Impact of Integrated nutrient management on growth and yield characteristics of mustard (*Brassica juncea* L.)

Abstract

The experiment wasconductedattheInstructionalFarm(SIF)ofChandraShekharAzadUniversityofAgricultureandTechnologyinKanpur,UttarPradesh in the *Rabi* season of 2023-24.ARandomizedBlockDesign was used for statistical analysis, with 10 treatments and 3 replications. The primaryobjectives of this study involved assessing the crop growth and yield attributes, in mustard crops subjected to different treatments.These treatments consisted of various chemical fertilizers, bio fertilizers, and nanofertilizers used in different combinations. Results revealed that,theeffect of treatment T10[NanoDAP@40ppm+RDofN&K(120:60)+Azotobacter@2kgha^{-1}+PSB@4kgha^{-1}]wasfoundto be bestintermsofgrowth and yieldattributes of crop,whereasminimumgrowth andyield attributes of cropwas found under the effect of treatment T5 [Nano urea @60ppm + RD of P&K (60:60)].

1. **Introduction:** It is crucial for Indian agriculture to become more knowledge intensive toeffectivelyaddressthechallengesposedbyagrowingpopulation,limitedlandavailability,and diminishing energy resources **(Swaminathan and Bhavani, 2013).** The group of oilseed crops has a significant impact on India's agricultural economy, with a total yield of 22.1million tonnes from an area of 25.4 million hectares. India holds the impressive positionofbeingthefourthlargestoilseedeconomyglobally,followingtheU.S.,China,andBrazil.It also ranks as the second biggest importer, after China.AccordingtoJha**et.**, **(2012),** this country contributes significantly to the global oilseeds area, vegetableoilsproduction,andtotaledibleoilsconsumption.With 13% of the total cultivated area, oil seeds are rather prominent on the agricultural landscape of the nation.Theyalso make a valuable contribution to the Gross National Productivity (GNP), representingabout 5% of it. Additionally, oil seeds contribute 10% of the overall value of agriculturalproductsin the country**(DOA&FW, 2022).**

Mustard, scientifically known as *Brassica juncea* (L.), is a significant oil seed cropthat falls under the family "Cruciferae." According to a study by **Bhowmik *et. al.* (2014)**,the oil content in mustard seeds can range from 37-49 percent. These seeds are known fortheirhighnutritionalvalue,containing38-57%erucicacidand27%oleicacid.Theoilcakeresidueiscommonlyusedascattlefeedandfertilizer,withanutrientcompositionof5.1%nitrogen(N),1.8%phosphoruspentoxide(P_2O_5),and1.1%potassiumoxide(K_2O).According to **Mukherjee (2010),** this crop has the potential to be grown in the winter*(Rabi)* season because it can adapt well and make use of leftover moisture. The proteincontent of mustard seed is approximately 30-45%, making it a highly nutritious food. Theseed and oil have various culinary uses, such as being used as a condiment in pickles andfor adding flavor to curries and vegetables. In northern India, the oil is often used for cooking and frying foods. Additionally, it finds application in the formulation of hair oil,pharmaceuticals, and the production of greases. This substance is commonly employed inthe production of soap and it is also utilized in combination with mineral oils to providelubrication.Theoilcakesserveadualpurpose,functioningasbothcattlefeedandmanure.Greenstemsandleavesprovideanutritioussourceoffodderforcattle. Mustardoiliscommonly utilized in the tanning industry to effectively soften leather, as noted by **SinghandSingh (2001).**

Mustard isasignificantoilseedcrop.However,itsproductivityinthestatefallsshortofitsfullpotential.Toenhanceitsyield,acombinationofbalancedfertilizationand effective management practices arenecessary. The role of nutrients in supporting plantgrowth and development cannot be overstated. They play a vital role in facilitating cellgrowth,cellenlargement,andnutrienttransportationthroughoutdifferentpartsoftheplant.Themustardplanthasagreaterdemandformacro-nutrients,suchasnitrogen,phosphorus,and potassium, in comparison to other nutrients. Understanding the importance of macro-nutrients is essential for assessing the fruit yield and quality of the citrus plant **(Albrigo,2002).** Nano-fertilizers have been developed to carefully release nutrients in a controlledmanner, perfectly matching the specific requirements of the crop. The controlled releasemechanismensuresthatthereisnoprematureinteractionwiththesoil,waterenvironment,ormicroorganisms. The plant system therefore effectively absorbs the nutrients once they are released. According to **De la Rosa *et al.* (2013),** these unique characteristics canimprovethe crop's nutrient use efficiency. Extensive use of chemical fertilisers has had negative consequences on soil quality,health, and productivity, as well as the pollution of surface and groundwater sources**Hazarika *et al.*, (2011).**

