__Original Research Article__

Effectoflevelsofnitrogenandphosphorusongrowth,yieldandeconomics oflentil(*Lensculinaris*L.).

ABSTRACT

The present investigation was carried out in *Rabi* (winter) season 2022-23 at AgronomyResearchFarmofChandraBhanuGuptaKrishiSnatakottarMahavidyalaya,BakshikaTalab,Lucknow(U.P).The16 treatments comprised of four nitrogen levels viz., 0, 15, 30 and 45 kg N ha^{-1} with four phosphoruslevels viz., 0, 20, 40 and 60 kg P_2O_5 were tried in Factorial Randomized Block Design (FRBD). Thesoilwassilty-loamtexturewithslightlyalkalinepH8.1,organiccarbon0.70%,availablenitrogen 270.00 kg ha^{-1}, available phosphorus 27.0 kg ha^{-1}, and available potash 262.0 kg ha^{-1} during 2022-2023. The rainfall received during the crop period was 0.00 and 0.02 mm, respectively. The relativehumiditywasrecordedmaximumduringmonthofDecemberstudywhile,thesunshinerangedfrom 2.3to 9.1 duringcrop period. Increasing levels of nitrogen and phosphorus significantly increased most of the growth andyield attributing characters viz., plant height, number of branches, dry matter accumulation and yieldattributes viz., number of pods $plant^{-1}$, number of grains pod^{-1}, grain weight and test weight weresignificantly higher with 45 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1} and superior to other doses of nitrogen andphosphorus. Yield studies viz., Grain yield, straw yield, biological yield and harvest index weresignificantly higher with 45 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1} and superior to other doses of nitrogen andphosphorus.TheN,P,andproteincontent(%)anduptakeofnutrientincreasedwithincreasinglevelsof nitrogen and phosphorus. The highest nutrient content and uptake were recorded with 45 kg N ha^{-1}with60kg$P_2O_5ha^{-1}$.Economicsanalysisviz.,grossreturn,netreturnandbenefitcostratiowasrecordedhighest with 45 kg N ha^{-1} + 60 kg P_2O_5 while lowest with control. Thus for obtaining better yield andprofitapply 45kg Nha^{-1}in combination with 60 kg $P_2O_5ha^{-1}$forlentil.

KEYWORDS: Nitrogen,phosphorus,Growth,Yield,Economicslentil.

INTRODUCTION

Lentil *(Lens culinaris*L.*)* is a herbaceasous annual plant which originated from MiddleEast and a rich source of protein. The genus *Lens* is part of the subfamily Faboideaewhich iscontained in the flowering plant familyFabaceae or commonly known as legume or beanfamily,of theorderFabalesin thekingdom Plantae.As food crop, the majority of world production comes from Canada and India, producing 58%together. India ranked first in area and second in the production with 39.79% and 22.79% of worldareaandproductionrespectively.Canadarankfirstinproduction(41.16%)duetoveryhighlevelofproductivity (1633 kg ha^{-1}) as compared to India (611 kg/ha). (FAO state, 2014). The major lentilproducingstatesareUttarPradesh,MadhyaPradesh andBihar.UttarPradeshaloneoccupies0.58mhaarea with0.44million tonsproduction and productivity of 701kg ha^{-1}.Nitrogen is critical element for increasing the quality of food crops. Nitrogen deficiencyoccurred frequently in every where, therefore, these elements should be comprised as a fertilizer.Application of optimum amount of nitrogen in legumes increased pod number, seed number andseed weight. Verma and Kalra *et al*. (1983) reported that lentil have good response to nitrogenfertilizerapplication.Studieshaveshownthatnitrogenfertilizerapplicationrateof20to25 kilograms of fertilizer per hectare as a starter is necessary to achieve maximum plant growth. Theabundant N supply through N_2 fixation is thought to exacerbate the indeterminate growth habit oflentil.Inaddition,whenalegumecroplikelentilhasaccesstoNfertilizer,thecropfavoursfertilizerN uptake instead of nitrogen fixation, due to nitrate or ammonium uptake being a less energyconsuming process for the plant. Inhibiting effects of nitrate on legume N_2 fixation have also beendescribed in the literature (Bremer *et al.,* 1989). Therefore, the N supply to lentil particularly due to N_2 fixation couldplay a role in delayed maturity. (Togay*et al.,*2005), (Deol, 2007).

