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Impact of integrated nutrients on soil fertility status under potato cultivation (*Solanum tuberosum* L.)

[1] Ghulam Mohammad, [2] Arun A David

[1] Research scholar, Department of Soil Science, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad School of Agriculture (Deemed-to-be-University) Allahabad, Uttar Pradesh, India
[2] Associate professor, Department of Soil Science, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad School of Agriculture (Deemed-to-be-University) Allahabad, Uttar Pradesh, India

Abstract
A field experiment was laid out to evaluate the effect of inorganic fertilizer and organic manure (FYM) on soil physical and chemical properties under potato cultivation (*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 decrease in soil pH, bulk density and increase in electrical conductivity, particle density, pore space(%), organic carbon (%), available nitrogen, phosphorous and potassium in treatment 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}).

Keywords: Soil physical and chemical properties, Soil amendment, in organic fertilizer, Farm yard manure, integrated nutrient management

1. Introduction
Potato belongs to the genus solanum, in the family of solanaceae. The commercially cultivated potato belong to the species Solanum tubersoum. Potato is the most important food crop in the world. Potato is a crop which has always been the poor man's friend. Potato is being cultivated in India for last more than 300 years for vegetable purpose it has become one of the most popular crop in this country (Singh *et al.*, 2010).
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).
In peninsular India Potato is grown under long day conditions in hills of northern and eastern Himalayas and under short day conditions in Indo-Gangetic plains of India. It is grown both during *Rabi* and *Kharif* seasons. In the hills of northern and eastern India, it is grown during summer months (April-September) under rain fed conditions while in plains, the crop is taken under assured irrigation during winter months (October-February) when the temperatures are conducive for tuber formation. Potato is the most sensitive crop to nutrient stress because of its sparse root system. Thus it needs high dose of fertilizers for getting full yield potential. Moreover, its application has a special significance in northern plains of India where crop is prone to frost during winter months. In north-western hills where the crop is rain fed, its application protects the crop from drought, a common feature observed in early stages of crop growth (Grewal and Trehan, 1993).

2. Materials and methods
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

Details of the Experimental Layout

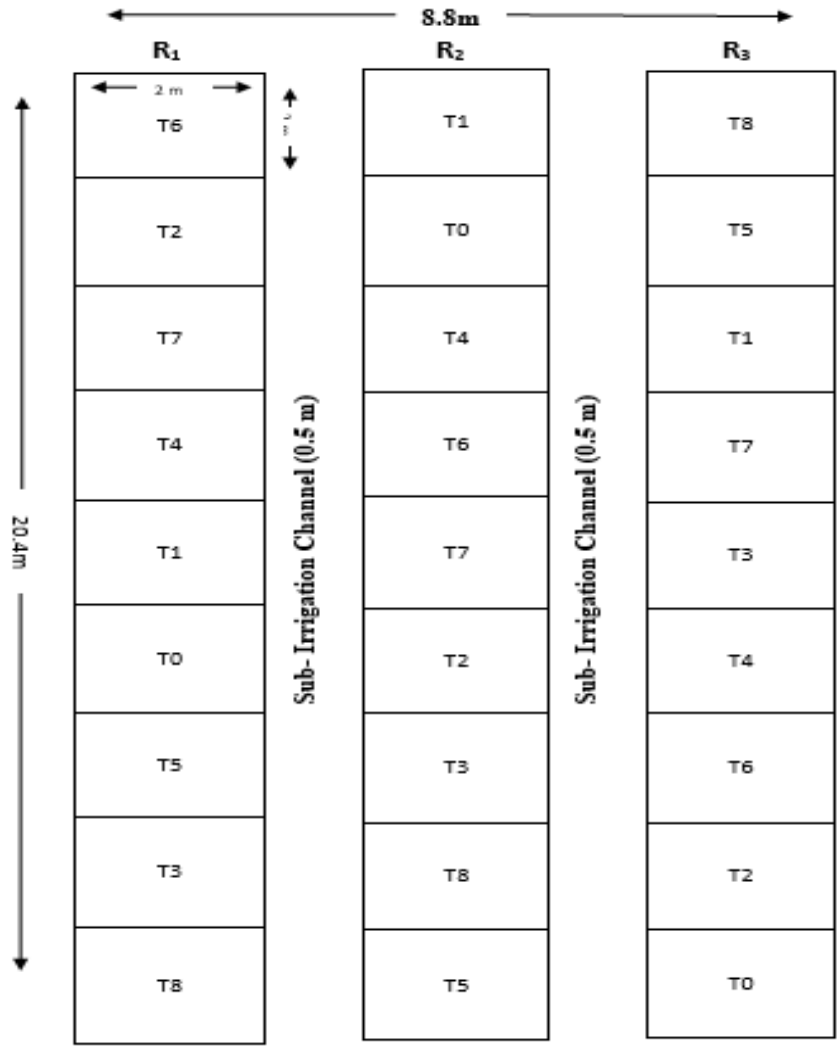
The details of the layout is furnished below;

