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Response of nitrogen level and nano urea on mustard (*Brassica juncea* L.) under Konkan condition

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Abstract
Field experiment was conducted during *Rabi*, 2022 at Instructional Farm, Department of Agronomy, College of Agriculture, Dapoli, Ratnagiri, Maharashtra in lateritic soils of Konkan to study the effect of nitrogen levels and nano urea on growth, yield and quality of mustard (Brassica juncea) under lateritic soils of Konkan. The treatments comprise of various levels where, main factor (nitrogen levels) *viz*., 0, 100, 75% of RDN and sub factor (nano urea) *viz*., 0, 20, 40, 60, 80 ppm @ 30 and 60 DAS. Significantly positive effects and higher values were observed on plant height, number of branches plant^{-1}, number of functional leaves plant^{-1} and dry matter production at 40, 60 and 80 DAS (Days after sowing) of mustard crop with the application of 75% RDN (F_3) and two spray of nano urea @ 40 ppm (N_3) whereas, least values were recorded with untreated control (F_1N_1) treatment combination. Significantly higher seed yield (2083.57 kg ha^{-1}) and straw yield (3646.24 kg ha^{-1}) were observed when 75% RDN (F_3) and two spray of nano urea @ 40 ppm (N_3) was applied over other treatments and lower seed and straw yields ware observed with respect untreated (F_1N_1) treatment combination.

Keywords: Nano urea, mustard (*Brassica juncea* L.), RDN, growth, yield

1. Introduction

Indian mustard (*Brassica juncea* L.) is one of the major oilseed crop in India and has been cultivated since ancient times. India is the third largest Rapeseed-Mustard producer in the world. In India mustard is an important *rabi* oilseed crop contributes 28.6 percent in total production of oilseeds. Indian mustard locally known as "Khardal" belongs to family *Cruciferae* and genus *Brassica*. Mustard has two centers of origin i.e., China and Middle - East and India. Rapa is believed to be the oldest species having widest distribution. It is second most important edible oilseeds after groundnut which sharing 27.8 percent in oilseed economy of India. The share of oilseed is 14.1 percent among the total cropped area in India, rapeseed-mustard accounts for 3 percent of it. The global production of rapeseed-mustard 38-42 mt and its oil is around 12-14 mt. India contributes 28.3 and 19.8 percent in world acreage and production. India produces around 6.7 mt of rapeseed-mustard next to China (11-12 mt) and Europe (10-13 mt) with significant contribution for rapeseed-mustard industry in world.

The mustard oil is used for human consumption and also used for preparation of hair oils, greases, medicines and tanning industry. Oilcake is used as manure. Mustard Oil cake contains 'sinirgin' that causes palatability problem due to its bitter taste and glucosinolate which limits its use as a protein supplement for cattle's. Leaves of mustard used as green vegetables as they contain sulphur and other important minerals and plays a significant role in meeting vitamins, fibre, proteins requirements in human diet. Cultivation of mustard as vegetable has been a ritual for centuries throughout the world. India is suffering from a great shortage of edible oils. The gap between production of oils and consumption is more. There are losses of nitrogenous fertilizers in Indian soils. Productivity of mustard is very low because it is grown in rainfed condition, inadequate fertilizer deficiency of essential plant nutrients. Agriculture also has to face a number of challenges in crop production system such as yield stagnation. Multi-nutrient deficiencies, declining organic matter, low use efficacy of fertilizers, shrinking arable land, climate change, water availability and restricted labour.

Conventional fertilizers offer nutrients in chemical forms that are not often fully accessible to plants. Additionally, inversion of these chemical fertilizers to sparingly soluble forms in soil is the reason for the very low utilization of most of the added micronutrients. These problems make it imperative to go in for the repeated use of fertilizers. It is fairly well known that the yield of many crops has begun to drop as a result of imbalanced fertilization and decrease in soil organic matter. Nano fertilizers possess unique feature which enhance plant performance in terms of ultrahigh absorption, increase in production, rise in the leaves surface area. Beside the controlled released of nutrients contributes in preventing eutrophication and pollution in water resources. Replacement of traditional fertilizers by nano fertilizer is beneficial as upon application, it releases nutrients into the soil steadily and in a controlled way, thus, preventing the water pollution (Naderi and Danesh shahraki 2013, Moaveni and Kheiri, 2011) [1, 2].