Phosphorus is an important macro element for growth of legumes. It has important role informationof root nodulesand thisopinion hasan important role innitrogen fixation.Phosphorus(P)isanon-renewableandsecondmostimportantmacronutrientwhichisrequiredfor young tissues and performs several functions related to growth, development, and metabolismof the plant and also regulates many metabolic activities of the plant life. Application of 20-80 kgP/ha in combination with 40 kg N ha^{-1} increased the number of filled pod lentil (Sharma *et al.,* 2004). Determining the appropriate amount and mix of fertilizer nitrogen and phosphorus is importantbecause that have a large role in increasing the performance of crops. Other studies showed thatpercentageof lentil seedprotein wasincreasedbyapplying 40-60 kg P ha^{-1}.

METHODSANDMATERIALS

AfieldexperimentwasconductatShradhayBhagwatiSinghAgricultureResearchFarm(Hajipur),Chandra Bhanu Gupta Krishi Snatkottar Mahavidyalaya, Bakshi-Ka-Talab, Lucknow University,Lucknow (U.P.) during Rabi season 2022-2023. The experimental site is situated at 26.50º Northlatitudeand80.50ºEastlongitudewithanaltitudeof123metersabovemeansealevel.Thesoilofexperimentalfieldwassilty-loamtexture,slightlyalkalineinreaction(8.0 p^H),mediuminorganiccarbon (0.70%) and available nitrogen (270 kg ha^{-1}) phosphorus (27 kg ha^{-1}) and potassium (262kg ha^{-1}). Sixteen treatments comprised of four levels of Nitrogen (0, 15, 30 and 45 N/ha) and fourlevelsofphosphorrus(0,20,40and60$P_2O_5$$ha^{-1}$)weretestedinFactorialRandomizedBlockDesignwiththreereplications.NitrogenandphosphorusweresappliedthroughureaandSSP,respectively.A full dose of Nitrogen and Phosphorus as per treatment was applied at the time of sowing. Acommon dose of potassium (20 kg K_2O ha^{-1}) was applied at sowing time to all plots through Singlesuper phosphate and muriate of potash, respectively. The Lentil variety (DPL-62) was sown thirdweek of November 2022, using 45 kg ha^{-1} seed at 25 cm apart rows and harvested in second weekof march 2023. All improved packages of practices were followed to raise the crop. The data onplant height and branches were recorded from the area already marked by tagged. Sample for drymatter accumulation was recorded by cutting of plants from ground level. The fresh samples werefirst sun dried and then kept in electric oven at 65-70ºC till the constant dry weight attained. Yieldattributes were recorded from 10 pod selected randomly from each plot. Grain and straw yields oflentil were recorded at harvest the harvest index was calculated as grain yield divided by totalbiological yield and multiplied by hundred. The uptake of nutrients was calculated as nutrientcontent in grain and straw multiplied by respective yield. Economics of different treatments wasworked out on the basis of prevailing market prices. The data so obtained on various parameterswereanalysedasperstandardstatisticalprocedures.Thecontent ofN,P,andKingrainandstrawwasdetermined using standard laboratory procedures.