Bio-fertilizersarespecializedformulationsthatharnessthepowerofmicro-organismstoconvertnutrientsfromtheirnon-usablestateintoaformthatcanbereadily absorbed by plants. This transformation occurs through a natural biological process. Bio-fertilizers have been shown to enhance both the quantity and quality of various plants.According to a study conducted by **Yosefi*et al.* (2011)**, the combination of bio-fertilizersandchemicalfertilizershasbeenfoundtoenhancecropproductivityandimprovenutrientuseefficiency. Bio fertilizers have proven to be highlyeffective in producing impressive results when compared to chemical fertilizers. This isbecause each gram of carrier for bio fertilizers contains a minimum of 10 million viablecells of a specific strain **(Anandaraj and Delapierre, 2010).** In non-leguminous crops, biofertilizers like Azotobacter play a crucial role asnitrogen-fixing bacteria. Azotobacter has been found to enhance plant growth and increasecrop yield in various soil conditions **(Okon and Gonzalez, 1994).** The bacteria are Gramnegativeandexhibitspolymorphism,withvaryingsizesandshapes.Thesizeofthesecellscanvary,typicallymeasuringbetween2-10x1-2.5 µm. Mustard is a crucial oilseed crop that holds great economic importance. It is vitalto optimize its production in order to ensure food security and support livelihoods invariousregions.

2. Method and Materials:

The experiment was conducted at Instructional Farm (SIF), Chandra Shekhar Azad University of Agriculture andTechnology in Kanpur, which was served as the experimental site. Kanpur Nagar is a city in centralUttar Pradesh that is at a height of 125.9 meters above sea level on the alluvial tract of theGangeticplains.Itscoordinatesare25°to28°Northlatitudeand79°to80°Eastlongitude. Thesemi-aridclimateandrichalluvialsoilcharacterizethisnorthernzone.About935mm of rain falls on the region each year on average.Relativehumidity(7am)isrelativelyconstantatabout80-90%fromJuly to the end of March, gradually declines to about 40-50% by the end of April, andremains at 80% until June, even though temperatures in May and June can reach 44°C to47°C or higher.

Edaphic condition: Soil samples were collected from different locations of the field before sowing and analysedforsome physio-chemical characteristics in the LaboratoryatC.S. Azad University of Agriculture and Technology, Kanpur. The available Nitrogen in soil was 189.12 kg ha^{-1}, which was estimated by the Alkaline permanganate method given by **Subbiah and Asija**(Year),the available Phosphorus was 14.60 kg ha^{-1} estimated by Olsen's method given by **Olsen*et al*.,**(1954). The available K was 167.31 kg ha^{-1} which was estimated by the Flame photometer method given by Black(1965). The available S was 18.50 kg ha^{-1} which was estimated by the calcium extraction method given by **William and Steinberg**(Year). The soil of the experimental field was clayey in texture and slightly alkaline in pH (8.12), byusing GlassElectrodepH was examined using **Piper's (1950)** technique.The electrical conductivity (EC) of the soil was 0.39 (d S m^{-1}) estimated following**MethodNo. 4, USDA HandBook by Piper(1950).** Organic carbon in the soil was 0.42% which was estimated by rapid titration (wet oxidation) method given by **Walkley and Black**.

Treatment details: The experiment was laid out in Randomized Block Design with three replications. There were fourteen treatment combinations **(T_1)** RDF(120:60:60) +Sulphur @25$kgha^{-1}$, **(T_2)** RDF(120:60:60) +Azotobacter@2$kgha^{-1}$, **(T_3)** RDF(120:60:60) +PSB @4$kgha^{-1}$, **(T_4)** RDF(120:60:60) +Azotobacter@2$kgha^{-1}$+ PSB@4 $kgha^{-1}$, **(T_5)** Nanourea@ 60ppm +RD ofP&K (60:60), **(T_6)** NanoDAP@40ppm + RDofN&K (120:60), **(T_7)** Nanourea@ 60ppm +RDofP&K (60:60) +Azotobacter@2$kgha^{-1}$, **(T_8)** Nanourea@ 60ppm +RDofP&K (60:60) +Azotobacter@2$kgha^{-1}$+PSB@4 $kgha^{-1}$, **(T_9)** NanoDAP@40ppm+ RD ofN&K (120:60)+ Azotobacter@2 $kgha^{-1}$, **(T_{10})** NanoDAP@40ppm+RDofN&K (120:60)+Azotobacter@2 $kgha^{-1}$+PSB@4 kg ha^{-1}.

SeedandSowing: The necessary number of seeds wasmeasured and planted in the furrows. The furrowswere created at a row distance of 30 cm and a depth of 3.0-3.5 cm using the desi Plough.Therecommended seeddosageof 5kgperhectarewas usedforsowing.

