Effectofnitrogenandsulphurongrowthandyieldofmustard(*Brassicajuncea*L.)

ABSTRACT

The investigation was undertaken in view to assess the effect of interaction between nitrogen and sulphur on growth and yield of mustard (*Brassica juncea*L.) was carried out at the Agronomy Research Farm of Acharya Narendra Deva University of Agriculture & Technology Narendra Nagar, Kumarganj, Ayodhya (U.P.) during Rabi (winter) season of 2021-22The experiment was conducted in Factorial randomized block design which comprised of 25 treatment combinations in which five levels of Nitrogen (0,40,80,120,160 kg N ha^{-1} designated as N_0,N_1,N_2,N_3,N_4respectively) and five levels of sulphur (0,25,35,45,55 kg S ha^{-1} designated as S_0,S_1,S_2,S_3,S_4respectively). The experiment was laid out in the two factorsRCBDwiththreereplications,.Theplantheight,numberofbranchesplant^{-1},Drymatteraccumulation, seed and stover yield increased with increasing N level of 160 kg N ha^{-1} which was at par with 120 kg N ha^{-1} and while significantlysuperioroverrestofthelevelsofnitrogen.Ontheotherhand,withincreasingSlevelsplantheight, increased significantly up to 55 kg S ha^{-1}. However, the numberof branches plant^{-1} and seed yield and shoot yield increased up to the highest dose of S (55 kg S ha^{-1}). Considering the combineeffectofNand S,thetreatmentcombination N_4S_4producedthemaximumseedyield(21.32qha^{-1}).

Keyword: Sulphur level, seed yield, Nitrogen level

INTRODUCTION

Indian mustard (*Brassica juncea*L.) belongs to family Cruciferae, is at most important winter (*rabi*) oil seed crop. India is one of the largest mustards growing country intheworld,occupyingthefirstpositioninareaandthirdpositioninproductionafterChina and Canada. Rapeseed and mustard is the third important oilseed crop in the world after Soybean (*Glycine max*) and Palm (*Elaiesguineensis*). Among the seven edible oil seeds cultivated inIndia,rapeseedmustard (*Brassica spp.*)contributes 28.6 % in the total production of oil seed crops. Mustard is an important *rabi*cropofRajasthan, Gujarat, M.P., Uttarakhand, Uttar Pradesh, Bihar, West Bengal and Assam. In India, cultivation of mustardisdoneoveranareaorabout6.85millionhectareswithproductionandproductivity of 9.12 million tonnes and 1331 Kg ha $^{-1}$, respectively (Anonymus). In India, Rajasthan ranks firstboth in areaandproductionandGujaratstatehasthehighest productivityof mustard.InU.P.,Mustardisgrownon0.75millionhectarewithproductionof0.95million tonnes and productivity of 1260 Kg ha^{-1}, (Ministry of Agriculture, 2019-20).The oil seed crops have a key role to human and animal nutrition for maintaining normalhealth.Indianmustardisafairlyhighremunerativecropandamajorsourceofhigh qualityedibleoil.Theoilofrapeseed-mustardservesasaverygoodcookingmediumand dietary fat of majority of population in Northern, North-Western, Central, Eastern and North-Eastern

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It is very focused on the production of mustard and oil, and the functions of nutrients, reduce this part, and add articles with research results on plant nutrition and fertilization, focus on bringing similar research results, with mustard and other crops.
Some articles are not in the reference list.
The objective of the research is missing.

