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Impact of integrated nutrients on vegetative growth and tuber yield of potato (*Solanum tuberosum* L.)

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Abstract
A field experiment was laid out to evaluate the effect of inorganic fertilizer and organic manure (FYM) on vegetative growth and yield of potato (*Solanum tuberosum* L.) Cv. Kufri badshah. The study was at factorial arrangement based on randomized block design (RBD). Inorganic fertilizer applied as recommended dose of fertilizer (RDF) with simple fertilizer (Urea, SSP and MoP) and organic manure applied as farm yard manure. It was observed that the highest plant height, number of branches, number of leaves and tuber yield (190.15 q ha^{-1}) was obtained in treatment combination T_8 - @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) and followed by T_7- @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t ha^{-1}). The treatment combination T_8 - (I_2F_2) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) with highest net profit Rs. (74646.41 ha^{-1}) and cost benefit ratio (B: C) (1.96).

Keywords: in organic fertilizer, Farm yard manure, tuber yield, integrated nutrient management

Introduction
Potato (*Solanum tuberosum* L.) is the fourth most important world crop, after rice, wheat, and maize (Spooner and Bamberg, 1994) [8]. It is an economical food and it provides a source of low cost energy to the human diet. Potato is the rich source of starch, vitamin C and B and minerals. It contains about 20.6 % carbohydrates, 2.1% protein, 0.3 % fat, 1.1 % crude fiber and 0.9 % ash. It also contains a good amount of essential amino acids like *leucine*, *tryptophane* and *isolucine* (Khurana and Naik, 2003) [6].

Potato is cultivated over an area of 19.3 million hectares in 150 countries of the world with a total production of 308 million tones. In India, potato is cultivated in an area of about 1.34 million hectares with a total production of about 24.7 million tones. It is cultivated on a large scale in Uttar Pradesh, West Bengal, Bihar and Punjab. The potato productivity is very low in North Eastern hill (NEH) region of India (8.64 t/ha) except in Tripura (17.3 t/ha) due to poor management practices (Burman *et al.*, 2007) [4].

Materials and methods
Experimental Site
The experiment was conducted at the soil science Research Farm of Sam Higginbottom Institute of Agriculture and Technology (Deemed-to-be-University), Allahabad, (U.P.) which is situated 6 km away from Allahabad city on the right bank of Yamuna river. The site was located at the 25˚.57' N latitude, 81˚.57' E longitude and 98 meter above the mean sea level. The plot was leveled and connected with the irrigation channels to facilitate timely irrigation.

Land Preparation
The selected experimental field was ploughed thoroughly with a cultivator, the ploughed field was leveled and weeded and grasses were removed with the help of rake. The field was divided into three main blocks (replication). The replication orders, plot paths, irrigation and drainage channels were prepared manually.

Fertilizer Application
Before sowing, fertilizers were carefully weighed and packed were prepared for application in the plots. Fertilizers were applied row to row.

Inorganic Fertilizer
Source of Nitrogen
Nitrogen requirement for the crop @ 240 kg ha $^{-1}$ was met with the application of urea (46% N). The requirement amount of N for treatments were calculated. Half of the nitrogen dose was applied as basal dressing and other half was applied in two equal splits.

Source of Phosphorous
Phosphorous requirement for the crop @100 kg ha^{-1} was met with the application of single super phosphate (16% P_2O_5). The requirement of the P_2O_5 for treatment was calculated and supplied as basal.

Source of Potassium
The potassium requirement for the crop @150 kg ha^{-1} was met with the application of Murate of potash (60% K_2O). The requirement of K_2O for treatment was calculated and was supplied as basal.

FYM
Well decomposed FYM was obtained from the University, Sundaran Animal Husbandry and Dairy Farm and was used as organic source of nutrients. FYM applied at 10 t ha^{-1}, 5 t ha^{-1} and 0 t ha^{-1}.

Experimental details
The experiment was laid out in the field of Soil Science,

Allahabad School of Agriculture, Research Farm of SHIATS (Deemed-to-be-University), Allahabad. All the facilities necessary for cultivation including labor and irrigation were readily available on research farm. The experiment comprises of inorganic and organic source (FMY), full dose were applied before sowing in the field. Potato seeds were sown in ridges. The detail of the different fertilizers and their composition and doses are given below:

Treatment Combinations

Treatments	Symbols	Doses (Kg/ha or t/ha)
To	I_0F_0	Control
T_1	I_0F_1	@$N_0P_0K_0$ + FYM 5 t/ha
T_2	I_0F_2	@$N_0P_0K_0$ + FYM 10 t/ha
T_3	I_1F_0	@$N_{120}P_{50}K_{75}$ + FYM 0 t/ha
T_4	I_1F_1	@$N_{120}P_{50}K_{75}$ + FYM 5 t/ha
T_5	I_1F_2	@$N_{120}P_{50}K_{75}$ + FYM 10t/ha
T_6	I_2F_0	@$N_{240}P_{100}K_{150}$ + FYM 0 t/ha
T_7	I_2F_1	@$N_{240}P_{100}K_{150}$ + FYM 5 t/ha
T_8	I_2F_2	@$N_{240}P_{100}K_{150}$ + FYM 10 t/ha