Manureandfertilizerapplication: In the experimental field, well decomposed farmyard manure (FYM) at a rate of 2.4tonsperhectare,aswellasvermicompostatarateof6tonsperhectare,wasappliedusingthebroadcastingmethodin eachplot. These fertilizers were appliedatdifferentrates,asper the treatmentof therecommended dose of NPKS (120:60:60:25 kg ha^{-1}). Theremainingnitrogenwasappliedastop dressing in two separate split doses. The first top dressing was applied after 35 daysafter sowing (DAS), followed by the second application at 50 DAS. Application on nanoUrea and nano DAP was done according to the treatment combinations 30 and 60 daysaftersowing.

Biofertilizerapplication: Biofertilizers Azotobacter and PSB were given by soil method @ 2 kg ha^{-1} and 4 kgha^{-1}respectivelybymixingwith theorganicmanures beforesowingof seeds.

3. **Results and Discussion**

1. Plant Population

The analysis of effect of various treatments has been thoroughly examinedandtheresultshavebeenpresentedinTable 1. Upon examining the table, itbecomes evident that the various treatment combinations had no significant impact onthe plant population (plants m^{-2}). At 20 days after sowing (DAS) effect of treatments T5 [Nano urea @60ppm + RD of P&K (60:60)] and T6 [Nano DAP @ 40ppm + RD of N&K (120:60)]werefoundtobehighestwith11.11plantsm^{-2}areawhereasleastplantpopulationof 10.97 plants m^{2} was found under the effect of treatment T3 [RDF (120:60:60) + PSB@4 kg ha^{-1}]. Also, at harvest, effect of treatment T10 [Nano DAP @ 40ppm + RD ofN&K (120:60) + Azotobacter @2 kg ha^{-1} + PSB @4 kg ha^{-1}] was found to be highestwith 11.08 plants m^{-2} area whereas least plant population of 10.3 plants per m^{2} wasfoundunderthe effectof treatmentT5[Nano urea @60ppm +RD ofP&K (60:60)].

3.2. Plant height (cm)

The datapertainingtoplantheight(cm)ofmustard*(Brassicajuncea*L.)at30, 60, 90 and at harvest is presented inTable no. 1. The datarevealedthat,effectoftreatmentT_{10}[NanoDAP@40ppm+RDofN&K(120:60) + Azotobacter @2 kg ha^{-1} + PSB @4 kg ha^{-1}] was found best and recorded significantly thehighest plant height (cm) i.e., 27.17 cm, 74.74 cm, 98.27 cm and 120.67 cm respectively. Whereas,treatment T_5 [Nano urea @ 60ppm + RD of P&K (60:60)] recorded significantly the lowest plant height (cm) i.e., 21.75 cm, 67.16 cm, 93.85 and 108.02 cm respectively

Table 1: Effect of Integrated Nutrient [Nano fertilizer (nano urea and nano DAP) andbiofertilizer (azotobacter and PSB)] Management on Plant population (plants m^{-2}) and plant height (cm) ofmustard

Symbols	Treatments	Plantpopulation(plantsm^{-2})		Plantheight(cm)			
		20DAS	Atharvest	30DAS	60DAS	90DAS	Atharvest
T1	RDF(120:60:60) +Sulphur @25kgha^{-1}	11.02	10.9	25.89	73.02	97.19	117.86
T2	RDF(120:60:60) + Azotobacter@2 kgha^{-1}	11.01	10.72	24.61	71.3	96.11	115.08
T3	RDF(120:60:60) +PSB @4 kgha^{-1}	10.97	10.78	25.1	72.51	96.8	117.22
T4	RDF(120:60:60) + Azotobacter @2 kg ha^{-1} +PSB@4 kg ha^{-1}	11.08	11.06	26.91	74.48	98.09	120.29
T5	Nano urea @ 60ppm + RD of P&K (60:60)	11.11	10.3	21.75	67.16	93.85	108.02
T6	Nano DAP @ 40ppm + RDofN&K (120:60)	11.11	10.42	22.54	68.37	94.44	110.16
T7	Nano urea @ 60ppm + RD of P&K (60:60)+ Azotobacter@2 kgha^{-1}	11.05	10.54	23.33	69.58	95.03	112.3
T8	Nano urea @ 60ppm + RDofP&K (60:60) + Azotobacter @2 kg ha^{-1} +PSB@4 kgha^{-1}	11.06	10.6	23.82	70.09	95.42	112.94
T9	Nano DAP @ 40ppm + RD ofN&K (120:60) + Azotobacter@2 kgha^{-1}	11.05	11.02	26.68	74.23	97.88	120
T10	Nano DAP @ 40ppm + RDofN&K (120:60) + Azotobacter @2 kg ha^{-1} +PSB@4 kgha^{-1}	11.09	11.08	27.17	74.74	98.27	120.67
F-test		**NS**	**NS**	**S**	**S**	**S**	**S**
S.E.(m) (±)		0.22	0.19	0.21	0.24	0.16	0.38
C.D.@ 5%		0.65	0.58	0.63	0.72	0.49	1.12
CV		3.43	3.14	1.49	0.59	0.3	0.57

