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Sumit Chaudhary
Ph.D. Scholar, Department of Agronomy, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

Anil Shukla
Professor, Department of Agronomy, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

Rajeew Kumar
Senior Research Officer, Department of Agronomy, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

MS Negi
Professor, Department of Agronomy, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

Naresh Malik
Professor, Department of Agronomy, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

PC Srivastava
Professor, Department of Soil Science, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

Corresponding Author:
Sumit Chaudhary
Ph.D. Scholar, Department of Agronomy, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India

Performance of Indian mustard (*Brassica juncea* L.) as influenced by application of nano sized gypsum

Sumit Chaudhary, Anil Shukla, Rajeew Kumar, MS Negi, Naresh Malik and PC Srivastava

Abstract
A field experiment was conducted during *rabi* season at NEB Crop Research Centre, Pantnagar, Uttarakhand to assess the effect of nano sized gypsum on performance of Indian mustard. The experiment consisting of ten treatments was laid out in randomized block design (RBD) with three replications during both the year of experimentation. The result revealed that seed treatment with nanosized gypsum along with 100% RDF remained significantly superior over all the other treatments in terms of seed yield during both the years. Foliar application of nanosized gypsum along with 100% RDF and soil treatment with nanosized gypsum along with 100% RDF remained at par with 100% RDF in terms of yield attributes and seed yield. Application nano sized gypsum through seed treatment resulted in better performance of Indian mustards as compared to other application methods. From the study it can be concluded that 100% RDF along with seed treatment with nanosized gypsum could be beneficial in boosting up the performance and productivity of Indian mustard under *tarai* region of Uttarakhand.

Keywords: nanosized, mustard, seed treatment, yield

Introduction
Despite of these statistical facts, India still continuous to be a major importer of oilseeds to meet the demands of its ever burgeoning population. Oilseed sector plays a pivotal role in forming the economy of nation. Globally, India ranks fourth in terms of vegetable oil economy and is after USA, China and Brazil. India is one of the largest oilseeds producing country that covers one fifth of the entire area under this group of crops and also yields one-fifth of the total oilseed production in the world. Globally, rapeseed mustard is grown by more than sixty nations including India. In terms of average yield, India (1128 kg/ha) is about 63% below the world average yield (1840 kg/ha) of rapeseed and mustard. In India, it is cultivated by more than 26 states (including Union Territories) with Rajasthan, Madhya Pradesh, Uttar Pradesh, Haryana and West Bengal being that major players in terms of area and production of rapeseed –mustard (DRMR (2020) and DOD (2020)) [4]. The crop grows well under both irrigated and rainfed conditions. Being more responsive to fertilizers, it give better return under irrigated condition, however only 30-40% of nutrients applied through fertilizers are utilized by the crops and the remaining is lost through various pathway (Davari and Mirzakhani, 2009) [2]. The seed and oil are used as a condiment in the preparation of pickles, flavouring, curries and vegetables as well as for cooking and frying purposes. Its oil is used in many industrial products, cake as cattle feed and manure and green leaves for vegetable and green fodder (Chauhan *et al*. 2011) [1].

Being a major source of edible oil (also soybean and groundnut oil) in India, it is very important to boost up yield and quality of crop. However, the yield tends to be stagnant under conventional management practices and needs to be upgraded with time and requirement of users. The nutrient requirements of mustard depend on the soil type and organic matter content. Rate of nutrient application depends on the initial soil status, climate, topography, cropping system in practice and crop husbandry. In India fertilizers application is little or non-existent as compared to global consumption of fertilizers which ultimately leads to poor productivity of crop. In India, nano- technology is emerging as a new area of study for input management in field crops like wheat and maize. However, at farmers levels its dissemination and adoption is less. Potential applications of nanotechnology in Indian agriculture include nano-fertilizers, nano herbicides nano insecticides/pesticides nanosensors for soil quality and plant health monitoring and many other. Nano-fertilizers release the nutrients as on-demand and preventing them from prematurely converting into chemical/gaseous forms.

Nano particles have the potential to interact within the plant system and helps in improving metabolic activity of plants and stress tolerance to biotic and abiotic stresses. Also they posses potential to increase the crop productivity by enhancing germination, improving growth, better photosynthesis, nitrogen metabolism and protein &carbohydrate synthesis in plants (Iqbal and Umar, 2019) [5]. Some of the ways for application can be seed treatment, soil application and foliar spray (Raliya, 2012; Tarafdar, 2012) [6, 7]. Considering the above facts in view, the present investigation was undertaken to assess the influence of nanosized gypsum on yield of Indian mustard.