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states. It's also most common medium of pickling and food preserving. Besideoil,theleavesofyoungplantsareusedasgreenfodder.Theseedsarehighlynutritivevaluecontaining 38-57 %erucic acid,5-13 %linoleicacidand 27 % oleicacid. Theper capitaperday oil availability is 19 g as against recommended oil 33 g per dayper capitabymedicalscientists.Thefertilizershaveplayedaprominentroleinincreasingthe oilseed production. The oil content in mustard seeds variesfrom 37-39% (Bhowmik *et. al*., 2014), balanced fertilization is the key to achieve higher production and increasing nutrient use efficiency. In our country, oil seed crops are predominantly grown under rainfed condition in less fertile marginal lands with low input supply.The importance of nitrogen to achieve the higher production potential in mustard iswell recognized.Nitrogenisanimportantmetabolicelementforgrowthanddevelopmentofplant. It is considered essential formetabolic activities and transformation of energy and essential for metabolism of protein and other biochemical product such asnucleic acid, chlorophyll and protoplasm. Nitrogen provide deep green colour to leaves due to better chlorophyll synthesis which increase the effective area of photosynthesis and resulting in higher dry matter, (Singh and Kumar 2014). It is thus, the basic constituent of plantlife. It tends to encourage vegetative growth and governs a considerable degree to the utilization of other nutrients.Significantresponseofseedcropstothetuneof30-40%wasrecordedduetothe useofsecondaryandmicronutrientsandwithsignificantresidualeffectincroppingsystem. Sulphur has been recognized as an essential element for plant and animal growth. Sulphur plays a vital role in the increasing yield and quality of Indianmustard. Application of Sulphur in combination with balanced amount of other nutrients on soil properties and is used as soil amendment to improve availability of other nutrient in soil (Verma *et. al*., 2018). It also plays an important role in protein synthesis. It is known to beindispensable formanyreactionsinalllivingcells.Itistheconstituentoftheaminoacidslikemethionine, cysteine and cystine. Sulphur level significantly influenced the seed and stover yield of mustard (Sharma *et al*.2008). Deficiencies of any one or all of these essential amino acids causeserioushumanmalnutrition.Thereiswidespread deficiencyofsulphur inthecountry (Hegde and Babu, 2009).Thepresentproductionisnotadequatetomeettheedibleoilrequirementofourfast growing population. A wide gap exists between the demand and supply resulting into a largescaleimportoffatandoilsattheexpanseofvaluableforeignexchange.Rapeseed – mustard is one of the most important Rabi oil seed crops of Northern India grown mainly for edible oil and cakes for animals. In order to meet the edible oil requirement of our fast growing population the efforts are to be made to increase the production and productivity of oil seed

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crops.

Materialand Methods

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Add some subsections.

Theexperimentwasconductedattheresearchfarm~~wasconducted~~atAgronomyResearchFarmofAcharyaNarendraDevaUniversity of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) during the Rabi season of 2021-22. The farm is located at 42 km away from Ayodhya city road at 26.47˚ N latitude, 82.12˚ E longitude and analtitude of about 113 ~~metres~~meters above the mean sea level.Narendra–8501(*Brassicajuncea*L.)wasusedasatestcropwhichisahighyieldingandshortdurationmustardvariety.

Theexperiment was laid out in a Factorial Randomized Block design (FRBD) with three replications of each fertilizer treatments consisted of 5 levels of N (0,40 80 120,160 kg N ha^{-1} designated as N_0, N_1, N_2, N_3, N_4respectively) and~~.~~ five levels of sulphur (0,25,35,45,55 kg S ha^{-1} designated as S_0, S_1,S_2,S_3,S_4respectively).Therewere25treatmentcombinations.Eachblock consistedof25plotsandindividualplotwas 5m×4m=20m^2in size. The row-to-row and seed to seed distance were 45cm and 15cm, respectively.Land preparation was started after harvesting of *kharif* crop. One ploughing was done by disc plough followed by two ploughing by tractor drawn cultivator andplanking was done invariably after each ploughing to get the fine seed bed. Layout was carefullydone as per technical programme of the experiment.

Thecropwasfertilizedwithauniformdoseofphosphorusandpotassiumattherateof60kgand 40kgha^{-1},respectively.However, nitrogen was applied as per treatments Urea, DAP and Murate of potash were used as the source of nitrogen, phosphorus and potassium.Thefulldoseofphosphorusandpotassiumandhalfdoseofnitrogenwasappliedasbasaldoseandremaininghalfdoseof nitrogen was given in two equal splits as top dressing each after first and second irrigations. Full dose of sulphur through elemental sulphur as per ~~the~~ treatments (0, 25, 35, 45 and 55 kg/ha) was given at seven days before sowingofsowing.Mustardseedsweresowninlinesatthedistanceof45cmwiththehelpofseeddrill.Theseedrate was used5kgha^{-1}.Mustardtaggingcanbedonewiththehelpoftags.Thinningwasdoneintwophases. Inthefirstphasedenseemergingseedlingswereuprooted after 10 days of sowing. Second phase of thinning was completed 25 DAS by maintaining plant to plant and rowto row distance as

