Effect of organic, inorganic and biofertilizers on soil characteristics and potato tuber yield (*Solanum tuberosum* L.)

Comment [A1]: Response of soil properties and yield of potato (Solanum tuberosum L.) tubers to organic, inorganic and biofertilizers

ABSTRACT

An experiment was conducted during winter (*rabi*) seasons of 2022–23 at VegetableResearchFarm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya,(UP),India.Toassesstheeffectofvariousorganic,inorganicandbiofertilizertuberyieldofpotato(*Solanum tuberosum* L.). The experiment consisted of 6 treatments combination oforganic andinorganic applications in a randomized block design with 4 replications. The results revealed thatthe application of recommended dose of NPK (150:100:120 kgha^{-1}) T_2 recorded highest tuber yield,plant height, emergence percentage and number of leaves, followed by treatment T_4 (Compost (likeNADEPmethod)+Cropresidueincorporation+Biofertilizer(AzotobacterandPhosphobacteria)+ Microbial culture to decompose crop Residue + FYM @ 25 t ha^{-1}).The experiment highlightstheimportanceoforganicfertilizer improvesthe soil physicalpropertiesand soilhealth.

Comment [A2]: It is necessary to expand the abstract to reach 140 words.

Key words:FYM,Vermicompost,Azotobacter,Phosphobacteria and Yield.

INTRODUCTION

Potato(*Solanumtuberosum*L.)isoneofmajorcropscontributingtotheworld'sfoodsecurity.**(Karam *et al*., 2009)**. It is the most popular tuber crops in the world. Potato is one of the mostimportantfieldcorpsnotonlytoitslocalconsumptionbutalsotoincreasemeetingincomethroughitsexportation among different countries in the world **(Kandil *et al.*, 2011).**It is a highlyinputintensivecrop,fertilizationwithinorganicsourcesofnutrientsplaysanimportantroleforitshigher production,but due to increased cost and detrimental effects on soil fertility and humanhealth,supplementingthenutrientsthroughorganicsourceslikefarmyardmanure(FYM),vermicompost,mustardcake,neemcake,etc.andbiofertilizerslikeAzotobacterandPhosphobacteria has become necessary to sustain production, improved food quality and tomaintainsoil health **(Patel *et al*., 2002).**

ThemajorpotatoproducingstatesareUttarPradesh,WestBengal,MadhyaPradesh,Bihar,Gujarat,Punjab,Haryana,Assam,JharkhandandChhattisgarh.Potatoesareavaluablecommodity that can be processed and exported. Potatoes offer a low-cost energy source in thehuman dietandarerichinstarch,aswellasvitaminsCandB,alongwithvariousminerals.**(Raj*et al.*, 2020)**.Potatoes are a vital component of the world's food supply, providing essentialnutrients and calories to millions of people **(Beals *et al.*, 2019).** Developing nations in Asiacurrently account for over 46% of the world's total potato production. Ranked fourth among theworld's most significant food crops, after rice, wheat, and maize, potatoes serve an essentialfunction in global food security. India stands as the second-largest potato producer worldwide,following China. China and India emerged as the leading producers, collectively contributingapproximately one-third of the global production. In India, the potato occupies a prominentpositionintheagriculturalsector.TheMinistryofAgriculture,GovernmentofIndia,reported thatin2023, thecountryproduced around59.74 million metric tons of potatoes.

Organic material is used to prevent or improve the negative stresses effects in plants andyield decreasing. It is material to decrease soil salinity. Increase the organic matter, improve thesoil structure and increase water and air permeability by root developing in soil. It is one the bestusedfertilizers **(Kumari *et al.*, 2024; Shukla*et al.*, 2024))**.

