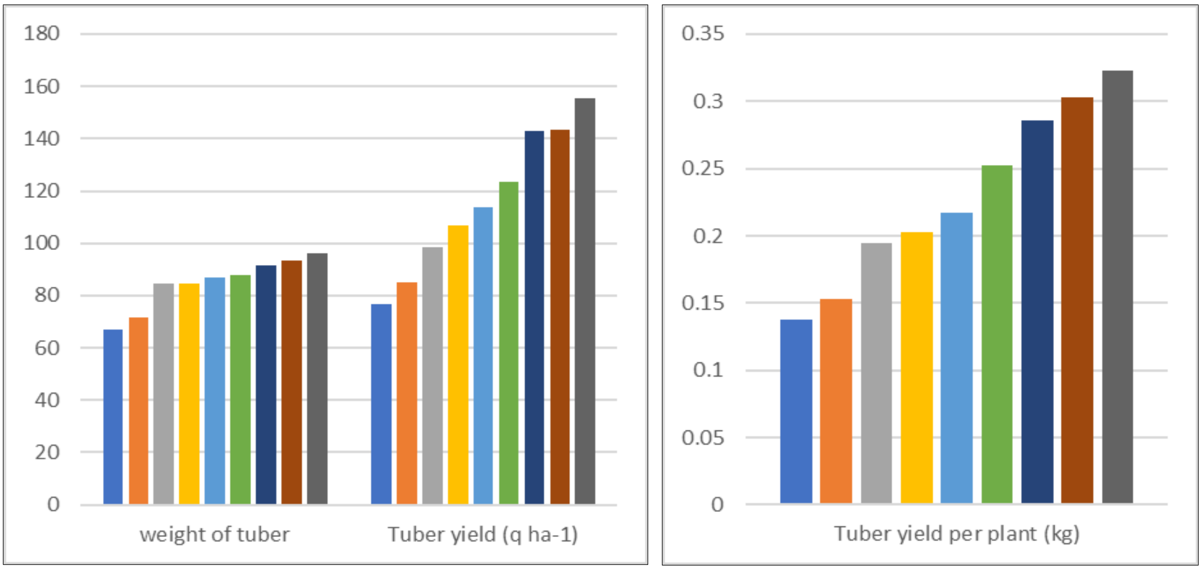

Fig 4: Response of various doses of organic manures and inorganic fertilizers on weight of tuber (g), tuber yield/plant and tuber yield (q/ha) of Sweet Potato (*Ipomoea batatas*) cv. Bhu Krishna

Conclusion

Among the various levels of organic manure and inorganic fertilizer used in the experiment, treatment T950% RDF+20% FYM+20% poultry manure+10% vermicompost (65.2kg Urea+125kg SSP+51.7kg MOP/ha+2t fym+1t poultry manure+0.5t vermicompost/ha) for vine length i.e., (154.09) cm, number of leaves per plant (170.00), number of vines per plant (10.40), highest internodal length (cm) (4.69), number of tubers per plant (3.35), tuber length (cm) (15.42), highest tuber diameter (cm) (7.24), weight of tuber (g) (96.34), Tuber yield per plant (kg) (0.323), Tuber yield (155.47 q ha- 1),was the best for the better plant growth and tuber yield of Sweet Potato under Prayagraj Agro-climatic condition.

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