The use of nano fertilizers not only causes increased use efficiency through ultra-high absorption of the nutrients, increase in photosynthesis caused by expansion in surface area of the leave but also reduce the toxicity generated due to over application in the soil as well as reduces the split application of fertilizer (Naderi and Danesh shahraki, 2013) [1]. Nano fertilizers and nanocomposites can be used to control the release of nutrients from the fertilizer granules so as to improve the nutrient use efficiency while preventing the nutrient ions from either getting fixed or lost to the environment (Subramanian *et al.* 2008) [3]. Nano urea (liquid) contains nano scale nitrogen particles which have more surface area (10,000 times over 1 mm urea prill) and number of particles (55,000 nitrogen particles over 1 mm urea prill). Further application of nano urea (liquid) improves yield, soil health, biomass, and nutritional quality of the produce (Prem Baboo, 2021) [4].

2. Materials and Methods

The field experiment was conducted at Instructional Farm, Department of Agronomy, Collage of Agriculture Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli during *Rabi*, 2022 with the mustard variety of Varuna. The site was selected on the basis of suitability of soil for growing of mustard under Konkan region. Topography of the plot was fairly uniform and flat. The soil analysis indicated that, the experimental plot was sandy clay loam in texture, low in available nitrogen (241.5 kg ha^{-1}), low in available phosphorus (10.03 kg ha^{-1}) and medium in available potassium (324.59 kg ha^{-1}), very high in organic carbon (12.03 g kg^{-1}) and acidic in reaction (pH 6.29).

The experiment was laid out in split plot design (SPD) with main factor (nitrogen levels) three treatments and sub facto (nano urea) five treatments replicated three times. The treatments are as given in table. The recommended dose of fertilizers (90: 45: 00 kg N, P and K kg ha^{-1}) and other package of practices for mustard were imposed uniformly for all the treatments including control treatments.

Table 1: Treatment details for the field experiment

Symbols	Treatments
A.	**Main Factor (Nitrogen levels)**
F_1	Control
F_2	100% of Recommended Dose of Nitrogen (RDN)
F_3	75% of Recommended Dose of Nitrogen (RDN)
B.	**Sub Factor (Nano urea)**
N_1	Control
N_2	Nano urea- 20 ppm
N_3	Nano urea- 40 ppm
N_4	Nano urea- 60 ppm
N_5	Nano urea- 80 ppm
Method of application: Foliar spray of nano urea 1st Application: 30 Days after sowing 2nd Application: 60 Days after sowing.	

3. Results and Discussion

In mustard (*Brassica juncea* L.) var. Varuna, the plant growth and yield attributes as well as crop yields were highly influenced by different treatments.

3.1 Effect on growth parameters

There was significance difference between treatments combinations for the plant height, number of branches $plant^{-1}$ and dry matter production of mustard crop at 40, 60 DAS (Days after sowing) and 80 DAS of mustard crop but no significant difference at 20 DAS, number of leaves found non-significant during all observations.

Table 2: Mean growth attributing characters of mustard as influenced by the different treatments

Treatments	Plant height (cm)				Number of branches $plant^{-1}$			
	20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**20 DAS**	**40 DAS**	**60 DAS**	**80 DAS**
Main plot								
F_1	6.62	54.81	84.97	95.63	1.05	2.38	3.47	5.14
F_2	12.07	101.04	121.24	137.81	1.24	6.45	8.39	11.23
F_3	10.37	106.76	125.65	141.47	1.21	7.13	8.95	11.86
S.Em. ±	0.11	0.11	0.27	0.21	0.01	0.09	0.19	0.05
C.D. at 5%	0.44	0.45	1.04	0.81	0.04	0.35	0.73	0.21
Sub Plot								
N_1	9.50	82.11	103.98	116.20	1.13	4.62	6.34	8.69
N_2	9.51	89.09	113.07	128.51	1.16	5.44	7.00	9.51
N_3	9.67	91.91	116.82	132.20	1.21	5.71	7.25	9.82
N_4	9.66	88.09	110.58	124.88	1.19	5.51	7.11	9.58
N_5	10.09	86.49	108.67	123.07	1.16	5.30	6.97	9.45
S.Em. ±	0.16	0.17	0.20	0.31	0.02	0.07	0.10	0.06
C.D. at 5%	N.S.	0.51	0.60	0.92	N.S.	0.21	0.29	0.16
Interaction Effect								
S.Em. ±	0.28	0.30	0.35	0.54	0.04	0.13	0.17	0.10
C.D. at 5%	N.S.	0.88	1.03	1.59	N.S.	0.37	0.49	0.28
General Mean	9.69	87.54	110.62	124.97	1.17	5.32	6.93	9.41