Continuous Use of chemical fertilizers had increased the crop yield, but caused manyenvironmental problem including soil, air and water pollution and finally human health hazardsand making the crop productivity unsustainable **(Eid *et al*., 2006).** The amount of organic matterin the soil influences the accessibility of micronutrients. Because they are cost-effective andenvironmentallyfriendly,employingorganicmatterandmicronutrientsofferssignificantbenefits.It promotes long-term ecological sustainability and soil fertility, essential for successful cropcultivation. Bio-fertilizer, an organic product containing specific microorganisms, plays a crucialrole in enhancing nutrient availability for crops. These microorganisms biologically transforminaccessible nutrients into formats readily accessible for plant uptake. The continuous applicationofheavydosesofchemicalfertilizerswithoutincorporatingorganicmanuresorbio-fertilizershasledtosoilhealthdeterioration.Thisincludesphysicalandchemicaldegradation,reducedmicrobialactivity,decliningsoil humus, andincreased soil, water, andair pollution.

MARERIALSANDMETHODS

SiteDescription:

The experiment was conducted at Vegetable Research Farm of Acharya Narendra DevaUniversityofAgricultureandTechnology,NarendraNagar,Kumarganj,Ayodhya(UP).TheVegetable Research Farm lies on Ayodhya-Raebareli Road, about 43 km from Ayodhya districtheadquarter.Geographically,thisregionfallsundersub-tropicalclimateanditissituatedat26^{0}47'N latitude, 82^{0}12' E longitude and at an Indo-Gangetic alluvial of eastern Uttar Pradesh in India.Thisregionexperiencesanannualrainfallofapproximately110cm,with85percentofitoccurringduringthemonsoonseason,whichlastsfrommid-JunetotheendofSeptember.Theexperimentalsoil was silty loam in texture having the pH (8.10), EC (0.24 dSm^{-1}) and organic carbon (3.10 gkg^{-1}).

VarietyDescription:

Kufri Ashoka variety was taken for experiment. Variety was developed through clonalselection from a segregating population derived from the hybrid EM/C-1021 x CP-1468. CentralPotato Research Institute, Shimla, released this variety in 1996. Kufri Ashoka an early-maturingvariety (70-80 days), suited for cultivation in Bihar, Haryana, Punjab, Uttar Pradesh and WestBengalthetubersofKufriAshokaaremediumtolargeinsize,white,oval-shaped,withmoderatelyshalloweyesandwhiteflesh.Theplantsaremedium-tall,upright,moderatelycompact, and vigorous the stems are limited in number, medium-thick, lightly pigmented at thebase,andcharacterizedbypoorlydevelopedstraightwings.Foliageisgreen.Leavesareintermediate having green rachis. Leaflets are ovate lanceolate, smooth glassy surface with entiremargin, Flowers are light red purple. This variety has profuse flowering. The anthers are orange-yellow,well-developed,andexhibitmediumpollenstainability.Althoughthevarietyissusceptibleto lateblight,itmanages to evadeits impact due toits earlymaturity.

SoilSamplingandAnalysis:

Soil sampling done by Auger randomly from each replicated plot after, harvesting of ricecrop and collect the sample in polythene bag plot wise. Samples are brought to Soil Science LabANDUAT Kumarganj Ayodhya for analysis. Soil texture, Bulk density, Soil pH, Electricalconductivity,Organic carbon.

RESULTSANDDISCUSSION

Physico-chemical Properties ofsoil-

Soil pH: The effect of various treatment combinations on soil pH is presented in Table 1.Therewerenon-significantlyaffectedbyvarioustreatmentcombinations.ThehighestvalueofpH(8.18) was recorded with T_1 control and lowest value (7.92) was recorded with T_4 (Compost (likeNADEPmethod)+Cropresidueincorporation+Biofertilizer(AzotobacterandPhosphobacteria) +Microbial cultureto decomposecropResidue+FYM@ 25 tha^{-1}However soil pH maintained or slight decreased to the initial value might be due to theformationoforganicacidsduringthedecompositionoforganicmanureandcropresidues.Similarresulthas beenreportedby**(Tiwari *et al.*, 2021).**

