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Effect of Integrated Nutrient Management on Growth and Yield of Potato, *Solanum tuberosum* L., Crop

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiments was conducted during winter season of 2019-20 and are presented in this chapter. The observations were recorded on growth, growth analysis, yield and yield attributes of different treatments and has been subjected to statistical analysis and presented in tables and graphical presentation as well, wherever necessary. The treatments effects have been described in the light of statistical inter pretations. The data pertaining to emergence percent of potato was recorded at 30days after planting (DAP) is given revealed the emergence(%) was not affected due to Integrated Nutrient Management-INM practice, the data further indicated that maximum emergence percent (94.40 %) was recorded underT6- 67% RDF through inorganic sources + 33% Recomended Dose of Fertilizer (RDF) through organic sources i.e., FYM + biofertilizer (Phosphate Solubilizing Bacteria/PSB), which was closely followed by T3 Poultry manure @ 5 t/ha + biofertilizer (PSB) (93.90) and minimum (91.30 %) and T2 - Farm Yard Manure (FYM) @ 30 t/ha) + biofertilizer (PSB).

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Keywords: INM- Integrated Nutrient Management; RDF- Recommended Dose of Fertilizer; FYM, Biofertilizer; poultry manure.

1. INTRODUCTION

"Potato (*Solanum tuberosum* L.) popularly known as "The King of Vegetables" is a native of South America (Peru) and occupies the largest area under any single vegetable crop in the world. Presently, developing countries of Asia accounts for more than 46% of global output under potato" [1]. "Potato is an important food crop at global as well as the country level. It is a rich source of protein, at least 12 essential vitamins such as vitamin C, thiamine and folic acid, minerals and superior dietary fiber etc. are also found in great amount in potato. It is an excellent source of carbohydrates with low fat percentage which makes it a balance food. Due to high protein: calorie ratio (17g protein: 1000 kcal) and short vegetative cycle, potatoes yield substantially more edible energy, protein and dry matter per unit area per unit time" [2]. "The potatoes cultivated on 19.30 million hectare area in the world with total production of 388.19 million tonnes. The average productivity of potato is 20.11tonnes, whereas India occupy 1.84 million ha area and production of 50.33 million tonnes with 27.31 t ha^{-1} productivity. In U.P. potato is cultivated on 0.61 million ha area, with total production of 13.9 million tonnes and productivity of 22.7 tha^{-1}, which is considered low as compared to productivity of India" [3]. "Presently, FYM is a major source of organic matter and nutrients, besides poultry manure and vermicompost. These organic sources generally contain low level of nutrients and are required in higher amounts to fulfill then seeds of crop, therefore, it is essential to supply the nutrient in integrated manner. vermicompost is a rich mixture of major and minor plant nutrients. On an average vermicompost contains 2% nitrogen, 1%phosphorus,1.5%potash. Besides, vermicompost is a rich source of nutrients, vitamins, enzymes, antibiotics, plant growth hormones and a number of beneficial microorganisms" [4]. Continuous application of heavy doses of chemical fertilizers without organic manures or biofertilizers has led to a deterioration of soil health in terms of physical and chemical properties of soil, declining of soil microbial activities, reduction in soil humus, increased pollution of soil, water and air.

2. MATERIALS AND METHODS

The experiment was conducted at the Agriculture Research Farm, Shri Durga Ji Post Graduate College, Chandeshwar, Azamgarh, (U.P.) during Rabi season of 2019-20 with Eight treatments T_1: Control, T_2: FYM @ 30 t/ha + biofertilizer (PSB), T_3: Poultry manure @ 5 t/ha + biofertilizer (PSB) , T_4: Vermicompost @ 7.5 t/ha + biofertilizer (PSB), T_5: FYM @ 10 t/ha + poultry manure 1.7 t/ha + vermicompost 2.7 t/ha+ biofertilizer (PSB), T_6: 67% RDF through inorganic sources + 33% RDF through organic sources i.e. FYM + biofertilizer(PSB) , T_7: 33% RDF through inorganic sources + 67% RDF through organic sources i.e. FYM + biofertilizer (PSB), T_8: Farmer practices (through organic). The treatments were allocated to respective plots randomly in all three replication by using the random number.