3.3 Numberof leaves per plant

The datapertainingtonumber of leaves plant^{-1}ofmustard*(Brassicajuncea*L.)at30, 60, 90 and at harvest is presented in Table no. 2. The datawasrevealedthat,the effectoftreatmentT_{10}[NanoDAP@40ppm+RDofN&K(120:60) + Azotobacter @2 kg ha^{-1} + PSB @4 kg ha^{-1}] was found best and recorded significantly thehighest number of leaves plant^{-1} i.e., 15.15, 19.89, 22.12 and 19.42 respectively, where- as treatment T_5 [Nano urea @ 60ppm + RD of P&K (60:60)] recorded significantly the lowest number of leaves plant^{-1} i.e., 7.77, 8.11, 15.18 and 7.52 respectively.

Table 2.

EffectofIntegratedNutrient[Nanofertilizer(nanoureaandnanoDAP)andbiofertilizer(azotobacterand PSB)]Managementonnumberofleavesper plantofmustard

Numberof leaves per plant					
Symbols	**Treatments**	**30DAS**	**60DAS**	**90DAS**	**Atharvest**
T1	RDF(120:60:60) +Sulphur @25kgha^{-1}	13.33	17.35	20.56	16.82
T2	RDF(120:60:60) + Azotobacter@2 kgha^{-1}	11.81	14.77	19	14.22
T3	RDF(120:60:60) +PSB @4 kgha^{-1}	12.07	15.31	19.43	14.77
T4	RDF(120:60:60) + Azotobacter @2 kg ha^{-1} +PSB@4 kg ha^{-1}	14.95	19.58	21.91	19.04
T5	Nano urea @ 60ppm + RD of P&K (60:60)	7.77	8.11	15.18	7.52
T6	Nano DAP @ 40ppm + RDofN&K (120:60)	9.03	10.15	16.31	9.57
T7	Nano urea @ 60ppm + RD of P&K (60:60)+ Azotobacter@2 kgha^{-1}	10.29	12.19	17.44	11.62
T8	Nano urea @ 60ppm + RDofP&K (60:60) + Azotobacter @2 kg ha^{-1} +PSB@4 kgha^{-1}	10.55	12.73	17.87	12.17
T9	Nano DAP @ 40ppm + RD of N&K (120:60) + Azotobacter@2 kgha^{-1}	14.59	19.39	21.69	18.87
T10	Nano DAP @ 40ppm + RDofN&K (120:60) + Azotobacter @2 kg ha^{-1} +PSB@4 kgha^{-1}	15.15	19.89	22.12	19.42

F-test	**S**	**S**	**S**	**S**
S.E.(m) (±)	0.21	0.35	0.21	0.34
C.D.@ 5%	0.63	1.03	0.63	1.01
CV	3.79	4.02	1.93	4.1

3.4 Numberof primarybranchesper plant

The datapertainingto number ofprimarybranchesplant^{-1}ofmustard*(Brassicajuncea*L.)at 60, 90 and at harvest is presented in the Table no. 3. The datarevealedthat,the effectoftreatmentT_{10}[NanoDAP@40ppm+RDofN&K(120:60) + Azotobacter @2 kg ha^{-1} + PSB @4 kg ha^{-1}] was found best and recorded significantly thehighest number ofprimarybranchesplant^{-1} i.e., 5.38, 6.49 and 6.1 respectively, where- as treatment T_5 [Nano urea @ 60ppm + RD of P&K (60:60)] recorded significantly the lowest number ofprimarybranchesplant^{-1} i.e., 4.26, 5.64 and 5.08 respectively.