3.1.1 Effect of nitrogen levels

The data pertaining to various growth attributing character *viz*., plant height (cm), number of branches plant^{-1}, number of leaves plant^{-1}, dry matter production plant^{-1} (g) of mustard were influenced significantly under the different nitrogen levels.

Plant height (Table 2) increased with the advancement in age of the crop and significantly higher values were observed in fertilizer level nitrogen level F_3 (75% of RDN) after 40 DAS till harvest. F_3 (75% of RDN) this treatment was found superior over rest of the nitrogen levels during study followed by F_2 (100% of RDN. These results were corroborated with the findings of Bhari *et al.* (2000) [7], Patil *et al.* (1997) [22], Jadhav (1992) [10], Khan *et al.* (2010) [14], Majnoun-hosseini *et al*. (2006) [20] also reported that levels of nitrogen significantly affect the plant height.

The growth stages at which number of siliquae is determined by the branching. The mean number of branches plant^{-1} (table 2) influenced periodically by the different treatments. In respect of branches responded in accordance with the nitrogen levels tested during the experimentation, the number of branches plant^{-1} influenced significantly during the study period. From 60 DAS till the harvest. Treatment F_3 i.e., (75% of RDN) recorded significantly more branches plant^{-1} over the rest of the treatments at all observations followed by F_2 (100% of RDN). These findings were supported by the observations registered in relation to plant height, number of branches plant^{-1}, number of functional leaves and dry matter accumulation during the investigation. These results are agreement with those of Kumar *et al.* (2016) [16], Bisht *et al.* (2018) [8], Shagata *et al.* (2020) [25] and Sukirtee *et al.* (2018) [29].

Table 3: Mean growth attributing characters of mustard as influenced by the different treatments

Treatments	Number of leaves Plant^{-1}				Number of branches plant^{-1}			
	20 DAS	40 DAS	60 DAS	80 DAS	20 DAS	40 DAS	60 DAS	80 DAS
Main plot								
F_1	2.72	8.40	15.55	10.05	1.26	6.78	14.78	25.78
F_2	3.39	16.11	26.33	19.49	1.60	13.33	23.86	39.23
F_3	3.25	17.39	28.15	20.65	1.38	14.27	26.58	41.86
S.Em. ±	0.04	0.22	0.36	0.40	0.05	0.08	0.54	0.58
C.D. at 5%	0.14	0.85	1.41	1.57	0.20	0.33	2.12	2.27
Sub Plot								
N_1	3.01	12.63	21.98	15.51	1.35	10.24	20.07	34.14
N_2	2.97	14.01	23.94	17.48	1.36	11.40	21.56	35.60
N_3	3.09	15.01	25.18	18.02	1.43	12.14	22.68	36.45
N_4	3.23	14.38	23.51	17.04	1.47	11.73	22.17	35.93
N_5	3.30	13.80	22.11	15.61	1.47	11.80	22.23	36.00
S.Em. ±	0.16	0.17	0.20	0.31	0.04	0.11	0.22	0.13
C.D. at 5%	N.S.	0.51	0.60	0.92	N.S.	0.33	0.65	0.36
Interaction Effect								
S.Em. ±	0.19	0.56	0.96	0.91	0.06	0.19	038	0.22
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	0.57	1.12	0.63
General Mean	3.12	13.97	23.37	16.73	1.42	11.46	21.74	35.62

Similarly, mean number of functional leaves plant^{-1} (Table 3) was also influenced due to the different nitrogen level during all the growth stages except at harvest. The higher number of functional leaves plant^{-1} were found at 60 DAS. Decreasing trend was observed in respect of number of functional leaves at 60 DAS till harvest. F_2 (100% of RDN) treatment recorded significantly higher number of leaves plant^{-1} than the remaining treatments from 20 DAS till 80 DAS followed by F_3 (75% of RDN). The mean dry matter accumulation (g plant^{-1}) (table 3) influenced significantly from 40 DAS till the harvest. These findings were scrutinized in relation to the effect of nitrogen levels. This higher dry matter accumulation in F_3 (75% of RDN) followed by F_2 (100% of RDN was observed due to mainly availability of nutrients to the crop show their performance at highest level which leads to synthesis of more source which hasted more dry matter production. These results are in agreement with those of Khatkar *et al.* (2009) [15].