Table 1: Different levels of inorganic and organic fertilizer, their composition (kg ha^{-1}) and symbols used for treatment combination

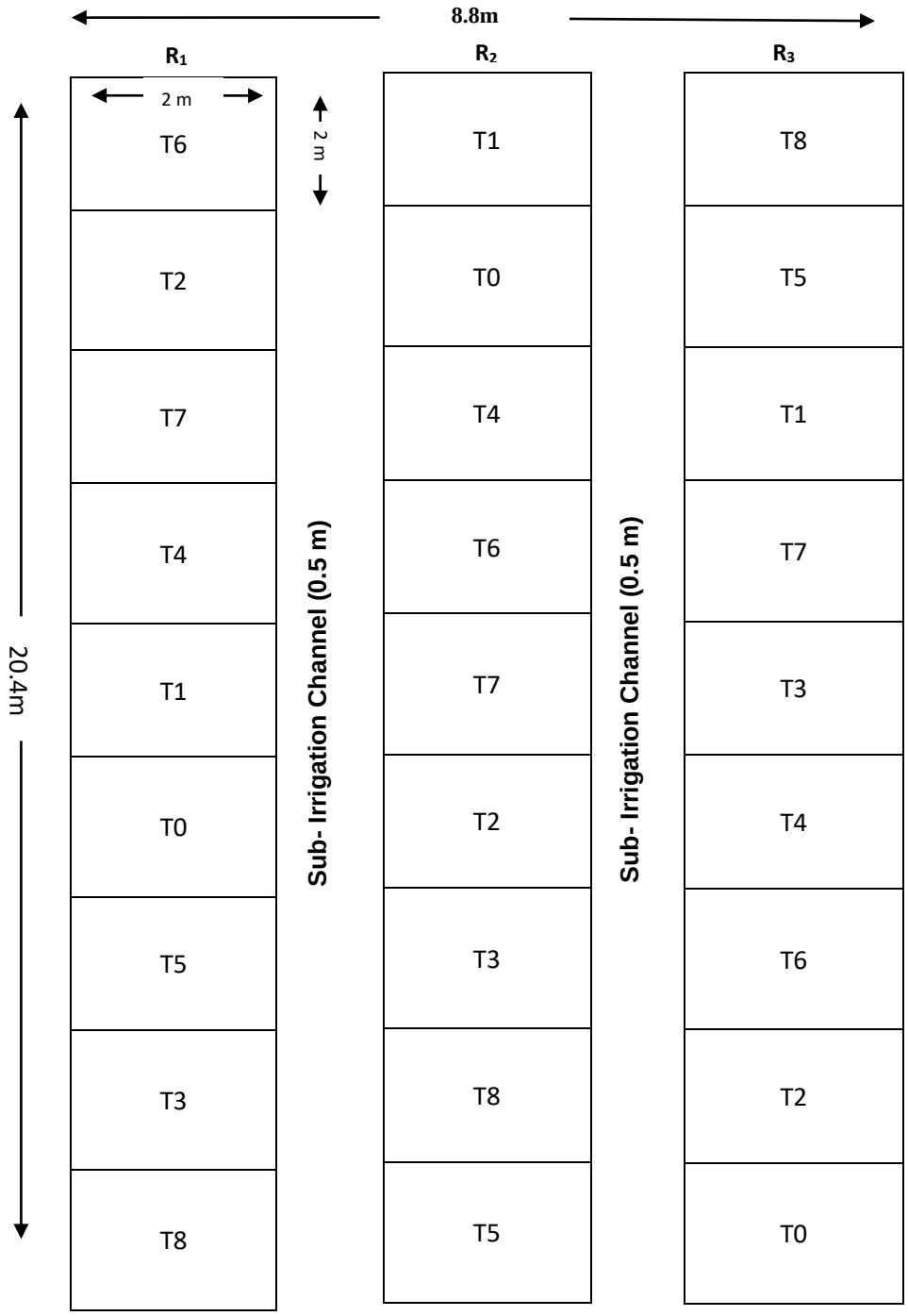
S. No.	Treatment	Kg ha^{-1}	Symbol
1.	Inorganic fertilizer	$N_0P_0K_0$	I_0
		$N_{120}P_{50}K_{75}$	I_1
		$N_{240}P_{100}K_{150}$	I_2
2.	Organic fertilizers Levels of FYM	FYM 0 t ha^{-1}	F_0
		FYM 5 t ha^{-1}	F_1
		FYM 10 t ha^{-1}	F_2

Details of the Experimental Layout

The details of the layout is furnished below

Crop	:	Potato.
Variety	:	Kufri Badshah.
Season	:	Rabi (Nov. 2015 - Feb. 2016)
Seed Rate	:	2.00 t ha^{-1}.
Design of experiment	:	3^2 F RBD.
No. of treatments	:	9.
No. of replication	:	3.
No. of plots in each replication	:	9.
Total number of plots	:	27.
Net plot size	:	4 m^2.
Width of main irrigation channel	:	1.0 m.
Row to row spacing	:	60 cm.
Plant to plant spacing	:	20 cm.
Net cultivation area of field	:	108 m^2.
Gross cultivation area	:	199.8 m^2.