Table 3. Effect of Integrated Nutrient [Nano fertilizer (nano urea and nano DAP) andbiofertilizer (azotobacter and PSB)] Management on number of primary branchesper plantofmustard

Numberof primarybranchesper plant				
Symbols	**Treatments**	**60DAS**	**90DAS**	**Atharvest**
T1	RDF(120:60:60) +Sulphur @25kgha^{-1}	5.07	6.25	5.84
T2	RDF(120:60:60) + Azotobacter@2 kgha^{-1}	4.8	6.04	5.63
T3	RDF(120:60:60) +PSB @4 kgha^{-1}	4.86	6.08	5.64
T4	RDF(120:60:60) + Azotobacter @2 kg ha^{-1} +PSB@4 kg ha^{-1}	5.34	6.46	6.08
T5	Nano urea @ 60ppm + RD of P&K (60:60)	4.26	5.64	5.08
T6	Nano DAP @ 40ppm + RDofN&K (120:60)	4.32	5.67	5.14
T7	Nano urea @ 60ppm + RD of P&K (60:60)+ Azotobacter@2 kgha^{-1}	4.53	5.84	5.35
T8	Nano urea @ 60ppm + RDofP&K (60:60) + Azotobacter @2 kg ha^{-1} +PSB@4 kgha^{-1}	4.59	5.87	5.41
T9	Nano DAP @ 40ppm + RD of N&K (120:60) + Azotobacter@2 kgha^{-1}	5.28	6.42	6.04

T10	Nano DAP @ 40ppm + RDofN&K (120:60) + Azotobacter @2 kg ha^{-1} +PSB@4 $kgha^{-1}$	5.38	6.49	6.1
F-test		**S**	**S**	**S**
S.E.(m) (±)		0.07	0.05	0.04
C.D.@ 5%		0.22	0.14	0.13
CV		2.61	1.38	1.31

3.5 Numberof secondarybranchesperplant

The datapertainingto number ofsecondary branchesplant^{-1}ofmustard*(BrassicajunceaL.)*at 60, 90 and at harvest is presented inTable no. 4. It wasrevealedthateffectoftreatmentT_{10}[NanoDAP@40ppm+RDofN&K(120:60) + Azotobacter @2 kg ha^{-1} + PSB @4 kg ha^{-1}] was found best and recorded significantly thenumber of secondary branches plant^{-1} i.e., 10.19, 12.28 and 12.0 respectively. Whereas,treatment T_5 [Nano urea @ 60ppm + RD of P&K (60:60)] recorded significantly the lowest number ofsecondary branchesplant^{-1}i.e., 8.24, 10.82 and 10.46 respectively.

Table 4. Effect of Integrated Nutrient [Nano fertilizer (nano urea and nano DAP) andbiofertilizer (azotobacter and PSB)] Management on number of secondary branches per plantofmustard.

Numberof secondarybranchesperplant				
Symbols	**Treatments**	**60DAS**	**90DAS**	**Atharvest**
T1	RDF(120:60:60) +Sulphur @25$kgha^{-1}$	9.66	11.89	11.64
T2	RDF(120:60:60) + Azotobacter@2 $kgha^{-1}$	9.12	11.55	11.28
T3	RDF(120:60:60) +PSB @4 $kgha^{-1}$	9.26	11.62	11.36
T4	RDF(120:60:60) + Azotobacter @2 kg ha^{-1} +PSB@4 kg ha^{-1}	10.09	12.25	11.98
T5	Nano urea @ 60ppm + RD of P&K (60:60)	8.24	10.82	10.46
T6	Nano DAP @ 40ppm + RDofN&K (120:60)	8.38	10.91	10.54
T7	Nano urea @ 60ppm + RD of P&K (60:60)+ Azotobacter@2 $kgha^{-1}$	8.79	11.21	10.92

T8	Nano urea @ 60ppm + RDofP&K (60:60) + Azotobacter @2 kg ha^{-1} +PSB@4 $kgha^{-1}$	8.93	11.28	11
T9	Nano DAP @ 40ppm + RD of N&K (120:60) + Azotobacter@2 $kgha^{-1}$	10.05	12.21	11.92
T10	Nano DAP @ 40ppm + RDofN&K (120:60) + Azotobacter @2 kg ha^{-1} +PSB@4 $kgha^{-1}$	10.19	12.28	12
F-test		**S**	**S**	**S**
S.E.(m) (±)		0.07	0.09	0.09
C.D.@ 5%		0.22	0.25	0.25
CV		1.36	1.27	1.3

3.6.Rootlength (cm): The analysis of effect of various treatments has been thoroughly examined andtheresultshavebeenpresentedinTable 5.The rootlength(cm)perplantofmustard*(Brassicajuncea*L.)depictseffectof treatment T10 [Nano DAP @ 40ppm + RD of N&K (120:60) + Azotobacter @2 kg ha^{-1} +PSB@4$kgha^{-1}$]wasfoundbestandrecordedsignificantlythehighestrootlength(cm)i.e.,71.28 cm. The 2nd best treatment i.e., T4 [RDF (120:60:60) + Azotobacter @2 kg ha^{-1} + PSB@4 kg ha^{-1}] was found with 70.89 cm root length (cm) where-as treatment T5 [Nano urea @60ppm+RDofP&K(60:60)]recordedsignificantlythelowestrootlength(cm)i.e.,57.06cm.It was also observed that the effect of Treatment T4 [RDF (120:60:60) + Azotobacter @2 $kgha^{-1}$ + PSB @4 kg ha^{-1}] and T9 [Nano DAP @ 40ppm + RD of N&K (120:60) + Azotobacter@2 kg ha^{-1}] was found statistically at par with treatment T10 [Nano DAP @ 40ppm + RD ofN&K(120:60)+Azotobacter@2$kgha^{-1}$+PSB @4 $kgha^{-1}$].