3.1.2 Effect of nano urea

The data pertaining to various growth attributing character *viz*., plant height (cm), number of branches plant^{-1}, number of leaves plant^{-1}, dry matter production plant^{-1} (g) of mustard were influenced significantly under the different nano urea levels. The findings indicated that, the nano urea spray significantly found to be superior in respect of almost all parameters under study.

The treatment N_3 (spraying of nano urea @ 40 ppm) recorded significantly more plant height (Table 2) than the remaining treatments from 40 DAS till the harvest stage. The treatment N_3 (40 ppm) also recorded significantly higher number of leaves plant^{-1} than the remaining treatments at all growth stages except 20 DAS and at harvest followed by N_2 and N_4 which were at par with each other during all the growth stages except 20 DAS and at harvest stage in respect of levels of significance. Significantly higher number of branches (table 2) were observed under the treatment N_3. Two spray of nano urea @ 40 ppm produces significantly more dry matter over rest of the treatment except 20 DAS. Nano fertilizers increase availability of nutrient to the growing plant which increase chlorophyll formation, photosynthesis rate, dry matter production and result improve overall growth of the plant. These results are in collaboration with Kanjana (2020) [12]. Who reported that, as compared to conventional, commercially available nano urea were better in increasing growth and yield parameters.

3.1.3 Interaction effect of nitrogen levels and nano urea

The interaction effect between nitrogen level and nano urea spray with respect to plant height, number of branches plant^{-1}, dry matter production plant^{-1} (g) (table 2 and 3) was found significant at 40, 60, 80 and at harvest. Nitrogen level 75% RDN with foliar application of 40 ppm nano urea recorded significantly higher plant height over rest of the treatment combinations of (F_3N_3) and found non-significant with respect to number of leaves plant^{-1}. This increase in the most of growth attributing characters under F_3N_3 combination is due to addition of nutrient application via foliar spray of nano urea which might have made instant availability of the nutrients for biochemical activities in conjugation with mustard crop in terms of formation of more source. This ultimately favour formation of more photosynthates that accumulate into the sink.

3.2 Effect on yield and yield attributing characteristics

The data pertaining to the yield attributing characters of mustard *viz.*, number of siliquae plant, number of seed siliquae, length of siliquae (cm) and test weight (g) (Table 4).