ElectricalConductivity(dSm^{-1}): Thedataregardingeffectofvarioustreatmentcombinations on electrical conductivity remained non-significant in between the treatments butthere is slightly decrease from initial (0.31 dSm^{-1}) to harvest (0.25 dSm^{-1}). However, the lowestEC (0.22 dSm^{-1}) at harvest recorded with T_4(Compost (like NADEP method) + Crop residueincorporation+Biofertilizer(AzotobacterandPhosphobacteria)+Microbialculturetodecompose crop Residue + FYM @ 25 t ha^{-1} and highest EC (0.25 dSm^{-1}) was recorded at harvest with T_2(RDF150:100:120 N: P_2O_5: K_2O). in potato havebeen presented in Table1.The abrupt drop in electrical conductivity in treatments involving organic materials mightbe caused by the buffering effect of the organic matter, which reduces the concentration of ionicspecies in the solution, thereby lowering the EC.In FYM, the significant increase in microbialactivity leads to the uptake of soluble salts by microorganisms for the growth of microbial cellmassleadstolessECwhencomparedtovermicompostSimilarresulthasbeenreportedby**(Tiwari*et al.*,2021).**

Organiccarbon(gkg^{-1}): ThemaximumorganiccarboncontentwasrecordedwithT$_4$(T_3+FYM@25t/ha)at3.6gkg^{-1},followedbyT_5(T_3+vermicompost@7.5tha^{-1})at3.4gkg^{-1}.Thelowestorganiccarboncontent was observed under theT_1control (3.0gkg^{-1}).The increased organic carbon content due to use of enriched FYM can be attributed tohigher contribution of biomass to the soil in the form of root, crop stubbles and residues but alsotobetterrootgrowthandplantresidueadditionbythegrowingcropatharvesting.Itisanimportantsource of soil organic matter and nutrients which after decomposition by the microorganismsbecomesavailable to the plants. Theseresultsarein linewith findings of**(Tiwari *et al*., 2021; Verma *et al.,* 2024).**

Growth andDevelopmentstudies-

Emergence percentage:

The plant emergence percentage was significantly affected by theapplication of various organic and inorganic treatments. The plant emergence percentage higherinthetreatment T_2(97.97 %) that wasfollowed byT_4significantlysuperiortocontrol (94.69 %).Organic and inorganic fertilizers are applied, then inorganic fertilizers have a quick effectontheplant,butwhengerminationtakesplacethenthereisnotmuchdifferenceintheemergenceoftheplant the similarresult is reported by**Nagar*et al*., (*2019*).**

Plant height:

The plant height was found also affected by the application of inorganic fertilizerto the crop. Thehighest plant height was recorded with the treatment T_2at 30 and 60 DAP(19.40cm) and (48.50cm) respectively, that was at par with the treatment T_4at 30 and 60 DAP(18.30cm)and(47.10cm)respectively.Biofertilizersincreasedtheefficiencyofnutrientsinthesoil andincreasedtheplantheightwhenapplied incombination withfertilizerssimilar resultreported by**Ram*etal*., (2017).**

Numbers of leaves:

The number of leaves per hill were also significantly influenced by theapplication of organic, inorganic and biofertilizer. The maximum number of leaves at 30 DAP(16.90)and60DAP(53.65)wererecordedinthetreatmentT_2(wheretherecommendeddoseofN150 : P_2O_5 100: K_2O 120 is applied),statistically at par with T_4 (16.20)at 30 DAP and T_4 and T_5(52.90) (52.30) at 60 DAP respectively, significantly higher than the control treatment. Similarresulthas beenreportedby**Sayed*et al*., (2014), Barman*et al*., (2018).**

Yieldattributesandtuberyield-

Tuberyield:

Thepotatotubersyieldwasfoundtobesignificantlyaffectedbythevariousorganicandinorganictr eatments. RDF(N:P:K=150:100:120 kg ha^{-1})recordedthehighesttuberyield,whichwassignificantly superior to all other nutrient treatments. This was followed by the treatment T_4(Compost (like NADEP method) + Crop residue incorporation +Biofertilizer (Azotobacter andPhosphobacteria) + Microbial culture to decompose crop Residue + FYM @ 25 t/ha). comparedtocontrol. Thetuberyield under$T_2$was 5.10% higher than T_4(Table 2).The increased tuberyields due to integrated nutrient management of the above saidfertilizerlevelshaveresultedinmorevegetativegrowthandaccumulationofmorephotosynthates.Thus, there may be more translocation of photosynthates to sink. Hence, they have resulted inmoretuberyield.Highernumberoftubersperhillalsocontributedtosignificantlyhighertotaltuberyield. The favourable effect of integrated nutrient management through both inorganic fertilizersand organic manures on increasing the tuber yield. Production was also noticed by **Kumar *et al*.(2011);Sarkar*et al*., (2017);(Sati *et al*., 2017);(Kromann *et al*., 2017).**