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.
Width if sub-irrigation channel	:	0.5m.
Width of each bund	:	0.3 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



Soil analysis

Soil samples were taken from 0-15 cm soil depth randomly pre sowing operations, air dried and passed through 2 mm sieve. Then the composite soil sample was taken for mechanical and chemical analysis. After crop harvest soil sample were taken to the plough levels up to 15 cm soil depth from each plot for determination of important physical and chemical properties of soil, *viz*. particle density, bulk density, pore-space, soil pH, soil EC, organic carbon and Available NPK.

Table 1: Physical properties of soil at Pre and Post-harvest.

Mechanical Analysis	Method
Bulk Density (gcm^{-3})	Core method.-C.A. Black (1965)
Particle Density (gcm^{-3})	Relative density bottle method -C.A. Black (1965)
Colour	Munsell Colour Chart

Table 2: Chemical Properties of soil at Pre and Post-Harvest.

Chemical analysis	Method
Soil pH (1:2 soil water)	Digital pH meter(Systronic type 331)
Soil EC (dSm^{-1}) (1:2 soil water)	Digital electrical conductivity meter
Organic Carbon (% O.C)	Walkley and Black Method (1947)
Available Nitrogen (kg ha^{-1})	Alkaline Permanganate Method. Subbiah and Asija (1956)
Available Phosphorous (kg ha^{-1})	Colorimeter Method Olsen (1954)
Available Potassium (kg ha^{-1})	Flam photometer Method Toth and Prince (1949)

3. Result and discussion

The pre and post values of physical and chemical properties of soil are giving below;

Pre sowing status of physical properties of soil at 0-15 cm of depth

Table 3: Physical Properties of pre - sowing soil**.**

Mechanical Analysis	Result	Method
Bulk Density (gcm^{-3})	1.43	Core method.-C.A. Black (1965)
Particle Density (gcm^{-3})	2.3	Relative density bottle method -C.A. Black (1965)
Colour	6/4 Light yellowish brown	Munsell Colour Charts

Pre sowing status of Chemical properties of soil at 0-15 cm depth

Table 4: Chemical Properties of Pre sowing soil.\

Chemical analysis	Result	Method
Soil pH (1:2 soil water)	7.45	Digital pH meter(Systronic type 331)
Soil EC (dSm^{-1}) (1:2 soil water)	0.335	Digital electrical conductivity meter
Organic Carbon (% O.C)	0.41	Walkley and Black Method (1947)
Available Nitrogen (kg ha^{-1})	234	Alkaline Permanganate Method. Subbiah and Asija (1956)
Available Phosphorous (kg ha^{-1})	18.0	Colorimeter Method Olsen (1954)
Available Potassium (kg ha^{-1})	235.21	Flam photometer Method Toth and Prince (1949)

Post-Harvest Status of Physical and Chemical properties of soil at 0-15 cm depth

Bulk density (g cm^{-3}): The maximum bulk density of soil was observed with T_0 - (I_0F_0) (1.363 g cm^{-3}) treatment combination followed by T_7 - (I_2F_1) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t ha^{-1}) was (1.282 g cm^{-3}) and the minimum value was observed with T_8 - (I_2F_2) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) (1.263 g cm^{-3}). The interaction between inorganic fertilizer and organic manure was Non-significant. Similar finding reported by (Aguilera *et al.* 2012) [1] and (Kusro *et al.* 2014) [6].