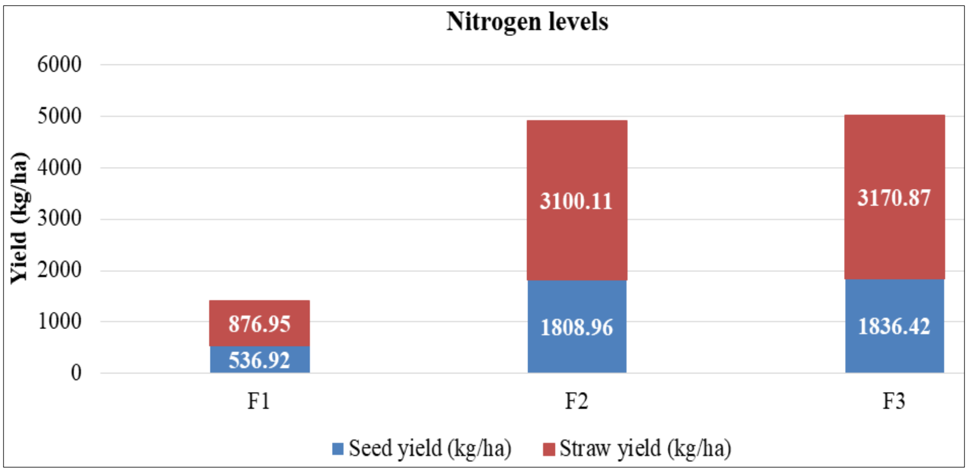
3.2.1 Effect of nitrogen levels

The data pertaining to the number of seeds per siliquae revealed that significantly more number of seeds was observed under nitrogen level F_3 (75% of RDN) and it was followed F_2 (100% of RDN. The possible reason could be an increase in number of siliquae due to nitrogen. The number of seeds per siliquae directly proportional to the nitrogenous fertilizer. Secondly though application of 75% recommended dose of nitrogen (RDN) recorded higher number of seeds per siliquae compared to 100% recommended dose of nitrogen (RDN) may be because of leaching or volatile losses of nitrogen which is detrimental to environment. (Roosta and Schjoerring 2007, Gao, *et al*. 2012.)

Table 4: Mean yield and yield attributing characters of mustard as influenced by the different treatments

Treatment	Number of siliquae plant^{-1}	Number of seed siliquae^{-1}	Length of siliquae (cm)	Test weight (g)	Seed yield kg ha^{-1}	Straw yield kg ha^{-1}
Main plot						
F_1	76.56	8.91	3.16	3.38	536.92	876.95
F_2	162.24	12.09	4.08	4.16	1808.96	3100.11
F_3	166.05	12.47	4.27	4.29	1836.42	3170.87
S.Em. ±	1.76	0.08	0.06	0.07	10.58	18.25
C.D. at 5%	6.91	0.30	0.22	0.29	41.54	71.53
Sub Plot						
N_1	116.18	10.18	3.56	3.75	1162.42	1945.44
N_2	137.48	11.36	3.94	4.01	1468.93	2524.79
N_3	156.92	11.82	4.06	4.03	1539.31	2667.40
N_4	137.60	11.47	3.93	4.01	1470.52	2512.11
N_5	126.58	10.96	3.71	3.93	1329.33	2263.47
S.Em. ±	1.85	0.17	0.09	0.04	25.51	43.69
C.D. at 5%	5.39	0.48	0.27	0.10	74.44	127.50
Interaction effect						
S.Em. ±	3.20	0.29	0.16	0.10	44.18	75.67
C.D. at 5%	9.34	N.S.	N.S.	N.S.	128.93	220.82
General Mean	134.95	11.16	3.84	3.94	1394.10	2382.64

The higher seed number per siliqua in F_3N_3 treatment combination implicated that in lower densities, due to lesser competition within the plants and a sufficient light intensity as a potent source for increasing crop biomass, higher dry matter accumulated in siliqua. Consequently, it increased the seed number per siliqua by producing lower number of shriveled seeds (Rana and Pachauri, 2001; Siadat *et al*., 2010) [23, 26]. These results were in line with the findings of Shagata *et al.* (2020) [25]. The data pertaining to the length of siliquae (cm) of mustard revealed that, significantly more length was observed under the nitrogen levels F_3 (75% of RDN) followed by F_2 (100% of RDN). Levels of nitrogen represented their significance in respect of the values to the test weight (g). The treatment F_3 (75% of RDN) recorded higher value of 1000 seeds weight (test weight) followed by F_2 (100% of RDN). Similar findings were reported by Singh (2002) [27], Khatkar *et al.* (2009) [15] and Singh (2010) [28].