Layout of Experimental Field
Department: Crop Research Farm of Soil Science, SHIATS, Allahabad.
Plot No:



Result and discussion

The present investigation was carried out at soil science crop research farm, SHIATS, (deemed-to-be-university) Allahabad, during the Rabi season of the crop year Nov. 2015 to Feb. 2016. The experiment was laid out in a 3x3 factorial randomized block design with three replication and nine treatments. The experiment included two different fertilizers (inorganic fertilizer and organic manure (FYM)). The observations were recorded at an interval of 30, 60 and 90 DAS. The main findings of the experimental study are summarized below.

Plant height (cm)

At 30 DAS, the maximum height of plant 29.30 cm in T_8 - (I_2F_2) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) treatment and followed by T_7 - (I_2F_1) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t ha^{-1} were 28.22 cm. whereas the minimum plant height was observed with T_0 - (I_0F_0) 20.01.

At 60 DAS, the maximum 61.12 cm in T_8 - (I_2F_2) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) treatment and followed by T_7 - (I_2F_1) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t ha^{-1} were 60.50 cm. whereas the minimum plant height was observed with T_0 - (I_0F_0) 30.38 cm.

At 90 DAS, the maximum height were 70.22 in T_8 - (I_2F_2) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) treatment and followed by T_7 - (I_2F_1) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t $ha^{-1)}$ 69.40 cm. whereas the minimum plant height was observed with T_0 - (I_0F_0) 41.12 cm. The interaction between inorganic fertilizer and organic manure was significant with respect to plant height at 60 and 90 DAS. Similar finding reported by (Jaipaul *et al.* 2011) and (Zelalem *et al.* 2009) [9].

Number of branches per plant

At 30 DAS, the maximum 13.03 in T_8 - (I_2F_2) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) treatment and followed by T_7 - (I_2F_1) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t ha^{-1}) were 12.88. Whereas the minimum number of branches per plant was observed with T_0 - (I_0F_0) 10.21.

At 60 DAS, the maximum number of branches per plant were 16.21 in T_8 - (I_2F_2) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) treatment and followed by T_7 - (I_2F_1) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t ha^{-1}) were 14.54. The minimum number of branches were observed with T_0 - (I_0F_0) 11.32.

At 90 DAS the maximum number of branches were 19.54 in T_8 - (I_2F_2) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) treatment and followed by T_7 - (I_2F_1) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t ha^{-1}) 18.64. Whereas the minimum number of branches per plant was observed with T_0 - (I_0F_0) 13.21. The interaction between inorganic fertilizer and organic manure was significant with respect to number of branch per plant at 60 and 90 DAS.

Number of leaves per plant

At 30 DAS, the maximum number of leaves were 55.06 in T_8 - (I_2F_2) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) treatment and followed by T_7 - (I_2F_1) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t ha^{-1}) were 54.98. Whereas the minimum number of branches were observed with T_0 - (I_0F_0) 34.33.

At 60 DAS, the maximum number of leaves per plant were 88.98 in T_8 - (I_2F_2) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) treatment and followed by T_7 - (I_2F_1) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t ha^{-1}) were 84.98. Whereas minimum number of leaves per plant were observed with T_0 - (I_0F_0) 56.43.

At 90 DAS, the maximum number of leaves per plant were 95.98 in T_8 - (I_2F_2) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) treatment and followed by T_7 - (I_2F_1) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t ha^{-1}) were 87.43. Whereas the minimum number of leaves per plant were observed with T_0 - (I_0F_0) 60.35. The interaction between inorganic fertilizer and organic manure was significant with respect to number of leaves per plant at 30, 60 and 90 DAS.

Tuber yield (q ha^{-1})

The highest tuber yield was observed 190.15 q ha^{-1} in T_8 - (I_2F_2) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) treatment were and followed by T_7 - (I_2F_1) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t ha^{-1}) were 173.29 q ha^{-1}. Whereas the minimum tuber yield was observed with T_0 - (I_0F_0) 76.23 q ha^{-1}. The interaction between inorganic fertilizer and organic manure was significant with respect to tuber yield. Similar finding reported by (Ahmed *et al.* 2015) and (Boke *et al.* 2014) [3].

Grade wise tuber yield (%)

The maximum percentage of large size tuber was observed in T_8 - (I_2F_2) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) treatment combination was (55.20 %) and followed by T_7 - (I_2F_1) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t ha^{-1}) was (46.20 %). Whereas the minimum large size of potato was observed with T_0 - (I_0F_0) (11.70) respectively. The interaction between inorganic fertilizer and organic manure was significant with respect to large size (%) tubers. Similar result reported by (Ali H. *et al.* 2004) [2].

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