2.1 Emergence Per Cent and Plant Population

The data on emergence (%) was recorded at 30 days of planting. The growth parameters were recorded at 30,60 and 90 days of planting.

2.2 Plant Height (cm)

The height of the main stem from the ground level to the apical bud (leaf apex) was measured with the meter scale at 30, 60 and 90 days after planting.

2.3 Number of Haulms (m^{-1})

The number of haulms m^{-1} was recorded randomly at 30, 60 and 90 days after planting. Plants selected for plant height were used for this purpose. The average number of haulms m^{-1} was calculated by dividing total number of shoots by five.

2.4 Number of Leaves (m^{-1})

Number of leaves m^{-1} was counted at 30, 60 and 90 days after planting from tagged plants and the average number of leaves m^{-1} was calculated by dividing total number of leaves by fives.

2.5 Fresh Weight of Haulm (gm^{-1})

Five tagged plants were taken for fresh weight at the time of haulms cutting. The plant was weighted on physical balance and their average fresh weight per plant was worked out for presenting in the table for result purpose.

2.6 Dry Weight of Haulm (gm^{-1})

The plants taken for fresh weight were also used for this observation and they were firstly dried in oven at 60 ^{0}C ± temperature. After complete drying of haulms and leaves then were weighted and their average weight (g) was worked out for dry weight m^{-1}.

2.7 Yield Studies

2.7.1 Number of 0-25g, 25-50g, 50-75g & >75g Tuber (grade wise) hill^{-1}

The plants selected for number of haulm hill^{-1} were also used for this purpose each grade of tubers were separated and counted the number of tubershill^{-1}.

2.7.2 Weight of 0-25g, 25-50g, 50-75g & >75g tubers grade (g hill^{-1})

The same tuber grades for number of tubers g hill^{-1} was used for this purpose. Average weight of each grade of tubers was calculated on the basisof tubers weighted of five hills.

2.7.3 Weight of 0-25g, 25-50g, 50-75g & >75g tubers grades (kg plot^{-1})

Each plot was harvested separately and tuber weight of 0-25g, 25-50g, 50-75g & >75g grade recorded in kg plot^{-1}.

2.7.4 Tuber yield (q ha^{-1})

After harvesting, the yield of total tubers plot^{-1} were recorded in kilograms separately and converted into q ha^{-1}.

3. RESULTS AND DISCUSSION

3.1 Emergence Percentage

The data pertaining to emergence percent of potato was recorded at 30 days after planting (DAP) and depicted in revealed the emergence(%) was not affected due to INM practice, the data further indicated that maximum emergence percent (94.40 %) was recorded under T_6 67% RDF through inorganic sources + 33% RDF through organic sources i.e. FYM + biofertilizer (PSB), which was closely followed by T_3 Poultry manure @ 5 t/ha + biofertilizer (PSB) (93.90) and minimum (91.30 %) at T_2 - FYM @ 30 t/ha) + biofertilizer (PSB).

3.2 Plant Height (cm)

It was observed that plant height was highest in the plots treated with T_6 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer(PSB) (47.09 cm) and (49.14 cm) at 60 and 90 days after planting, respectively followed by T_7 33% RDF through inorganic sources + 67% RDF through organic sources i.e. FYM + biofertilizer (PSB) (44.95 cm) and (47.06 cm) at 60 and 90 days after planting, respectively however the least values were recorded under T_1 control *i.e*., 41.20 and 44.26. The increase in plant height under T_6 was because of continuous supply of plant nutrient, due to FYM application enable the plant for higher uptake of plant nutrients (macro and micro) both helped the crop for higher photosynthetic activity and finally the higher plant height. Similar higher plant height of potato crop due to heavy dressing of FYM (30 ton/ha) was reported by Sharma et al*.,* [5] and Anchal et al*.,* [6] in tomato crop.