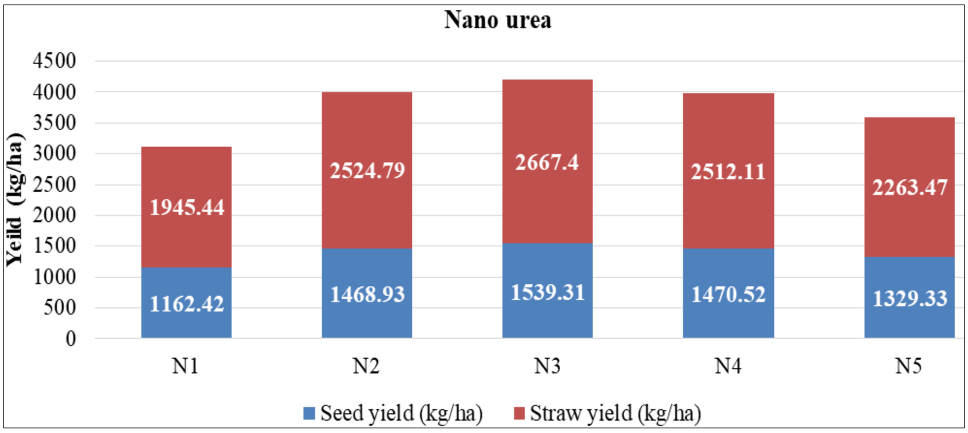


Fig 1: Graph showing seed and straw yield

The data pertaining to the seed yield and straw yield (kg ha^{-1}) of mustard as influenced by the different treatments reveals that, the mean seed yield (kg ha^{-1}) implies treatment F_3 (75% of RDN) recorded significantly higher seed yield (1836.42) followed by F_2 (100% of RDN) recorded (1808.96) but found at par with each other. The treatment F_3 (75% of RDN) recorded significantly maximum straw yield (3170.87 kg ha^{-1}) followed by F_2 (100% of RDN). These results are in conformity with Murudkar (2002) [21], Akbari *et al.* (2011) [6], Keivanrad and Zandi (2012) [13], (Babar and Dongale, 2013) [9] and Kumar *et al.* (2016) [16]. Application of nitrogen enhance the cell division and multiplication which enhance cell elongation that strengthen the sink capacity which favours to acquire more photosynthesis.

Application of 75% recommended dose of nitrogen (RDN) recorded significantly higher seed yield compared to 100% recommended dose of nitrogen (RDN) the possible reason for increasing seed yield is to produce more number of branches $plant^{-1}$, number seeds per siliquae, length of siliquae and 1000 seed weight which could be positive effect of nitrogen as a nitrogen is believed to help in cell division and expansion strengths sink capacity and acquired more photosynthates. The large source created F_3 and F_2 results in production of sink i.e., number of siliquae plant, number of seed siliquae, length of siliquae (cm) and test weight (g). Therefore, the seed and straw yield ha^{-1} were under F_3 (75% of RDN) followed by F_2 (100% of RDN) than control. These results are in conformity with Maity *et al.* (1980) [19], Patil *et al.* (1996) [22], Ahmad *et al.* (1998) [5], Khatkar *et al.* (2009) [15] and Kachroo and Kumar (1999) [11].

3.2.2 Effect of nano urea

The higher value regarding to the mean number of siliquae $plant^{-1}$ under treatment N_3 (two spray of nano urea @ 40 ppm) over the remaining nano urea sprays treatment. However, significantly higher length of siliquae (4.06 cm) was observed under treatment N_3 (40 ppm) followed N_4 and N_2 which was at par with each other. Kumar *et al.* (2022) [18] also found increase in number of siliquae $plant^{-1}$ and number of seeds per siliquae by using nano urea. The mean number of seeds per siliquae was also significantly influenced due to nano urea spray. Significantly higher number of seeds per siliquae was found under the treatment N_3 followed by N_4 and N_2, which was at par with each other. The enhancement in the growth attributes results with increase in the photosynthetic activities with production of more photosynthates produced that accumulate into sink which has shown positive effect in number of siliquae $plant^{-1}$, seeds per siliquae, length of siliquae and test weight (g).

The increase in yield (table 4 and graph 1) might be directly associated with concomitant increase in growth and yield attributes of mustard plant, because of improved nutritional environment in the plant metabolic system leading to higher plant metabolism and photosynthetic activity due to nano urea. Two spray of nano urea @ 40 ppm (N_3) produces significantly higher seed yield (1539.31 kg ha^{-1}) which was significantly higher than the other nano urea treatments. Similarly, data pertaining to the straw yield observed that, two spray of nano urea @ 40 ppm (N_3) produced significantly higher straw yield (2667.40 kg $ha^{-1)}$ over remaining treatments. This can be attributed to higher photosynthetic activities in the crop provided with two sprays of nano urea @ 40 ppm (N_3) than the other treatments, which stimulated growth in both roots and shoots, which consequently induced higher biomass production that finally resulted in production of significantly higher straw yield. Similar results were also observed by Kumar *et al.* (2020) [17] and Kumar *et al.* (2022) [18].