3.7. Daysto 50%flowering: The data pertaining to was recorded to Daysto 50%flowering in presented table no. 5**.** The effect oftreatmentT10[NanoDAP@40ppm+RDofN&K(120:60)+Azotobacter@2$kgha^{-1}$+PSB@4$kgha^{-1}$]wasfoundbestandrecordedsignificantlythelowestDaysto50% flowering i.e., 44.12 days. The 2nd best treatment i.e., T4 [RDF (120:60:60) + Azotobacter @2kg ha^{-1} + PSB @4 kg ha^{-1}] was found with 44.39 days for 50% flowering where-as treatmentT5[Nanourea@60ppm+RDofP&K(60:60)]recordedsignificantlythehighestDaysto50% flowering i.e.,52.72days.ItwasalsoobservedthattheeffectofTreatmentT4[RDF(120:60:60) +

Azotobacter @2 kg ha^{-1} + PSB @4 kg ha^{-1}] and T9 [Nano DAP @ 40ppm + RDof N&K (120:60) + Azotobacter @2 kg ha^{-1}] was found statistically at par with treatment T10[NanoDAP @ 40ppm +RD ofN&K (120:60)+Azotobacter@2 kgha^{-1}+PSB@4 kgha^{-1}].

3.8. Daysto50%maturity: The data pertaining to was recorded to daysto 50%maturity in presented table no. 5.ItwasfoundthattheeffectoftreatmentT10[NanoDAP@40ppm + RD of N&K (120:60) + Azotobacter @2 kg ha^{-1} + PSB @4 kg ha^{-1}] was found best andrecordedsignificantlythe lowestDaysto50%maturityi.e.,56.56days.The2ndbesttreatmenti.e., T4 [RDF (120:60:60) + Azotobacter @2 kg ha^{-1} + PSB @4 kg ha^{-1}] was found with 57.01 days for 50% maturity. Whereas,treatment T5 [Nano urea @ 60ppm + RD of P&K (60:60)]recorded significantly the highest Days to 50% maturity i.e., 69.98 days. It was also observedthat the effect of Treatment T4 [RDF (120:60:60) + Azotobacter @2 kg ha^{-1} + PSB @4 kg ha^{-1}]andT9[NanoDAP@40ppm+RDofN&K(120:60)+Azotobacter@2kgha^{-1}]was foundstatistically at par with treatment T10[Nano DAP @ 40ppm + RD of N&K (120:60) +Azotobacter@2 kgha^{-1}+PSB@4 kgha^{-1}].

Table5.EffectofIntegratedNutrient[Nanofertilizer(nanoureaandnanoDAP)andbiofertilizer(azotobacterandPSB)]Management onrootlength(cm), daysto50% flowering and daysto50% maturity of mustard

Symbols	Treatments	Rootlength (cm)	Daysto 50%flowering	Daysto50%maturity
T1	RDF(120:60:60) +Sulphur @25kgha^{-1}	68.1	46.12	59.86
T2	RDF(120:60:60) + Azotobacter@2 kgha^{-1}	64.92	48.12	62.92
T3	RDF(120:60:60) +PSB @4 kgha^{-1}	65.76	47.42	62.14
T4	RDF(120:60:60) + Azotobacter @2 kg ha^{-1} +PSB@4 kg ha^{-1}	70.89	44.39	57.01
T5	Nano urea @ 60ppm + RD of P&K (60:60)	57.06	52.72	69.98
T6	Nano DAP @ 40ppm +	59.4	51.42	68.26

	RDofN&K (120:60)			
T7	Nano urea @ 60ppm + RD of P&K (60:60)+ Azotobacter@2 kgha^{-1}	61.74	50.12	65.98
T8	Nano urea @ 60ppm + RDofP&K (60:60) + Azotobacter @2 kg ha^{-1} +PSB@4 kgha^{-1}	62.58	49.42	65.2
T9	Nano DAP @ 40ppm + RD of N&K (120:60) + Azotobacter@2 kgha^{-1}	70.44	44.82	57.58
T10	Nano DAP @ 40ppm + RDofN&K (120:60) + Azotobacter @2 kg ha^{-1} +PSB@4 kgha^{-1}	71.28	44.12	56.56
F-test		**S**	**S**	**S**
S.E.(m) (±)		0.44	0.31	0.42
C.D.@ 5%		1.3	0.92	1.25
CV		1.16	1.12	1.16