Particle density (g cm^{-3}): The maximum particle density of soil was observed with T_8 - (I_2F_2) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) treatment combination (2.56) followed by T_7 - (I_2F_1) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t ha^{-1}) was (2.45) and the minimum value was observed with T_0 - (I_0F_0) (2.32). The interaction between inorganic fertilizer and organic manure was significant with respect to soil particle density (g cm^{-3}).

Soil pH: The highest pH was recorded with T_0 - (I_0F_0) treatment combination was (7.45) followed by T_7 - (I_2F_1) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t ha^{-1}) was (7.15) whereas the lowest observed with T_8 - (I_2F_2) @ $N_{240}P_{100}K_{150}$ Kg ha^{-1} and FYM 10 t ha-1 (7.13). The interaction between inorganic fertilizer and organic manure proved that it was significant. Similar finding reported by (Suh *et al.* 2015) [11] and (Aguilera *et al.* 2012) [1].

Soil Electrical Conductivity (dS m^{-1}): The highest value was observed with T_8 - (I_2F_2) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) treatment combination (0.389 dS m^{-1}) followed by T_7 - (I_2F_1) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t ha^{-1}) was (0.379 dS m^{-1}) and the minimum value was observed with T_0 - (I_0F_0) (0.341 dS m^{-1}). The interaction between inorganic fertilizer and organic manure was significant.

Organic Carbon (%): The percentage of Organic Carbon (%) of soil significantly increase with increase in level of NPK and organic manure. The highest soil organic carbon content was found in T_8 - (I_2F_2) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) (0.61%) followed by T_7 - (I_2F_1) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t ha^{-1}) (0.60%) and the minimum value was observed with T_0 - (I_0F_0) (0.47%). The interaction between inorganic

fertilizer and organic manure proved that it was significant. The percentage of organic carbon (%) of soil significantly increase with increase in level of NPK and organic manure. Similar results reported by (Aguilera *et al.* 2012) [1] and (Kusro *et al.* 2014) [6].

Available Nitrogen (kg ha^{-1}): The effect of NPK and organic manure on available nitrogen (kg ha^{-1}) was found significant. The availability of nitrogen increased with increase in level of NPK and organic manure. The maximum Nitrogen content of soil after harvest was in T_8 - (I_2F_2) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) (250.57 kg ha^{-1}) followed by T_7 - (I_2F_1) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t ha^{-1}) (248.31 kg ha^{-1}), and the minimum amount being available with T_0 - (I_0F_0) (241.31). The interaction between inorganic fertilizer and organic manure was significant. Similar finding reported by (Najm *et al.* 2013) [7] and (Vidyavathi *et al.* 2012) [13].

Available Phosphorous (kg ha^{-1}): The effect of NPK and organic manure on available phosphorus (kg ha^{-1}) was found significant. The available phosphorus of soil significantly increased with increase of NPK and organic manure. The maximum phosphorous content of soil after harvest was in T_8 - (I_2F_2) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) (27.91 kg ha^{-1}) followed by T_7 - (I_2F_1) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t ha^{-1}) (26.89 kg ha^{-1}), and the minimum amount was observed with T_0 - (I_0F_0) (22.67 kg ha^{-1}). The interaction between inorganic fertilizer and organic manure proved that is was significant. Similar result reported by (Powon *et al.* 2005) [9] and (Vidyavathi *et al.* 2012) [13].

Available Potassium (kg ha^{-1}): The effect of NPK and organic manure on available potassium (kg ha^{-1}) was found significant. The available potassium of soil significantly increased with increase of NPK and organic manure. The maximum potassium content of soil after harvest was in T_8 - (I_2F_2) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 10 t ha^{-1}) (258.03 kg ha^{-1}) followed by T_7 - (I_2F_1) @ ($N_{240}P_{100}K_{150}$ Kg ha^{-1} + FYM 5 t ha^{-1}) with (256.11 kg ha^{-1}), and the minimum amount being available with T_0 - (I_0F_0) (241.92 kg ha^{-1}). The interaction between inorganic fertilizer and organic manure proved that is was significant. Similar finding reported by (Jatav *et al.* 2011) [4] and (Vidyavathi *et al.* 2012) [13].

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