3.2.3 Interaction effect of nitrogen levels and nano urea

Mean number of siliquae $plant^{-1}$ influenced significantly due to interaction effect between nitrogen level and nano urea and treatment combination F_3N_3 i.e., application of 75% RDN with foliar application of 40 ppm nano urea recorded significantly higher value (200.53) than the remaining treatment combinations except F_2N_3 (195.03) which were at par with each other. The seed yield and straw yield (kg ha^{-1}) of mustard influenced significantly due to the interaction effects between nitrogen levels and nano urea spray. The treatment combination F_3N_3 i.e., application of 75% of RDN along with 40 ppm foliar spray of nano urea recorded significantly higher seed and straw yield followed by except F_3N_2, F_2N_3 which was found at par with each other.

4. Conclusion

The study on response of nitrogen level and nano urea on mustard (*Brassica juncea* L.) under Konkan condition concluded that, application of 75% Recommended dose of nitrogen (RDN) along with two sprays of nano urea @ 40 ppm significantly recorded higher growth attributing characters, yield and yield attributing characters in mustard crop, as well as registered maximum gross returns (1, 110, 80 Rs. ha^{-1}), net returns (36,097 Rs. ha^{-1}) and highest B: C ratio (1.48). Thus, spraying of nano urea @ 40 ppm could substitute's 25% nitrogen need of mustard crop, which can economize the 25% nutrient requirement without any detrimental effect on mustard production. Hence, 75% Recommended dose of nitrogen (RDN) along with two sprays of nano urea @ 40 ppm is judicious blend in south Konkan region of Maharashtra to stabilized yield of mustard at maximum level without adverse effect on soil.