3.7 Numberofsiliquasper plant

AccordingtotheTable no. 6 datapertainingtothe number of siliquasper plant of mustard *(Brassica juncea* L.) depicts that the effect of treatment T10 [Nano DAP @ 40ppm + RD of N&K (120:60) + Azotobacter @2kg ha^{-1} + PSB @4 kg ha^{-1}] was found best and recorded significantly the highest number ofsiliquas per plant i.e., 117.17. The 2nd best treatment i.e., T4 [RDF (120:60:60) + Azotobacter@2 kg ha^{-1} + PSB @4 kg ha^{-1}] was found with 116.84 number of siliquas per plant where-astreatmentT5[Nanourea@60ppm+RDofP&K(60:60)]recordedsignificantlytheminimum number of siliquas per plant i.e., 96.63. It was also observed that the effect of Treatment T4[RDF(120:60:60)+Azotobacter@2kgha^{-1}+PSB@4kgha^{-1}]andT9[NanoDAP@40ppm +RDofN&K(120:60)+Azotobacter@2kgha^{-1}]wasfoundstatisticallyatparwithtreatment T10[NanoDAP@40ppm+RDofN&K(120:60)+Azotobacter@2kgha^{-1}+PSB@4kgha^{-1}].

3.8 Lengthof siliqua(cm)

The data pertaining to length of siliqua of mustard is presented in the table no. 6. It was found that,the effect of treatment T_{10} [Nano DAP @ 40ppm + RD of N&K (120:60) + *Azotobacter* @2 kg ha^{-1} + PSB @4 kg ha^{-1}] was found best and recorded significantly the highest length of siliqua (cm) i.e., 6.80 cm. The 2nd best treatment i.e., T_4 [RDF (120:60:60) + *Azotobacter* @2 kg ha^{-1} + PSB @4 kg ha^{-1}] was found with 6.71 cm length of siliqua (cm) where-as treatment T_5 [Nano urea @ 60ppm + RD of P&K (60:60)] recorded significantly the lowest length of siliqua (cm) i.e., 4.38 cm. It was also observed that the effect of Treatment T_4 [RDF (120:60:60) + *Azotobacter* @2 kg ha^{-1} + PSB @4 kg ha^{-1}] and T_9 [Nano DAP @ 40ppm + RD of N&K (120:60) + *Azotobacter* @2 kg ha^{-1}] was found statistically at par with treatment T_{10} [Nano DAP @ 40ppm + RD of N&K (120:60) + *Azotobacter* @2 kg ha^{-1} + PSB @4 kg ha^{-1}].

3.9. Numberof seedsper siliqua

The data pertaining to number of seeds per siliqua of mustard is presented in the table no. 6. It was foundthattheeffectoftreatmentT10[NanoDAP@40ppm + RD of N&K (120:60) + Azotobacter @2 kg ha^{-1} + PSB @4 kg ha^{-1}] was found best andrecordedsignificantlythe highestnumberofseedspersiliquai.e.,20.2.The2ndbesttreatmenti.e., T4 [RDF (120:60:60) + Azotobacter @2 kg ha^{-1}+ PSB @4 kg ha^{-1}] was found with 19.81numberofseedspersiliquawhere-astreatmentT5[Nanourea@60ppm+RDofP&K(60:60)]recorded significantly the lowest number of seeds per siliqua i.e., 12.95 days. It was alsoobserved that the effect of Treatment T4 [RDF (120:60:60) + Azotobacter @2 kg ha^{-1} + PSB@4 kg ha^{-1}] and T9 [Nano DAP @ 40ppm + RD of N&K (120:60) + Azotobacter @2 kg ha^{-1}]wasfoundstatisticallyatparwithtreatmentT10[NanoDAP@40ppm+RDofN&K(120:60) +Azotobacter@2 kgha^{-1}+PSB@4kgha^{-1}].