45 cm and 15 cm, respectively.Onehandweedingwasdonebykhurpiat45daysaftersowingtokeepthefield weedfree.Twoirrigationsweregiventothemustardcrop.Firstirrigationwasdoneatrosettestage(25 DAS)andsecondirrigationwasdoneatsiliqua formation stage (55 DAS) of the crop. Tube well was the source of irrigation.Thecropwasinfestedwithaphids*(Lipaphierysimi)*atthetimeofsiliquafilling.Theinsects werecontrolledsuccessfullybyspraying rogar at the rate of 250 ml per hectare was sprayed at pod formation stage. The crop was kept under constant observations from sowing to harvesting.Fiveplants(5)fromeachplotwereselectedatrandomandweretaggedfordatacollection. Somedatawerecollectedfromsowingto harvesting with 30 days interval and some data were collected at harvesting stage. The sample plants were uprooted prior to harvest anddriedproperlyinthesun.

Thecropwasharvestedplotwise90%siliquaeweramatured,wasdoneon20February2022.Theseed yield and stover yield plot^{-1} were recorded after cleaning and drying those properly in the sun. Data were collected on the following parameters:1)Plantheight(cm),2)Numberofbranchesplant^{-1},3)Drymatteraccumulation(gha^{-1}),4)Leafareaindex,5)biological yield, seed yield (q ha^{-1}), 6) Stover yield (q ha^{-1}), 7) harvest index (%). The textural class was determined Triangular method (Bouyoucos,1936).SoilpH(1:1.25soil:water)wasestimatedby(GlasselectrodepHmeterJackson, 1973)Soilorganiccarbonwas calculated(Walkley & black's rapid titration method 1934). EC dSm^{-1} at 25 ^{0}C (Conductivity Bridge Jackson, 1973). Available N (kg ha^{-1}) was estimated by Alkaline potassium permanganate method (Subbiah and Asija, 1956). Available P_2O_5(kg ha^{-1}) was calculated by Olsen's method (Olsen's *et al.*1954) Available K_2O (Kg ha^{-1}) was recorded by Flame photometer (Jackson, 1973).

TheCollecteddataarestatisticallyanalyzedbyusingtheANOVAtechnique.Thetestof~~significance~~significanceof allparameterswasdone.TheDuncan'sMultipleRangeTest(DMRT)with~~Least~~leastsignificancedifferencevalue wasdeterminedwithpropriatelevelsof significance and the means were tabulated. The mean comparison was carried out by DMRT technique (Gomez and Gomez, 1984).

ResultsandDiscussion

~~Thedatapertainingtop~~Plantheightrecordedatdifferentgrowthstageshad non-significant effect~~onplantheight~~ at30(DAS)~~ofcropgrowth~~.Maximumplant height was recorded at higher

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Tables must be cited in the text.
Enter the letters for the statistical difference in the table.
There's no discussion. Authors should add discussion. Just mentioning that other authors have obtained similar results is not a discussion. A discussion should be made up of results from other authors, explaining what they did, and what they observed, in which culture. And the discussion must be made up of explanations of why something happens or doesn't happen.

160 kg N ha^{-1}, which was *at par* with 120 kg N ha^{-1}, 80 kg N ha^{-1}, while significantly superior over rest of the N levels. The plant height increased significantly with levels of nitrogen. The results are in close conformity with those of Chandra and Damor (1982), Singh (1984), Ali andRahman(1986),Khanpara*etal*.(1993).DifferentSulphurlevelshadsignificanteffectonplantheightatallstagesexcept,30DAS.Plantheightincreases significantlywithincreasesinsulphurdosesupto55kgSha^{-1}.Higherplantheightwasrecordedunder55kgSha^{-1},whichwasatparwith45kgha^{-1}and35 kgSha^{-1},whilesignificantlysuperioroverrestofthetreatments at all stages of crop growth.Theresultsofpresentinvestigationarealsoinagreementwith thefindingofKhanpara*etal*.(1993)andSinghandSaran(1993).