5. References

1. Naderi MR, Danesh-Shahraki A. Nano fertilizers and their roles in sustainable agriculture. International Journal of Agriculture and Crop Sciences. 2013;5:2229-2232.
2. Moaveni P, Kheiri T. In 2nd International Conference on Agricultural and Animal Science; November 25-27, in Maldives. Singapore: IACSIT Press. 2011;22:160-163.
3. Subramanian KS, Paulraj C, Nataraja S. Nanotechnological approaches I nutrient management in nanotechnology application in agriculture. 2008;37-42.
4. Prem B. Nano urea the philosophy of future, research gate academic social networking site. 2021.
5. Ahmad A, Abraham G, Gandotra N, Abrol YP, Abdin MZ. Interactive effect of nitrogen and sulphur on growth and yield of rapeseed-mustard (*Brassica juncea* L.) and (*Brassica campestris* L.) genotypes. J. Agron. Crop Sci. 1998;181:193-19.
6. Akbari P, Ghalavand A, Modarres, Sanavy AM, Alikhani MA. The effect of biofertilizers, nitrogen fertilizer and farmyard manure on grain yield and seed quality of sunflower (*Helianthus annus* L.). J. of Agril. Tech. 2011;7(1):173-184.
7. Bhari NR, Siag RK, Mann PS. Response of Indian mustard (*Brassica juncea* L.) to nitrogen and phosphorus on Tropopsamments of north-western Rajasthan, Indian. Agron. 2000;45:746-751.
8. Bisht S, Saxena AK, Singh S. Effect of integrated nutrient management on growth and yield of mustard (*Brassica juncea* L.) cultivar T-9 under Dehradun region (Uttarakhand). International Journal of Chemical Studies. 2018;6 (4) 1856-1859.
9. Babar S, Dongale JH. Effect of organic and inorganic fertilizers on soil crop productivity under mustard-cowpea –rice cropping sequence on lateritic soil of Konkan. An Asian Journal of Soil Science. 2013;6(1):33-3.
10. Jadhav AD. Effect of FYM and vermicompost on the yield of rice (*Oryza sativa* Linn.) and physic-chemical properties of lateritic soil of Konkan. M.Sc. (Agri.) Thesis submitted to Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished). 1992.
11. Kachroo D, Kumar A. Seed weight, oil and protein contents of Indian mustard (*Brassica juncea* L.) as influenced by nitrogen and sulphur fertilization. Annals Agric. Res. 1999;20:369-371.
12. Kanjana D. Evaluation of foliar application of different types of nano fertilizers on growth, yield and quality parameters and nutrient concentration of cotton under irrigated conditions. Int. J. Curr. Microbial. App. Sci. 2020;9(7):429-444.
13. Keivanrad S, Zandi P. Effect of nitrogen levels on growth, yield and oil quality of Indian mustard grown under different plant densities. J Agric. Sci. 2012;45(2):105-113.
14. Khan AM, Rajamaniand AK, Reddy PK. Effect of integrated nutrient management on yield, quality, nutrient content and uptake of sweet sorghum in pongamia based Agri silviculture system. Ind. J. Dryland Agril. Res. and Dev. 2010;25(2):95-99.
15. Khatkar Y, Dawson J, Zade KK, Dixitand PM, Khatkar R. Effect of nitrogen, phosphorus and sulphur fertilization on growth and yield of mustard (*Brassica juncea* L.) Int. J. Agric. Sci. 2009;5(2):396-398.
16. Kumar V, Kandpal BK, Dwivedi A, Kumar SV, Kumar V and Sharma DK. Effect of nitrogen and zinc fertilizer rates on growth, quality and yield of Indian Mustard (*Brassica juncea* L.). International Journal of Agril. Sci. 2016;8(06):1031-1035.
17. Kumar Y, Tiwari KN, Nayak RK, Abhimanyu RA, Singh SP, Singh AN, *et al*. Nano fertilizers for increasing nutrient use efficiency, yield and economic returns in important winter season crops of Uttar Pradesh. Indian Journal of Fertilisers. 2020;16(8):772-786.
18. Kumar A, Singh K, Verma P, Singh O, Panwar A, Singh T, *et al*. Effect of nitrogen and zinc nano fertilizer with the organic farming practices on cereal and oil seed crops. Scientific reports. 2022 Apr 28;12(1):1-7.
19. Maity PK, Sengupta AK, Jana PK. Response of mustard variety Varuna to levels of irrigation and nitrogen. Indian agriculturist. 1980;24(1):43-47.
20. Majnoun-hosseini N, Alizadeh HM, Malek-ahmadi H. Effects of plant density and nitrogen rates on the competitive ability of canola (*Brassica napus* L.) against weeds. J. Agric. Sci. Technol. 2006;8:281-291.
21. Murudkar MR. Integrated nutrient management system for productivity potential of hybrid rice (*Oryza sativa* L.)-Mustard (*Brassica juncea* L.) cropping sequence. M.Sc. (Agri) Thesis submitted to Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished). 2002.
22. Patil BN, Lakkineni KC, Bhargava SC. Ontogenic changes in growth and assimilate distribution as influenced by N supply in rapeseed-mustard. y. Agron. Crop. Sci. 1997;178:15-21.
23. Rana DS, Pachauri DK. Sensitivity of zero erucic acid genotypes of Oleiferous Brassica to plant population and planting geometry. Ind. J Agron. 2001;46:736-740.
24. Roosta HR, Schjoerring JK. Effects of ammonium toxicity on nitrogen metabolism and elemental profile of cucumber plants. Journal of Plant Nutrition. 2007;30(11):1933-1951.
25. Shagata IS, Mohammed ASP, Mohammed AS, Moshtari AM, Mohammed AH, Biswas A, *et al*. Effects of nitrogenous fertilizer on growth and yield of Mustard Green Tropical Plant Research. 2020;7(1):30-36.
26. Siadat SA, Sadeghipour O, Hashemi-dezfouli AH. Effect of nitrogen and plant density on yield and yield component of Rapeseed. J Crop Prod. Res. 2010;2:49-62.
27. Singh PC. Effect of different levels of nitrogen and phosphorus on yield, yield components and oil content of mustard (*Brassica juncea* L.) cv. Varuna. J. Living World. 2002;9:1-4.
28. Singh RK, Singh Y, Singh AK, Rakesh Kumar, Singh VK, Anjani Kumar, *et al*. Response of fertility level on growth, yield and economics of Indian mustard (*Brassica juncea* L.) varieties under late sown condition. Int. J. Trop. Agric. 2010;28:379-383.

29. Sukirtee Singh YV, Rajan KR, Menka K, Bharteey PK. Interaction effect of nitrogen and Sulphur on yield, oil and nutrient content of mustard (*Brassica juncea* L.) in an Inceptisol. International Journal of Chemical Studies. 2018;6(6):1234-1238.