Gradewisetuberyield:

Theweightoftubers(qha^{-1})indifferentsizecategories(0-25g,25-50g,50-75g, and >75g) was significantly influenced by the various treatments. It was observed thatunder treatment T_2, which involved the recommended dose of fertilizers (N 150: P_2O_5 100: K_2O120 kg ha^{-1}), significantly higher weights of tuber yield (14.10, 64.70, 76.50, and 102.90 (q ha^{-1})were recorded at par T_4= T_3+ FYM @ 25 t ha^{-1} with yields of 12.90, 62.20, 66.70, and 95.30quintals per hectare. The control treatment, T_1, produced the statistically lowest yield per hectare(9.50,51.70, 58.20, and65.10 q)acrossall sizecategories.Thefavourableeffectofintegratednutrientmanagementthroughbothinorganicfertilizersand organic manures on increasing the different grades tuber production was also reported by**Das*et al*., (2009); Kumar*et al*., (2017);Tiwari et al., (2022); Chandra *et al*.,(2023).**

Table1.Effectofvariousorganic,inorganicandbiofertilizeronthesoilproperties.

Treatments	pH(1:2.5)	EC(dSm^{-1})	OC(g kg^{-1})
T_1	8.18	0.24	3.0
T_2	8.03	0.25	3.1
T_3	7.98	0.23	3.3
T_4	7.92	0.22	3.6

T_5	7.94	0.23	3.4
T_6	7.96	0.23	3.2
SEm±	0.03	0.02	0.22
C.Dat 5%	0.09	N/A	N/A

Table2:Effectofvariousorganic,inorganicandbiofertilizerontheplantemergence(%), numberof leaveshill^{-1} and plantheight(cm) .

Treatments	Emergence(%)	Numberof leaveshill^{-1}		PlantHeight(cm)	
	30 DAP	30 DAP	60 DAP	30 DAP	60 DAP
T_1	94.69	14.10	42.00	16.00	30.50
T_2	97.97	16.90	53.65	19.40	48.50
T_3	95.31	14.50	45.70	16.15	40.20
T_4	97.03	16.20	52.90	18.30	47.10
T_5	96.09	15.60	52.30	17.20	46.20
T_6	95.31	14.75	47.00	16.40	44.00
SEm±	1.05	0.36	1.39	0.14	1.53
C.Dat 5%	NS	1.12	4.24	0.43	4.66

Table 3: Effect of various organic, inorganic and biofertilizer on the tuber yield (q ha^{-1}) andgradewise tuberyield.

Treatments	Tuberyield (q ha^{-1})	Weight of tuber(q ha^{-1})			
		(0-25g)	(25-50g)	(50-75g)	(>75g)
T_1	184.50	09.50	51.70	58.20	65.10
T_2	249.20	14.10	64.70	68.50	101.90
T_3	194.40	10.30	53.60	60.40	70.10
T_4	237.10	12.90	62.20	66.70	95.30
T_5	229.50	11.50	61.80	65.00	91.20

T_6	206.80	11.20	54.30	64.80	76.50
SEm±	2.75	0.61	1.24	1.26	2.17
C.Dat 5%	8.38	1.87	3.78	3.85	6.62

CONCLUSION:

On the basis of experimental results, it may be conducted that the application of various treatmentthemaximumyieldandyieldattributes,wasfoundintreatment (T$_2$) RDF (N:P: K=150:100:120 kg ha^{-1}). Although the organic manure treatments resulted inloweryields,buttheyimprovedthetubersqualityandalsoimprovesthesoilhealthparameters.

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