RESULTSANDDISCUSSION

Growthattributes

Plantheight,numberofbranches,anddrymatteraccumulationoflentilwereaffectedsignificantlydue to application of different levels of Nitrogen and phosphorus (Table1). Increasing levels ofNitrogen up to 45 kg N/ha increased the plant height, number of branches, and dry matteraccumulationsignificantlyoverrestoftheNitrogenlevels.Themaximumplantheight(34.47cm),numberofbranches(12.20$plant^{-1}$)anddrymatteraccumulation(13.16q ha^{-1})wasrecordedsignificantly with 45 kg N ha^{-1} over rest of nitrogen levels but being at par with 30 kg N ha^{-1}.Significantimprovementingrowthparameterswithincreasingthelevelsofnitrogenmightbedueto increased availability of nitrogen and its uptake by plant increased the metabolic activity andformation of meristematic tissues which improved the cell elongation and cell division which isturn improved the plant height, number of branches, and dry matter accumulation of crop. Theseresults are supported by the findings of **(**Khare *et al.,* 2017)**, (**Methhew*et al.,* 2002). Plant height increased significantly with increasein phosphorus dose up to 40 kgP_2O_5 ha^{-1}. This may be because of the fact that phosphorusencourages the cell division and root development thereby resulting in improved growth anddevelopmentoftheplant.Theresultsareinclose conformitywith thefindingsof(Niri*et al.,* 2010), (Rabbi *et al.,* 2011), (Verma *et al.,* 1983)

Application of phosphorus @ 40 kg P_2O_5 ha^{-1} being at par with 60 kg P_2O_5ha^{-1} but recordedsignificantlytallerplant,highernumberofbranches,anddrymatteraccumulationascomparedtowithoutphosphorustreatment.Thehighestplantheight(33.37cm),numberofbranches(10.68 plant^{-1})anddrymatter accumulation (9.76 q/ha) was recorded with the application of 60 kg P_2O_5ha^{-1}. The favourableinfluence of phosphorus application on growth may be due to its role in various enzymatic reactions,growthprocesses,hormoneproductionandproteinsynthesisandalsotranslocationofphotosynthatesinvariousplantpartsleading tohighergrowthof crop. Similarresultswereobtained by**(**Gan*et al*., 2005)**,(**Joudi *et al*., 2008)**.**

Yieldattributes

Yield attributing characters like No. of pod plant^{-1}, number of grains pod^{-1}, grain weight (g) andtest weight (g) were affected significantly due to application of Nitrogen and phosphorus (Table2). Crop fertilized with 45 kg N/ha produced significantly the highest number of pod plant^{-1}(57.13),number of grains pod^{-1} (2.80), grain weight (4.74 g) and test weight (21.80 g) over rest of thenitrogen levels, however the difference between 60 kg N ha^{-1} and 40 kg N ha^{-1} was recorded non-significant.Drymatteraccumulationshowedsignificantandconsistentimprovementwithnitrogenapplication up to 45 kg N ha^{-1} at all stages of crop growth. Similar findings were reported by(Hoque *et al.,* 1994), (Kumar *et al.,* 1993). Increase in number of pod plant^{-1} with increasing level of nitrogen might be due to increasedavailability of nitrogen which enhanced the cell division. The higher availability of nitrogen withsupply of N-levels enhance the meristematic tissue activity located at initiation of branching pointwhich improved with supply of nitrogen and recorded higher no. of pod plant^{1} with increasinglevels of nitrogen resulted more branches with increasing levels of N. Similar results were alsoreportedby **(**Verma *et al.,* 1983)

The increase supply of nitrogen leads to improve pod. The higher values of yield attributes withapplication of N was mainly due to increase availability of nitrogen to plant which enhanced thephotosynthetic activity and its translocation to since resulted in improved yield attributes. Theseresultsarein agreement with the findingsof(Kumar *et al.,* 1993), (Methhew*et al.,* 2002) However, (Joudi *et al.,* 2008)reportednon-significanteffectofNfertilizersongrainnumber plant^{-1},grainnumber/podand filled pod number.

Application of phosphorus had remarkable effects on yield attributes of lentil (Table 2). Themaximumvaluesofyieldattributeslikeno.ofpodplant^{-1}(58.10),numberofgrains/pod(2.65),grainweight/pod (4.11 g) and test weight (21.83g) was obtained with application of phosphorus @ 60 kgP_2O_5/ha, however being on par with 40 kg ha^{-1} phosphorus. Significant response of phosphorusapplication on yield attributes of lentil was due to its favourable influence on various enzymaticreactions, growth processes, hormone production, protein synthesis and also the translocation ofphotosynthatesto reproductiveparts thereby leading to highergrowth andyield attributes.