3.3 Number of Haulms m^{-1} and Number of Leaves m^{-1}

The number of haulm m^{-1} and number of leaves m^{-1} were highly influenced by integrated nutrient management practices. The T_6 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) has recorded the highest number of haulms *i.e*., 36.37 and 38.59 at 60 and 90 days after planting, respectively followed by T_7 33% RDF through inorganic sources + 67% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) has recorded that number of haulms *i.e*., 34.84 and 36.69 the least T_1 control *i.e*., 33.29 and 34.08. In the same way, T_6 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) has recorded the highest number of leaves *i.e*., 449.76 and 433.68 At 60 to 90 days after planting respectively followed by T_7 33% RDF through inorganic sources + 67% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) has recorded that number of leaves *i.e*., 434.35 and 415.29 the least T_1 control *i.e*., 399.14 and 399.41. At 90 DAP the number of leaves plant^{-1} get reduced in all the treatments linearly due to high defoliation near to maturation. This increase in number of haulms and leaves might be due to increased availability of all plant nutrients continuously and higher uptake of nitrogen, phosphorus and potassium resulted in more number of hulms and higher number of leaves in these treatments. Naidu et al. [7] also reported similar higher number of leaves in okra.

Table1. Emergence percentage of potato, plant height and Number of haulm at successive stage as influencedby integrated nutrient management practices (Chaurasiya et al., 2020)

Treatments	Emergence 30 DAP	Plant height (cm)			Number of haulm m^{-1}		
		Days After Planting			Days After Planting		
		30	60	90	30	60	90
T_1: Control	92.34	18.55	41.20	44.26	7.60	33.29	34.08
T_2: FYM @ 30 t/ha) + biofertilizer (PSB)	91.30	20.87	42.78	45.07	7.62	33.91	34.30
T_3: Poultry manure @ 5 t/ha + biofertilizer (PSB)	93.90	21.59	43.11	45.60	7.63	33.94	34.35
T_4: Vermicompost @ 7.5 t/ha + biofertilizer (PSB)	92.86	21.90	43.58	45.59	7.67	33.98	34.39
T_5: FYM @ 10 t/ha + poultry manure 1.7 t/ha + vermicompost 2.7 t/ha + biofertilizer (PSB)	93.38	22.20	44.54	45.78	7.69	34.89	35.30
T_6: 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer (PSB)	94.40	24.00	47.09	49.14	8.01	36.37	38.59
T_7: 33% RDF through inorganic sources + 67% RDF through organic sources i.e. FYM + biofertilizer (PSB)	91.30	22.30	44.95	47.06	7.78	34.84	36.69
T8: Farmer practices (through organic)	91.82	22.19	44.92	46.93	7.75	34.54	36.62
SEm±	0.71	0.93	0.88	0.49	0.08	0.48	0.60
CD (P= 0.05)%	NS	NS	1.88	1.47	0.25	1.45	1.81

Table 2. Number of leaves, Fresh weight of haulm and Dry weight of haulm at successive stage of crop growth as influenced by integrated nutrient management

Treatments	Number of leaves m^{-1}			Fresh weight of haulm gm^{-1}	Dry weight of haulm gm^{-1}
	Days After Planting				
	30	60	90		
T_1: Control	69.22	399.14	399.41	356.47	34.08
T_2: FYM @ 30 t/ha) + biofertilizer (PSB)	69.37	414.91	402.03	359.40	34.30
T_3: Poultry manure @ 5 t/ha + biofertilizer (PSB)	69.46	418.20	402.58	361.30	34.35
T_4: Vermicompost @ 7.5 t/ha + biofertilizer (PSB)	69.82	422.73	403.05	362.25	34.39
T_5: FYM @ 10 t/ha + poultry manure 1.7 t/ha + vermicompost 2.7 t/ha + biofertilizer (PSB)	70.43	431.84	413.79	366.61	35.31
T_6: 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer (PSB)	72.34	449.76	433.68	383.79	38.45

	Number of leaves m^{-1}			Fresh weight of haulm gm^{-1}	Dry weight of haulm gm^{-1}
T_7: 33% RDF through inorganic sources + 67% RDF through organic sources i.e. FYM + biofertilizer(PSB)	71.34	434.35	415.29	371.75	36.22
T8: Farmer practices (through organic)	70.55	432.07	415.18	371.41	36.21
SEm±	0.83	4.76	5.47	3.83	0.52
CD (P= 0.05)%	2.50	14.43	16.58	11.60	1.57

Table 3. Number of tuber grade wise at harvest as affected by integrated nutrient management practices in potato

