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RESPONSE OF TILLAGE PRACTICES AND FARM YARD MANURE ON SOIL HEALTH, GROWTH, YIELD AND NUTRIENT UPTAKE BY POTATO (*SOLANUM TUBEROSUM* L.) CV. KUFRI BADSHAH

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Abstract: *The Field experiment was conducted on Response of Tillage Practices and Farm Yard Manure on Soil Health, Growth, Yield and Nutrient uptake by Potato (Solanum tuberosum L.) cv. Kufri Badshah at the Research farm of Department of Soil Science, Sam Higginbottom Institute of Agriculture, Technology & Sciences Allahabad, Uttar Pradesh during Rabi season 4 Nov-28 Feb 2011. The experiment was laid out in 3×3 factorial randomized block design with three replications. The treatment consisted of three combination of tillage practices and FYM, T_0 - (D_1F_0) Depth of tillage at 10 cm + FYM at 0 t ha^{-1}, T_1 - (D_1F_1) Depth of tillage at 10 cm + FYM at 15 t ha^{-1}, T_2 - (D_1F_2) Depth of tillage at 10 cm + FYM at 30 t ha^{-1}, T_3 - (D_2F_0) Depth of tillage at 20 cm + FYM at 0 t ha^{-1}, T_4 - (D_2F_1) Depth of tillage at 20 cm + FYM at 15 t ha^{-1}, T_5 - (D_2F_2) Depth of tillage at 20 cm + FYM at 30 t ha^{-1}, T_6 - (D_3F_0) Depth of tillage at 30 cm + FYM at 0 t ha^{-1}, T_7 - (D_3F_1) Depth of tillage at 30 cm + FYM at 15 t ha^{-1}, T_8 - (D_3F_2) Depth of tillage at 30 cm + FYM at 30 t ha^{-1}. The observations of crop were taken at 30, 60 and 90 DAS (Days After Sowing). The results obtained after the statistical analysis of the data revealed that the plant growth was significantly influenced by combined application of tillage and FYM at different proportions. The plant height, number of branches & leaves plant^{-1} was found to be significant at 30, 60 and 90 days after sowing in the experiment. The above mentions parameters are in T_8 were found to be significantly greater than the remaining treatments. It is evident from the data on tuber yield, size of tubers, fresh and dry weight of tubers of potato crop was found to be significant at the time of crop harvest in the experiments. The tuber yield, size of tubers, fresh and dry weight of tubers of potato in T_8 treatment tended to be significantly greater than the remaining treatments. The data on percent N, P, K and Zn in tuber of potato crop at 90 DAS and in tuber after harvesting of crop was found to be significant in the experimental year. The percent N, P, K and Zn in tuber of potato crop in T_8 were significantly greater than the remaining treatments.*
Key words: *Tillage practices, FYM, Potato, Soil properties, yield attributes.*

Introduction: The potato is a starchy tuberous crop from the perennial (*Solanum tuberosum* L.) of the Solanaceae family (also known as the nightshades). It is the world's largest food crop, following rice, wheat and maize. During the short winter the crop is grown in plains from October to March, during summer season in Northern Hills (April to September). It is well grown in sunny days at the temperature of 23-30^{0}C at day and 17-23^{0}C at night. High night temperature seems to decrease tuber yield more than high day temperature. Low temperature high light intensity and short day are conductive for early initiation of tuber, generally accelerate the development of potatoes; stem elongation terminate early, tuber initiation starts early and the plant die early. In order of importance for food production among twenty major food crops (on fresh weight basis) potato ranks 6th in the developing countries, 4th in the developed countries, 4th in all world and 3rd in India [1].

Potato consumption has increased in the developing countries and over the last decade, global potato production has increased at an annual average rate of 4.5 percent [2]. Potato (*Solanum tuberosum* L.) is one of most important vegetables in Egypt. It gained a considerable importance as an export crop to European markets and one of the national income resources. One of the most important vegetable crops in Punjab is popular for its high yield, adaptability and ability to produce more food ha^{-1}

than any other crop. Potato, being a heavy surface feeder, needs huge quantity of nutrients for proper growth and development of tubers. Therefore, sole application of inorganic fertilizers not only leads to their imbalanced and inadequate use but also results in poor yield, deterioration of soil fertility and multiple nutrient deficiencies [3]. So, combined application of available organic sources along with inorganic fertilizers assures better nutrients uptake, high crop yield and soil productivity on sustainable basis [4]**.** It may help in improving nutrient uptake and yield in potato crop.

China is now the world's largest potato producing country, and nearly a third of the world's potatoes are harvested in China and India. In India potato is grown in almost all the states. Nearly 80% of the crop is grown in Indo-Genetic plains comprising Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal. Gujarat has the highest productivity in India.