3.10. Weightof seed per plant(g)

The data pertaining to weight of seed per siliqua (g) of mustard *(Brassica juncea*L.) is presented in the table no. 6. Itdepictsthat,the effect of treatment T10 [Nano DAP @ 40ppm + RD of N&K (120:60) + Azotobacter@2kgha^{-1}+PSB@4kgha^{-1}]wasfoundbestandrecordedsignificantlythehighestweightofseedpersiliqua(g)i.e.,16.37g.The2ndbesttreatmenti.e.,T4[RDF(120:60:60)+Azotobacter@2kgha^{-1}+PSB@4 kgha^{-1}]wasfoundwith15.63gweightofseedpersiliqua(g)whereastreatmentT5[Nanourea@60ppm+RDofP&K(60:60)]recordedsignificantlytheminimum weight of seed per siliqua (g) i.e., 5.38. It was also observed that the effect of Treatment T4[RDF(120:60:60)+Azotobacter@2kgha^{-1}+PSB@4kgha^{-1}]andT9[NanoDAP@40ppm +RDofN&K(120:60)+Azotobacter@2kgha^{-1}]wasfoundstatisticallyatparwithtreatment T10[NanoDAP@40ppm+RDofN&K(120:60)+Azotobacter@2kgha^{-1}+PSB@4kgha^{-1}].

3.11. 1000seed weight (g)

The data pertaining to the 1000 seed weight (g) of mustard (*Brassica juncea* L.) is presented in the the table no. 6. This depicts that the effect of treatment T_{10} [Nano DAP @ 40ppm + RD of N&K (120:60) + Azotobacter @ 2kg ha^{-1} + PSB @4 kg ha^{-1}] was found best and recorded significantly the highest 1000 seed weight (g) i.e., 6.92 g. The 2nd best treatment i.e., T_4 [RDF (120:60:60) + Azotobacter @2 kg ha^{-1} + PSB @4 kg ha^{-1}] was found with 6.75 g 1000 seed weight (g) where-as treatment T_5 [Nano urea @ 60ppm + RD of P&K (60:60)] recorded significantly the minimum 1000 seed weight (g) i.e., 4.29 g. It was also observed that the effect of Treatment T_4 [RDF (120:60:60) + Azotobacter @2 kg ha^{-1} + PSB @4 kg ha^{-1}] and T_9 [Nano DAP @ 40ppm + RD of N&K (120:60) + Azotobacter @2 kg ha^{-1}] was found statistically at par with treatment T_{10} [Nano DAP @ 40ppm + RD of N&K (120:60) + Azotobacter @2 kg ha^{-1} + PSB @4 kg ha^{-1}].

Table 6. Effect of Integrated Nutrient [Nano fertilizer (nano urea and nano DAP) andbiofertilizer (azotobacter and PSB)] Management on Number of siliquasper plant, Lengthof siliqua(cm), Numberof seedsper siliqua, Weightof seed per plant(g) and 1000seed weight (g) ofmustard.

Symbols	Treatments	Number of siliqua plant^{-1}	Lengthof siliqua(cm)	Numberof seedssiliqua^{-1}	Weightof seed plant^{-1}(g)	1000seed weight (g)
T1	RDF(120:60:60) +Sulphur @25kgha^{-1}	111.73	6.25	18.78	13.25	6.31
T2	RDF(120:60:60) + Azotobacter@2 kgha^{-1}	106.29	5.70	17.06	10.34	5.70
T3	RDF(120:60:60) +PSB @4 kgha^{-1}	107.51	5.90	17.62	11.24	5.93
T4	RDF(120:60:60) + Azotobacter @2 kg ha^{-1} +PSB@4 kg ha^{-1}	116.84	6.71	19.81	15.63	6.75
T5	Nano urea @ 60ppm + RD of P&K (60:60)	96.63	4.38	12.95	5.38	4.29
T6	Nano DAP @ 40ppm + RDofN&K (120:60)	100.85	4.77	14.21	6.76	4.71
T7	Nano urea @ 60ppm + RD of P&K (60:60)+ Azotobacter@2 kgha^{-1}	105.07	5.12	15.37	8.23	5.09
T8	Nano urea @ 60ppm + RDofP&K (60:60) + Azotobacter @2 kg ha^{-1} +PSB@4 kgha^{-1}	102.07	5.32	15.93	8.66	5.32

T9	Nano DAP @ 40ppm + RD of N&K (120:60) + Azotobacter@2 kgha^{-1}	115.95	6.60	19.94	15.48	6.69
T10	Nano DAP @ 40ppm + RDofN&K (120:60) + Azotobacter @2 kg ha^{-1} +PSB@4 kgha^{-1}	117.17	6.80	20.2	16.37	6.92
F-test		**S**	**S**	**S**	**S**	**S**
S.E.(m) (±)		0.74	0.53	0.25	0.38	0.09
C.D.@ 5%		2.19	0.74	0.74	1.13	0.27
CV		1.18	2.52	2.52	5.93	2.74

Conclusion

Treatment T10 [Nano DAP @ 40ppm + RD of N&K (120:60) + Azotobacter @2 kgha^{-1}+PSB@4kgha^{-1}]wasfoundtobebestintermsofgrowthand yieldattributes.Itwasfoundto havebest effectin termsofyieldattributes.

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