Materials and Methods

The present study was carried out during *rabi* season of 2016 and 2020 at the Norman E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar, District Udham Singh Nagar, Uttarakhand. Pantnagar (29^0 N latitude, 79.29^0 E longitude and an altitude of 243.83 m above mean sea level) to assess the influence of nanosized gypsum on yield of Indian mustard. The soil of the experimental site was silty clay loam with pH 7.3, organic carbon 0.89%; and 269, 22.3 and 241 kg/ha of N, P_2O_5 and K_2O, respectively.The experiment consisting of ten treatments *v.i.z* T_1: 100% RDF alone; T_2: Seed treatment @ 50 ppm with nanosized gypsum along with 100% RDF; T_3: Soil application of nanosized gypsum @ 20 g/ha along with 100% RDF; T_4: Foliar spray @ 50 ppm with nanosized gypsum along with 100% RDF; T_5:Seed treatment @ 50 ppm with nanosized gypsum along with 75% RDF; T_6: Soil application of nanosized gypsum @ 20 g/ha along with 75% RDF; T_7: Foliar spray @ 50 ppm with nanosized gypsum along with 75% RDF; T_8:Seed treatment @ 50 ppm with nanosized gypsum along with 50% RDF; T_9:Soil application of nanosized gypsum @ 20 g/ha along with 50% RDF and T_{10}: Foliar spray @ 50 ppm with nanosized gypsum along with 50% RDF was laid out in randomized block design along with three replications. Application of nano sized gypsum through seed treatment (50 ppm), foliar spray (50 ppm after first irrigation) and soil application (broadcasting 20g/ha as basal mixing with sand) along with different RDF (RDF@120:40:20 kg N: P_2O_5:K_2O) levels were done. Normal crop husbandry was followed for management of crop. The nanosized gypsum was taken from Nanotech lab of Department of Agronomy, College of Agriculture, GBPUAT, Pantnagar, Uttarakhand, India. The nano sized gypsum was applied as per the treatment. For soil application it was mixed with soil and then broadcasted in the experimental plot prior to sowing. The experimental data obtained from various observations on growth, yield and quality were analysed using standard procedure for randomised block design and treatment comparisons were made at 5 per cent level of significance.

Results and Discussions

The data pertaining to plant height, total branches per plant at harvest, total siliquae per plant at harvest and seed yield of Indian mustard for both the year of experimentation is presented in Table 1.

The maximum plant height was obtained in treatment T3 and T2 during the year 2016 and 2020, respectively. The influence of various treatments found to be non-significant on plant height during both the years. During 2016, maximum branches/plant was obtained in treatment T4 and it remained significantly superior over all the treatments except T1, T2 and T3 where it did not differ significantly. During second year of expermentation, T2 remained significantly superior over all the other treatments in terms of branches per plant except T1, T3 and T4 where it did not differ significantly. More branches per plant might be due to more availibilty of nutrients under 100% RDF condition. With decrease in fertility levels, there was decrease in branches per plant during both the years; however no significant difference were seen in 75% and 50% RDF levels for branchers per plant. Silquae per plant were obtained maximum in treatment T2 and remained significantly superior over all the other treatments during both the years. With decrease in fertility levels, number of siliqua per plant decreased and minimum siliquae per plant was recored with 50% RDF levels for both the years.

Maximum siliquae per plant in T2 revealed that application of nano sized gysum through seed treatment can help in increasing number of siliquae of mustard under 100% RDF levels. The application of nano sized gypsum through foliar application and soil application along with 100% RDF did not differ significantly with each other and also remained at par with 100% RDF. With reduction in RDF levels, influence of nano sized gypsum was non-significant on performance of mustard crop. The data pertaining to seed yield also followed the similar pattern as in case of siliquae per plant. Higher seed yield were obtained in treatment T2 during both the years and remained significantly superior over all the other treatments. More seed yield with application of nano sized gypsum through seed treatment along with 100% RDF may be attributed to more number of total siliquae per plant under this treatment. With decrease in fertility levels yield decrease was significant.

Table 1: Performance of Indian mustard as influenced by nano sized gypsum

Treatment(s)	Plant height (cm)		Brancher per plant		Siliquae per plant		Seed yield (kg/ha)	
	2016	2020	2016	2020	2016	2020	2016	2020
T_1	175.1	176.3	35.2	38.0	359.7	382.0	1,660	1,725
T_2	177.2	184.3	39.4	39.3	415.3	427.0	1,892	1,936
T_3	185.2	183.0	38.0	38.8	347.0	372.1	1,652	1,760
T_4	182.5	174.7	40.6	37.6	350.7	370.8	1,663	1,737
T_5	175.4	179.7	25.7	28.6	286.0	321.4	1,405	1,380
T_6	173.1	174.7	25.2	29.9	289.7	320.2	1,366	1,364
T_7	171.6	177.2	26.2	28.8	284.8	310.0	1,361	1,347
T_8	160.3	176.3	21.6	26.5	250.1	249.6	1,070	1,134
T_9	161.8	176.7	21.5	27.5	259.1	262.4	1,085	1,100
T_{10}	165.1	176.0	21.2	27.9	248.0	241.2	1,033	1,144
SEm±	6.2	6.0	2.8	2.1	16.2	14.7	75	63
CD	N/A	N/A	8.4	6.2	48.5	44.0	223	190

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Conclusion

The study revealed that that nano sized gypsum can help in enhancing seed yield of Indian mustard when applied as seed treatemnt along with 100% recommended dose of fertilizers. From this study we can conclude that application of nano sized gypsum through seed treatment along with 100% RDF could be beneficial in boosting up the yield of Indian mustard for tarai region of Uttarakhand.

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