Tillage brings about a suitable tilth which results into desirable physical conditions required for better plant growth. Tillage helps in proper mixing of applied fertilizers, organic manures and residual organic matter in the soil, thus it increases rate of mineralization by promoting decomposition. The increased humus content of the soil, buffers soil reaction through which soil reaction becomes stable and the availability of almost all the plant nutrients remain ideal for better crop production.

It refers to free movement of gases between the soil and atmosphere which is often hindered by excess soil moisture, crusting and poor soil structure. poor Aeration result in an increase in CO_2 content in the soil an excess of CO_2 impedes absorption of K, P, Ca and other mineral elements besides a reduce water uptake by plants due to reduction in rate of root respiration.

Increased gaseous exchange (aeration) in soil mass increases temperature regulation also. Low soil temperature is most critical to seed germination, plant emergence and root growth but tillage helps in regulation of soil temperature.

Surface permeability to rainfall or irrigation is increased by tillage especially when the soil surface is crusty however, this improvement may be temporary. The increase in permeability reduces run off and control erosion. Moreover sub-soil permeability is least affected by tillage [5].

Potato needs nitrogen, phosphorus and potassium in suitable combinations and at optimum labels for obtaining higher yield, variable response to nitrogen, phosphorus and potassium have been reported and the responses were observed to vary with a number of factors like soil, climate and varieties [6]. Application of nitrogen increases tuber number and weight plant^{-1} along with increased nitrate content but decreased vitamin-C content [7].

Farm yard manures (FYM) acts as buffering agent which reduces the toxicity of excessive acid, alkali or salts present in the soil. Being the store house the various nutrients both macro as well as micro, is of vital importance. The soil physico-chemical and biological characteristics are very much benefited by FYM. The average composition of FYM nitrogen 1.13%, phosphorous 1.25%, potassium 1.30%, lime 0.6% ,ash 4.9%, Sulphuric acid 0.13%, magnesium 0.15% (source: Fertility and Nutrient Management). The content of nitrogen phosphorus and potassium in Farm Yard Manure are quite variable because of variation in quality of dung.

The 100 g of raw potato with skin has nutritional value having Energy 321 KJ (77 kcal), carbohydrates 19 g (starch-15 g, dietary fiber 2.2 g), fat 0.1g, protein 2.0g, water 75 g, thiamine (vit.B1) 0.08 mg (6%), riboflavin (vit.B2) 0.03 mg (2%), niacin (vit.B3) 1.1 mg (7%), vitamin- B6 0.25 mg (19%), vitamin- C 20 mg (33%), calcium 12 mg (1%), iron 1.8 mg (14%), magnesium 23 mg (6%), phosphorus 57 mg (8%), potassium 421 mg (9%), sodium 6 mg.

Materials and Methods

The experiment was conducted at Research Farm of Department of Soil Science at Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad, the area is situated on the south of Allahabad on the right side of the river Yamuna on the South of Rewa Road at a distance of about 6 km from Allahabad city. It is situated at 25.57^{0}24'08.71-N latitude, 81^{0}50' 16.95"E longitude and at the altitude of 98 meter above mean sea level.

The area of Allahabad District comes under subtropical and semi arid climate. Due to subtropical climate prevailing in the south east part of U.P with the extremes in temperature dropping to 1-2 ^{0}C in December and January and very hot in summer with temperature ranging between 46-48 ^{0}C in the month of May-June. The average rainfall is around 1013.4 mm with maximum concentration during July to September and occasional frost in winter and hot wind (Loo) in summer. The climatic condition of

the investigation area is most suitable for the cultivation of tuber crops. The soil of experimental area falls in order Inceptisol and the experimental field is alluvial in nature, the experiment were conducted during Rabi season 2011 and 2012 to study the "Response of Tillage Practices and Farm Yard Manure on Soil Health, Growth, Yield and Nutrient uptake by Potato (*Solanum tuberosum* L.) cv.Kufri badshah in Allahabad District (India)".

The treatments were allocated in 3×3 factorial randomized block design with three replications and three levels of tillage and FYM for the crop (T_0 - Depth of tillage at 10 cm + FYM at 0 t ha^{-1}), (T_1 - Depth of tillage at 10 cm + FYM at 15 t ha^{-1}), (T_2 - Depth of tillage at 10 cm + FYM at 30 t ha^{-1}), (T_3 - Depth of tillage at 20 cm + FYM at 0 t ha^{-1}), (T_4 - Depth of tillage at 20 cm + FYM at 15 t ha^{-1}), (T_5 - Depth of tillage at 20 cm + FYM at 30 t ha^{-1}), (T_6 - Depth of tillage at 30 cm + FYM at 0 t ha^{-1}), (T_7 - Depth of tillage at 30 cm + FYM at 15 t ha^{-1}) and (T_8 - Depth of tillage at 30 cm + FYM at 30 t ha^{-1}). Each plot size was of 2m x 1.5m ($3m^2$) and the crop was applied recommended dose of fertilizers i.e. N, P, K & Zn @ 160, 80, 120 & 25 kg ha^{-1}**.** Half entire dose of Nitrogen and total doses of Phosphorus, Potash and Zinc were applied as basal dressing before sowing and mixed in soil with rakes. The rest of the nitrogen was applied as top dressing at 40 DAS. The fertilizers were given in the form of Urea, DAP, Murate of Potash and $ZnSO_4$. The potato was sown at 25 q ha^{-1} and sowing in the November month at the 50 cm x 20 cm row to row and plant to plant distance.