Treatments	Number of tuber grade wise) $hill^{-1}$				Weight of tubers grade (g $hill^{-1}$)			
	0-25g	25-50g	50-75g	>75g	0-25g	25-50g	50-75g	>75g
T_1: Control	3.04	2.09	1.90	1.89	9.35	46.77	56.19	76.80
T_2: FYM @ 30 t/ha) + biofertilizer (PSB)	3.10	2.11	1.95	1.92	15.75	78.74	94.52	125.90
T_3: Poultry manure @ 5 t/ha + biofertilizer (PSB)	3.11	2.12	1.96	1.96	16.37	81.81	98.28	130.81
T_4: Vermicompost @ 7.5 t/ha + biofertilizer (PSB)	3.11	2.12	1.97	1.96	17.55	87.76	105.42	140.32
T_5: FYM @ 10 t/ha + poultry manure 1.7 t/ha + vermicompost 2.7 t/ha + biofertilizer (PSB)	3.11	2.15	1.98	1.97	17.92	89.58	107.58	143.26
T_6: 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer (PSB)	3.26	2.24	2.05	2.04	23.17	115.66	138.93	184.88
T_7: 33% RDF through inorganic sources + 67% RDF through organic sources i.e. FYM + biofertilizer(PSB)	3.20	2.17	2.01	1.98	19.47	97.35	116.92	155.62
T8: Farmer practices (through organic)	3.12	2.16	1.99	1.98	18.49	92.45	111.06	147.83
SEm±	0.01	0.01	0.01	0.01	0.53	2.68	3.22	4.57
CD (P= 0.05)%	0.04	0.04	0.03	0.03	1.60	8.12	9.76	13.85

Table 4. Weight of potato tuber grade wise (kg $plot^{-1}$) and tuber yield (q ha^{-1}) as affected by integrated nutrient management practices [1]

Treatments	Wt. tuber grade kg $plot^{-1}$				Tuber yield (qha^{-1})
	0-25g	25-50g	50-75g	>75g	
T_1: Control	1.16	6.07	7.34	5.63	150.00
T_2: FYM @ 30 t/ha) + biofertilizer (PSB)	1.78	10.22	12.93	8.98	262.53
T_3: Poultry manure @ 5 t/ha + biofertilizer(PSB)	1.86	10.93	13.80	9.75	280.50

Treatments		Wt. tuber grade kg plot^{-1}			Tuber yield
T_4: Vermicompost @ 7.5 t/ha + biofertilizer (PSB)	1.99	11.36	14.36	10.17	292.60
T_5: FYM @ 10 t/ha + poultry manure 1.7 t/ha + vermicompost 2.7 t/ha + biofertilizer(PSB)	2.02	11.64	14.71	10.43	298.66
T_6: 67% RDF through inorganic sources +33% RDF through organic sources *i.e.* FYM + biofertilizer (PSB)	2.50	14.98	18.99	13.48	386.60
T_7: 33% RDF through inorganic sources + 67% RDF through organic sources *i.e*. FYM + biofertilizer (PSB)	2.16	12.68	16.03	11.29	324.53
T_8: Farmer practices (through organic)	2.05	12.00	15.18	11.70	308.26
SEm±	0.07	0.31	0.37	0.29	2.70
CD 5 %	0.22	0.93	1.11	0.86	8.20

Fresh weight and dry weight haulms were significantly influenced by sources of nutrients. In both the cases the plant treated with, T_6 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) recorded highest values for fresh weight and dry weight of haulms *i.e*., 383.79 and 38.45 this might also be associated with increased in uptake of nitrogen, phosphorus and potassium because of application of farmyard manure along with recommended dose of fertilizer which resulted in better plant growth. high fertility levels plant had more vegetative growth, which might have been associated with acceleration of high rate of photosynthesis. Thus, the concentration might had ultimately increased in fresh weights of shoots plant^{-1}. The result confirms the finding of Khurana et al. [8]. Similar higher dry weight of shoots plant^{-1} with the application of FYM @ 10 t ha^{-1}+100% RDF was reported by Raghav et al. [9].