Numberofbranchesplant^{-1}ofmustard wassignificantlyaffectedbynitrogenandsulphurlevels. numberofbranchesplant^{-1}increasedwithincreasinglevelsofnitrogen,~~recorded~~thehighernumberofbranchesplant^{-1}wasrecordedwith160kgNha^{-1}which was at par with 120 kg N ha^{-1} and 80 kg N ha^{-1}while significantly superior over rest of the N levels. The progressive increase in growthofplantswith successiveincrementsinthelevelsofnitrogenareinagreementwith Kachroo and Kumar (1999) and Chubey*et al*. (2001). Higher number of branches plant^{-1} was recorded with 55 kg S ha^{-1}, which was at par with 45 kg ha^{-1} and 35 kg S ha^{-1} while significantly superior over rest of the treatments. Higher number of branches plant^{-1} was recorded with 55 kg S ha^{-1}, which was at par with 45 kg ha^{-1} and 35 kg S ha^{-1} while significantly superior over rest of the treatments.

Table-1
Effectofdifferentnitrogenandsulphurlevelsongrowthparametersofmustardatharveststage.

Treatments		Plant height (cm)	Numberof branches plant^{-1}	Dry matter accumulation (g plant^{-1})	Leafarea index
A.Nitrogenlevels					
N	0kgNha^{-1}	145.73	18.15	30.97	1.64
N1	40kgNha^{-1}	152.00	19.15	37.16	1.66
N2	80kgNha^{-1}	158.27	20.34	40.26	1.68
N3	120kgNha^{-1}	162.97	20.94	42.19	1.69
N4	160kgNha^{-1}	164.54	21.14	42.97	
SEm±		***2.62***	***0.355***	***0.621***	***0.034***
CD(P= 0.05)		***7.46***	***1.011***	***1.763***	***0.097***
B.Sulphurlevels					
S0	0kgSha^{-1}	140.81	18.78	34.76	1.65
S1	25KgSha^{-1}	148.55	19.59	38.32	1.66
S2	35kgSha^{-1}	157.84	20.40	39.90	1.67

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S3	45kgSha^{-1}	162.48	21.00	41.87	1.70
S4	55kgSha^{-1}	164.03	21.21	42.66	1.71
SEm±		***2.62***	***0.355***	***0.621***	***0.028***
CD(P= 0.05)		***7.46***	***1.011***	***1.763***	***0.08***

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Table2.Effectofdifferentnitrogenandsulphurlevelsonyieldofmustard crop.

Symbol	Treatments	Yield			
		Biologicalyield (q ha^{-1})	Seedyield (q ha^{-1})	Stoveryield (q ha^{-1})	Harvest index (%)
A.	**Nitrogenlevel**				
N0	0kgN ha^{-1}	69.61	15.37	54.24	22.07
N1	40 kgN ha^{-1}	82.34	18.44	63.90	22.39
N2	80 kgN ha^{-1}	88.28	19.98	68.31	22.62
N3	120kgN ha^{-1}	91.68	20.94	70.74	22.83
N4	160kgN ha^{-1}	92.53	21.32	71.21	23.04
SEm±		1.593	0.326	1.219	0.412
CDat5%		4.530	0.927	3.466	1.173
B.	**Sulphur level**				
S0	0kgS ha^{-1}	76.90	17.25	59.65	22.40
S1	25KgS ha^{-1}	83.81	19.01	64.80	22.65
S2	35kgS ha^{-1}	87.26	19.80	67.47	22.65
S3	45kgS ha^{-1}	91.58	20.78	70.81	22.65
S4	55kgS ha^{-1}	92.45	21.17	71.28	22.86
SEm±		1.593	0.326	1.219	0.412
CDat5%		4.530	0.927	3.466	1.173

Data pertaining to dDry matter accumulation was influenced by different levels of nitrogen and sulphur. Drymatteraccumulation increased with increased in nitrogen levels up to 160 kg N ha^{-1}, which was *at par* with 120 kg N ha^{-1} and 80 kg N ha^{-1}, while it is significantoverrest of the treatments. Similar results have also been reported by Patel and Shelke (1998),Bhari *et al*. (2000). Higher dry matter accumulation was recorded under 55 kg S ha^{-1} which was at par with 45 kg S ha^{-1} and 35 kg S ha^{-1}, while significantly superior over rest of the treatments. Increasing thedry matter accumulation in plants with increasingthelevelsofsulphur was observed.SinghandDhiman(2005)also reportedsimilarresults.Leaf areaindexof mustard wassignificantly influencedby thenitrogen andsulphurlevels. The data pertaining to lLeaf area index recorded at different crop growth stages was influenced by treatment,Hhigher leaf areaindex was recorded with 160 kgha^{-1}, which was *at par* with 120kgNha^{-1}and80kgNha^{-1}whilesignificantlysuperioroverrestofthenitrogenlevels.Thesignificant increase in growth characters with nitrogen fertilization has also been reported by Kumar and Gangwar (1985), Singh *et al*. (1998) and Bhari*et al*. (2000).