The observations of crop were taken at 30, 60 and 90 DAS (at an interval of 30 days). The height of the three tagged plants was recorded from ground level to the tip of the leaves. The number of branches & leaves of all the three randomly selected plants were counted and averaged $plants^{-1}$ carefully forms the soil in natural condition. The yield of Potato from each plot was recorded and converted into t ha^{-1}.

Soil sample were taken from 0-15 cm and 15-30 cm depth randomly prior to tillage operations, air dried and passed through 2 mm sieve and the size of sample was reduced by couning and quataring. Then the composite soil sample was taken for mechanical and chemical analysis. Bouyoucos–Hydrometer method (1957) was used for the mechanical analysis of soil to determine sand, silt and clay fraction in the sample. The composition of soil sample was found of the Sand 60.80%, Silt 24.10% and Clay 15.10%. Texture was sandy loam according to USDA system.

After crop harvest soil sample were taken to the plough level, i.e. up to 0-15 and 15-30 cm depth each plot for determination of important physical and chemical properties of soil, viz. Soil texture, Particle density, Bulk density, Pore-space. Soil pH, EC, Organic carbon, Available N, P, K and Zn.

Result and Discussion

The plant height, number of branches and number of leaves of potato crop were increased with increasing levels of tillage practices and farm yard manure in potato crop. The treatment combination T_8 - (D_3F_2) Depth of tillage at 30 cm + FYM at 30 t ha^{-1} were found to be the maximum vegetative growth, It may be due to application higher amount FYM and maximum depth of tillage, because FYM contains higher amount of N, P, K and other nutrients. The yield of tubers was increased with increasing levels of tillage practices and farm yard manure in potato crop. The maximum yield of tubers was found in treatment combination T_8 - (D_3F_2) Depth of tillage at 30 cm + FYM at 30 t ha^{-1} were found to be the maximum yield 44.833 t ha^{-1}.

The percent nitrogen, phosphorus and potassium in plants and tuber of potato crop were increased with increasing levels of tillage practices and farm yard manure in crop during the experiment. The maximum percent of nitrogen, phosphorus and potassium were found in treatment combination T_8 - (D_3F_2) Depth of tillage at 30 cm + FYM at 30 t ha^{-1}, because FYM as we know FYM is a rich source of N, P, K, and other nutrients.

The bulk density and particle density of after crop harvest soil of potato grown plot were decreases with increasing levels of tillage practices and farm yard manure and it increases with increasing soil depth. The maximum decrease in bulk density was recorded in T_8 - (D_3F_2) Depth of tillage at 30 cm + FYM at 30 t ha^{-1} treatment combination. The percentage pore space of after crop harvest soil of potato grown plot were increases with increasing levels of tillage practices and farm yard manure and it increases with increasing soil depth. The maximum percentage pore space was observed in T_8 - (D_3F_2) Depth of tillage at 30 cm + FYM at 30 t ha^{-1} treatment combination.

The pH of post harvest soil of potato grown plot were decreased with increasing the

levels of tillage practices and farm yard manure and it also decreases with increasing soil depth, T_8 - (D_3F_2) Depth of tillage at 30 cm + FYM at 30 t ha^{-1} treatment combination were found with lower pH than the remaining treatments. Therefore, it is considered that the reduction in pH values due to the addition of FYM. The electrical conductivity of post harvest soil of potato grown plot were increased with increasing the levels of tillage practices and farm yard manure and it is decreases with decreasing soil depth, T_8 - (D_3F_2) Depth of tillage at 30 cm + FYM at 30 t ha^{-1} treatment combination were found higher EC than the remaining treatments.

The percent organic carbon of post harvest soil of potato grown plot were increased with increasing the levels of tillage practices and farm yard manure and it is decreases with increasing soil depth, T_8 - (D_3F_2) Depth of tillage at 30 cm + FYM at 30 t ha^{-1} treatment combination were found the maximum percentage of organic carbon than the remaining treatments, because in its dilution resulted in an increase in organic matter and the retention of dissolved organic matter leading to change in percentage of organic carbon in soil profiles of post harvest soil of potato grown plot.