ApplicationofNitrogenupto45kgN ha^{-1}improvedsignificantlythegrainandstrawyieldrestlevels of nitrogen (Table 2) However, the difference between 45 kg ha^{-1} and 30 kg/ha was recordedsignificant.Cropfertilizedwith45kgN ha^{-1}producedsignificantlyhighestgrainyield(8.74q ha^{-1})andstraw yield (12.37 q ha^{-1}) over rest of the Nitrogen levels except 30 kg N ha^{-1}. Application of Nitrogentocrop enhancedthe growthandyield attributesofwheat thus resultedhigheryield.

Application of phosphorus from 0 to 60 kg P_2O_5 ha^{-1} increased significantly the grain yieldand straw yield. The highest grain yield (8.74 q ha^{-1}) and straw yield (11.60 q ha^{-1}) was recorded withapplication of 60 kg P_2O_5 ha^{-1}, however the difference between 60 kg P_2O_5 ha^{-1} and 40 kg P_2O_5 ha^{-1}was found significant regrading to grain yield and straw yield. The seed yield was also increasedsignificantly up to 40 kg P_2O_5 ha^{-1} as the seed yield is directly dependent on the yield attributingcharacters. The straw yield also showed the same trend like the seed yield. These results are inconformitywith the findings of (Sharma *et al.*, 2004), (Mandal *et al.,* 2001),[Gan *et al.,* 2005], (Sharma *et al.,* 1999), (Rabbi *et al.*, 2011).

Table1.Growthattributesoflentilasaffectedbylevelsofnitrogenandphosphorus

Treatments	Plantheight(cm)	Number ofBranches plant^{-1}	Drymatter accumulation(q ha^{-1})
LevelsofNitrogen (Kg ha^{-1})			
N_0-0	28.98	8.34	10.39
N_1-15	30.29	9.10	12.05
N_2-30	33.54	10.84	12.87
N_3-45	34.47	12.20	13.16
SEm±	1.20	0.48	0.10
CDat5%	NS	1.34	0.30
Levelsofphosphorus (Kg ha^{-1})			
P_0-0	30.34	8.10	9.22
P_1-20	32.99	9.30	9.32
P_2-40	33.02	1.51	9.60
P_3-60	33.37	10.68	9.76
SEm±	0.94	0.48	0.10
CDat5%	2.83	1.34	0.30

Table2.Yieldattributescharactersandyieldoflentilasaffectedbylevelsofnitrogenand Phosphorus

Treatments	No. ofpod/plant(g/m)	No. ofgrain/pod	Grainweight/ plant(g)	Testweight(g)	Grainyield(q/ha)	Strawyield(q/ha)
LevelsofNitrogen (Kg ha^{-1})						
N_0-0	30.90	1.61	2.50	16.76	5.30	7.55
N_1-15	53.71	2.04	3.11	18.79	7.42	10.21
N_2-30	56.87	2.76	4.31	21.71	9.28	11.35
N_3-45	57.13	2.80	4.74	21.80	9.30	12.37
SEm±	0.08	0.018	0.16	0.037	0.86	1.14
CDat5%	0.25	0.053	0.48	0.107	2.52	3.31
Levelsofphosphorus (Kg ha^{-1})						
P_0-0	34.95	1.41	2.57	16.90	5.70	7.36
P_1-20	26.03	2.34	3.56	18.16	7.04	9.03
P_2-40	57.93	2.51	3.85	21.79	8.72	11.58
P_3-60	58.10	2.65	4.11	21.83	8.74	11.60
SEm±	0.089	0.01	0.09	0.037	0.86	1.14
CDat5%	0.30	0.30	0.27	0.107	2.52	5.31

NutrientContentanduptake-

Datarevealedthat crop fertilized with 45 kg N ha^{-1} being at par with 30 kg N ha^{-1} but recorded significantlythemaximum uptake (kg ha^{-1}) of N, P, in grain (19.62 kg ha^{-1}, 4.60 kg ha^{-1},) and in straw (21.23 kg ha^{-1},5.65 kg ha^{-1}), respectively over rest of phosphorus levels (Table 3) The uptake of nitrogen andphosphorus by seed and straw increased significantly at higher levels of nitrogen. This could beattributedtobetterfixationofnitrogenbytherhizobiumathighernitrogenlevels.Earlier(Singh *et al.,* 2005),alsoreported similar findings. They further reported that there was an increase in root growth anddevelopment distributed widely up to different depths and thus creating a proper gradient for Nabsorptionat the root soil interface.