3.4 Number of Tubers (grade wise) hill^{-1}

The data on number of tuber hill^{-1} was recorded at harvest. The data pertaining to number of tuber hill $^{-1}$. It is also evident from the analysis of variance table that number of tuber hill^{-1} was significantly affected due to different treatments applied during course of investigation. Significantly maximum number of tuber (grade wise) hill^{-1} in 0-25g, 25- 50g, 50-75g and >75g (3.26, 2.24, 2.05 and 2.04) was recorded under T_6 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) over rest of the treatments which was followed by T_7 33% RDF through inorganic sources + 67% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) (3.20, 2.17, 2.01 and 1.98) the least T_1 control (3.04, 2.09, 1.90 and 1.89).

3.5 Weight of Tubers (gm hill^{-1})

The data on weight of tuber (gm hill^{-1}) was recorded at harvest. The data pertaining to weight of tuber (gm hill $^{-1}$) . A perusal of data from the analysis of variance table that weight of tuber (gm hill^{-1}) was significantly affected due to different treatments applied during the course of investigation. It is evident from the data that significantly the maximum weight of tuber (gm hill^{-1}) in 0- 25g, 25-50g, 50-75g and >75g was recorded under T_6 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) 23.17, 115.66, 138.93 and 184.88 as compared to rest of the treatments. However T_7 33% RDF through inorganic sources + 67% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) 19.47, 97.35, 116.92 and 155.62 was found the next best over the rest of the treatments. However, the least value of weight of tuber (gm hill $^{-1}$) 9.35, 46.77, 56.19 and 76.80 respectively of registered under T- control treatment.

3.6 Yield and Yield Attributes

Undoubtedly adequate supply of nutrients in available from determines the number of tuber (grade wise) hill^{-1} and weight of tuber gram hill^{-1} as the present study, application of the T_6 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) has recorded the highest number of tuber grade wise hill^{-1} (0-25g, 25-50g, 50-75g and >75g) *i.e*., 3.26, 2.24, 2.05 and 2.04, respectively followed by T_7 33% RDF through inorganic sources + 67% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) *i.e*., 3.20, 2.17, 2.01 and 1.98 the least T_1 control *i.e*., 3.04, 2.09, 1.90 and 1.89. Application of T_6 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) recorded the highest number of tuber grade g hill^{-1} (0-25g, 25-50g, 50-75g and >75g) *i.e*., 23.17, 115.66, 138.93 and 184.88 respectively followed by T_7 33% RDF through inorganic sources + 67% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) *i.e*., 19.47, 97.35, 116.92 and 115.62 the least T_1 control 9.35,46.77,56.19 and 76.80. The highest grade wise number of tuber plot^{-1} was found in (10 t FYM ha^{-1} with 100% RDF NPK) reported by Raghav et al. (2008). The improvement in growth (plant height, dry matter accumulation, no. of leaves) and yield attributes(tuber weight/plant, no. of tubers/plant) under integrated nutrient management practices in the present experiment due to continuous supply of plant nutrients was mainly responsible for higher potato tuber yield(q/ha) under this experiment. Barman et al. [10] observed that possibility of improving, growth and tuber yield of potato by the use of integrated nutrient management. Results obtained after statistical analysis of data revealed that the height of plant, number of compound leaves/hill, number of haulms/hill, yield attributes and yield. Further number of A, B, C and D grade tubers/plot, percent of A, B, C and D grade tubers/plot, yield of A, B, C and D grade tubers/plot (kg), total number of tubers plot, total weight of tubers per plot (kg) and tuber yield (t/ha) showed the beneficial response by the use of integrated levels of N, FYM and vermicompost. However, on the basis of pooled

data it was also further observed that the application of 150 kg N, 20 t FYM and 5 ton vermicompost /ha of improvement in growth and tuber yield of potato.

4. CONCLUSION

Application of integrated nutrient management (INM) in the ratio of 2:1 (67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) was found to be effective for growth, and yield of potato and nutrient uptake. Potato crop fertilized with 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + biofertilizer (PSB) gave the higher yield. On the basis of one year experiment, it is recommended that potato crop should be fertilized with 67% RDF through inorganic sources + 33% RDF through organic sources *i.e*. FYM + PSB to obtain the higher potato yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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