The available N, P, K and Zn kg ha^{-1} of post harvest soil of potato grown plot were increased with increasing the levels of tillage practices and farm yard manure and it is decreases with decreasing soil depth, T_8 - (D_3F_2) Depth of tillage at 30 cm + FYM at 30 t ha^{-1} treatment combination were found maximum available N, P, K and Zn (kg ha^{-1}) than the remaining treatments, because FYM contains appreciable amount N, P, K and Zn therefore, it brings significant increase in available nitrogen, phosphorus and potassium of post harvest soil of potato grown plot.

Table 1. Response of tillage practices and farm yard manure on plant height (cm), number of branches & leaves plant^{-1} at 30, 60 and 90 DAS and yield (t ha^{-1}).

Treatment Combination	Plant height plant^{-1} (cm)			Number of Branches plant^{-1}			Number of leaves plant^{-1}			Yield (t ha^{-1})
	30 (DAS)	60 (DAS)	90 (DAS)	30 (DAS)	60 (DAS)	90 (DAS)	30 (DAS)	60 (DAS)	90 (DAS)	
T_0	11.866	25.200	39.066	2.866	6.200	9.300	11.966	44.633	66.400	20.000
T_1	16.633	32.433	49.433	4.100	7.766	11.966	15.966	53.766	81.533	35.333
T_2	19.866	38.200	56.633	4.866	8.666	13.300	16.200	60.633	88.433	39.666
T_3	12.066	27.733	40.966	2.966	5.500	9.533	12.400	40.833	65.633	20.833
T_4	16.533	32.766	52.066	3.300	7.500	11.500	14.533	52.600	82.833	40.333
T_5	18.100	38.633	56.866	4.633	9.433	13.333	18.866	64.166	89.966	39.333
T_6	11.300	25.533	39.766	3.166	6.533	8.633	12.533	44.400	68.166	19.833
T_7	15.733	32.833	50.400	3.966	8.966	12.500	15.966	59.533	81.500	43.666
T_8	18.400	38.033	52.833	5.166	11.300	13.866	21.300	68.633	91.766	44.833
F- test	S	S	S	S	S	S	S	S	S	S
S. Em (±)	0.896	1.521	1.211	0.332	0.659	0.554	1.110	2.965	2.321	2.121
C.D. at 5%	2.028	3.549	3.136	0.751	1.512	1.300	2.472	7.641	6.341	4.239

Table 2. Before sowing & after crop harvest soil properties of the experimental field at 0-15 & 15-30 cm depth of soil.

Soil properties	Before sowing		After crop harvest		Method (Year)
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	
	Sandy loamy		Sandy loamy		Bouyoucos Hydrometer method [8]
Bulk density (g cm^{-3})	1.238	1.241	1.351	1.337	Core method [9]
Particle density (g cm^{-3})	2.529	2.511	2.497	2.503	Relative density bottle method [9]
Pore space (%)	54.174	53.187	53.888	53.555	Use of 100 ml Graduated Cylinder [9]
pH	7.137	7.256	7.339	7.424	Digital Electric pH meter [10]
EC (dS m^{-1})	0.17	0.22	0.181	0.220	Digital Conductivity meter [11]
Organic carbon (kg kg^{-1})	0.438	0.386	0.498	0.401	Walkley method [12]
Nitrogen (kg ha^{-1})	227.462	210.436	225.555	212.110	Alkaline permanganate method [13]
Phosphorous (kg ha^{-1})	166.629	154.480	20.351	17.862	Colorimetric method [14]
Potassium (kg ha^{-1})	20.807	19.310	160.888	152.221	Flame Photometric method [15]
Zinc (kg ha^{-1})	0.446	0.419	0.460	0.421	Atomic Absorption Spectrophotometer [16]

Conclusion: In view of the experiment investigation it is concluded that tillage practices and farm yard manure is an important source of plant nutrients. The physical properties of soil were not altered by tillage practices and farm yard manure. However, there was an increased in soil fertility parameters and continuous tillage practices and farm yard manure had adverse effect on some soil properties like pH, EC and plant nutrients contents, therefore, the long term and indiscriminate application of tillage practices and farm yard manure which contains plant nutrients in association with solid particles may cause accumulation of plant nutrients in surface and sub- surface soils and the build-up of plant nutrients on soil profile may prove harmful not only to plants, but also to consumers of the harvested crops. Under tropical agricultural practices in future.

The maximum tuber yield of potato crop 44.833 t ha^{-1} was found in treatment combination T_8 - (Depth of tillage at 30 cm + FYM at 30 t ha^{-}

^{1}) and the minimum tuber yield of potato crop 19.833 t ha^{-1} was recorded in the treatment T_6 – (Depth of tillage at 30 cm + FYM at 0 t ha^{-1}) respectively.

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