Economics

The economics of different treatment combinations was worked out on the basis of input-output analysis. The data pertaining to economics have been presented in Table 4 variouscomponentsof economicsarebeing described hereasunder.

The data presented in table 4 regarding the cost of cultivation make it clear that thehighestcostofcultivation(Rs.20254.58),Grossreturn(Rs. 56256),Netreturn(Rs. 36001.42)andBenefitcostratio(1.77)wasrecordedintreatmentcombinationwhere45kgNha^{-1}wasappliedwith60kg$P_2O_5ha^{-1}$.

The lowest cost of cultivation (Rs. 19435.58), Gross return (26422), Net return (6986.42) andBenefitcostratio(0.35)wasrecordedintreatmentcombinationwhere0kgNha^{-1}wasappliedwith0kg $P_2O_5ha^{-1}$.

Table3N and Puptakebylentilcropwasaffectedbydifferentlevels of nitrogenandphosphorus

Treatment	NUptake(kg ha^{-1}) by grain	NUptake(kg ha^{-1}) by straw	PUptake(kg ha^{-1}) by grain	PUptake(kg ha^{-1}) by Straw
LevelsofNitrogen (Kg ha^{-1})				
N_0	18.03	16.42	2.48	4.34
N_{15}	18.29	19.03	3.91	4.03
N_{30}	18.56	20.20	4.29	4.25
N_{45}	19.62	21.23	4.60	5.65
Sem±	0.53	0.51	0.17	0.20
CD at 5 %	1.10	1.05	0.35	0.42
LevelsofPhosphorus (Kg ha^{-1})				
P_0	18.01	17.31	3.38	3.61
P_{20}	18.38	19.08	4.09	4.80
P_{40}	18.52	20.12	5.36	5.45
P_{60}	19.05	20.31	6.67	5.64
Sem±	0.53	0.51	0.17	0.20
CD at 5 %	1.10	1.05	0.35	0.42

Table4Economicswasaffectedbydifferenttreatmentcombinationoflentilcrop

Treatments	Total cost ofcultivation (Rs. ha^{-1})	Grossincome (Rs. ha^{-1})	Netincome (Rs. ha^{-1})	B.C. Ratio
$N_0P_0(T_1)$	19435.58	26422	6986.42	0.35
$N_0P_1(T_2)$	19615.58	28920	9304.42	0.47
$N_0P_2(T_3)$	19795.58	31880	12084.42	0.61
$N_0P_3(T_4)$	19975.58	35418	15442.42	0.77
$N_1P_0(T_5)$	19528.58	41150	21621.42	1.10
$N_1P_1(T_6)$	19708.58	42372	22663.42	1.14
$N_1P_2(T_7)$	19888.58	44100	24211.42	1.21
$N_1P_3(T_8)$	20068.58	45260	25191.42	1.25
$N_2P_0(T_9)$	19621.58	46408	26786.42	1.36
$N_2P_1(T_{10})$	19801.58	47560	27758.42	1.40
$N_2P_2(T_{11})$	19981.58	48700	28718.42	1.43
$N_2P_3(T_{12})$	20161.58	50376	30214.42	1.49
$N_3P_0(T_{13})$	19714.58	52718	33003.42	1.67
$N_3P_1(T_{14})$	19894.58	53890	33995.42	1.70
$N_3P_2(T_{15})$	20074.58	55098	35023.42	1.74
$N_3P_3(T_{16})$	20254.58	56256	36001.42	1.77

CONCLUSION

Itcanbeconcludedfrom theaboveresultsthatlentilcropshouldbefertilizedwith45kgN/haalongwith60kgP2O5ha^{-1} toobtainhigheryieldandmorenetincomeundercentralplainzoneofU.P.

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