Different sulphur level brought significant influence on LAI at all the stages,

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higherleaf area index (LAI) was recorded at 55 kg Sha^{-1}whichwas significantly superior over 25 kg S ha^{-1} and 0 kgS ha^{-1} while at par with 45 kg S ha^{-1} and 35 kgS ha^{-1}.

Application of nitrogen at different level showed the significant variation for seed yield per hectare under the present trial, Wwith increasing nitrogen levels. Significantly higher seed yield was obtained with 160 kg N ha^{-1} (N_4) which is 21.32 q ha^{-1} at par with 120 kg N ha^{-1} (N_3), which is 20.94 q ha^{-1}, while significantly superior over rest of the levels of nitrogen, and the lowest was recorded at (N_0) which is control. These results are in conformity with that of Tomar et al. (1997), Bhari et al. (2000), Bhlaerao et al. (2002). Statistically yield of mustard The data pertaining to stover yield presented in Table 1 and indicatedthatthedifferentdoseofnitrogenandsulphurlevelsinfluencedthestoveryield(qha^{-1}).Thehigheststoveryieldwasobtainedwiththeapplication of160kgNha^{-1},andwhichwasatpar with the applicationof 120 kg N ha^{-1} while significantly superior over the rest levelsofnitrogen.Thedatapertaining to biologicalyield in Table 2 indicated that the different dose of nitrogen and sulphur levels influenced the biological yield (kg ha^{-1}). Significantly higher biological yield was obtained with the application of 160 kg N ha^{-1}, and which wasat par with the application of 120 kg N ha^{-1}while significantly superior overtherest levelsofnitrogen.

Harvestindexofcropdidnotvarysignificantlylevelbydifferentlevelofnitrogendosesandsulphur level.Thismightbedue to thefact that nitrogen application increased all thegrowth contributing characters viz. plant height, branches plant^{-1}, leaf areaand drymatteraccumulation whichenhancedthestoverproduction.Thebeneficialeffectofnitrogen fertilizationonstoveryieldofmustardhasalsobeenreportedbyTomer *etal.*(1997), Singhand Singh (1998), Singh *et al*. (1998)Bhari *et al*. (2000)and Bhalerao(2001). The higher seed yield was obtained with higher dose of sulphur by 55 kg S ha^{-1}, which was at par with 45 kg S ha^{-1} and while significantly superior over rest doses of sulphur. The higher stover yield was obtained with the applicationof55kgSha^{-1} whichwasatpar with45kgSha^{-1}whilesignificantlysuperioroverrestofthe Slevels. Thehigherbiologicalyieldwasobtained withtheapplicationof55kgSha^{-1}whichwasatparwiththeapplicationof45kgSha^{-1}whilesignificantlysuperioroverrestofthetreatments.Harvestindex of crop did not vary at significant level at a differentlevel of sulphur doses.

The increase in seed yield under adequate sulphur supply might beascribed mainly due to the combined effect of higher number of siliquae plant^{-1}, more number of seed siliqua^{-1} and higher 1000-seed weight, which was the result of bettertranslocationof

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photosynthatesfromsourcetosink.Sulphuralsostimulatesthepodsetting,seedformationandoilsynthesisintheseedofmustardand it increases the biological, seed and stover yields of mustard. **Rana *et al.* (2005) and Dongarkar*et al.* (2005)** also reported the similar results.

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Conclusion

Thus, the application of 160 kg N ha^{-1}and 55 kg S ha^{-1}seems to best option for maximum plant growthandhigheryieldundereasternUP.Thestudyistobecontinuingforfewmoreyearstodrawdefinite conclusion for application of liquid biofertilizers and variable source of nutrients in mustard.

Comment [SN19]: In fact there was no difference between 160, 120 and 80 kg of N applied, so the dose of 160 is not the best. The three doses can be used with the same gain, so the smallest dose would be the best, also considering sustainability and costs.

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