Int.J.Curr.Microbiol.App.Sci (2018) *7*(04): 3761-3768

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 7 Number 04 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.704.423

Managing Nitrogen Requirements through Foliar Application of Nitrogen in Mustard (*Brassica juncea* L. *Czernj*. and *Cosson*.)

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Keywords

Foliar sprays, Soil application, 2% urea solution, Days after sowing

Article Info

Accepted:
30 March 2018
Available Online:
10 April 2018

A B S T R A C T

A field experiment was conducted at oilseed block of Norman E. Borloug Crop Research Center of G.B. Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar (Uttarakhand) during *rabi* season of 2014-2015 to study the nitrogen requirements through foliar applications in mustard. The experiment was laid out in split plot design containing three nitrogen levels viz. recommended dose of nitrogen (120 kg ha^{-1}), 75% of the recommended dose of nitrogen (90 kg ha^{-1}), and 50% of the recommended dose of nitrogen (60 kg ha^{-1}) in main plots; with four foliar sprays viz. single spray of water, single foliar spray of 2 % urea solution at 20 days after sowing (DAS), two foliar sprays of 2 % urea solution at 20 and 40 DAS and three foliar sprays of 2 % urea solution at 20, 40 and 60 DAS in sub plots, replicated thrice. The results revealed that the soil application of 75% of the recommended dose of nitrogen (90 kg ha^{-1}) was found significantly superior over rest of the soil application treatments as in all the growth indices and the yield attributing characters like plant height, dry matter accumulation, number of branches, number of siliquae per plant, 1000 grain weight, oil content in seeds and ultimately resulted to higher yields (1463.6 kg ha^{-1}) yield. Among the foliar sprays, two foliar sprays of 2 % urea solution at 20 and 40 DAS proved superior over rest of the foliar applications and recorded highest yield (1622.6 kg ha^{-1}).

Introduction

Oilseeds occupy an important place in Indian economy. Nine annual oilseed crops are grown in India of which, oilseed *Brassica*, has a great significance due to high oil content, large acreage and diversified uses of oil. Eight species of oilseed *Brassicas* are grown in India mainly for edible oil (Prasad, 2013). Among all these species Indian mustard (*Brassica juncea*) predominates in the country accounting for more than 70 % of the area and production of oilseed *Brassicas.* Amongst the agronomic factors known to augment crop production, fertilizer stands first and is considered as one of the most productive inputs in agriculture. Of the major elements, nitrogen which is insufficient in most of the Indian soils plays an appreciably important role in *Brassica* crops (Kumar, 1986). Nitrogen is the most energy intensive element and various losses in form of volatilization, leaching and fixation are more often with this than any other nutrient element. About 50% of the applied nitrogen to the soil remains unavailable to a crop because of combination of leaching, fixation and volatilization. However, the wastage of nutrients can be reduced by foliar applications of dilute solutions of nutrients to supplement the basal applications (Jamal and Chaudhary, 2007).

Since its first recorded use in the early 19th century, foliar fertilization has been the subject of considerable controlled environment, and field research and has become widely adopted as a standard practice for many crops. The rationales for the use of foliar fertilizers include: 1) when soil conditions limit availability of soil applied nutrients; 2) in conditions when high loss rates of soil applied nutrients may occur; 3) when the stage of plant growth, the internal plant demand and the environmental conditions interact to limit the delivery of nutrients to critical plant organs.

Furthermore, foliar fertilization is theoretically more environmental friendly, immediate and target-oriented than the soil fertilization as the nutrients can be directly delivered to the plant tissues during critical stages of plant growth (Fernández *et al.*, 2013). Foliar application is highly efficient in terms of absorption as nutrients are not subjected to various losses that occur with soil application. If dose of nitrogen could be reduced by foliar application, it would curtail the cost of cultivation significantly and would be an economically viable technology.

Studies have been conducted on foliar application of nutrients but precise information on foliar application of nitrogen in Indian mustard is meager.

In Tarai region of Uttarakhand due to high rainfall and changing climatic situations, nitrogen is subjected to more losses which can be prevented to a greater extent by foliar fertilization. Thus, reducing the amount of soil applied nitrogen and increasing the efficiency of the input. Hence, to study the effect of foliar application of nitrogen on mustard an experiment was conducted.

Materials and Methods

A field experiment was conducted during *rabi* season of 2014-15 at G.B Pant University of Agriculture and Technology, Pantnagar. The soil of the experimental site was silty loam in texture with pH 7.8. In nutrient profile, it was low in nitrogen (266 kg ha^{-1}), medium in potassium (182 kg ha^{-1}) and high in phosphorus (45kg ha^{-1}).

The experiment was laid out in split plot design containing three nitrogen levels *viz.* recommended dose of nitrogen (120 kg ha^{-1}), 75% of the recommended dose of nitrogen (90 kg ha^{-1}), and 50% of the recommended dose of nitrogen (60 kg ha^{-1}) in main plots; with foliar sprays *viz.* single spray of water, single foliar spray of 2 % urea solution at 20 days after sowing (DAS), two foliar sprays of 2 % urea solution at 20 and 40 DAS and three foliar sprays of 2 % urea solution at 20, 40 and 60 DAS in sub plots. Variety 'Kranti' of the crop was sown on 29th October, 2014 with crop geometry 30×15 cm^2 and harvested on 24th March, 2015.

A uniform basal application of whole amount of phosphorus in the form of single super phosphate and whole amount of potassium as muriate of potash and one third of nitrogen in form of urea as per treatment was applied. Remaining quantity of nitrogen was top dressed twice, 40 and 60 days after sowing.

Treatments were designated as:

T_1- Recommended dose of nitrogen with single spray of water regarded as control

T_2- Recommended dose of nitrogen with single spray of 2% urea solution 20 days after sowing

T_3- Recommended dose of nitrogen with two sprays of 2% urea solution 20 and 40 days after sowing

T_4- Recommended dose of nitrogen with three sprays of 2% urea solution 20, 40 and 60 days after sowing

T_5- 75% of recommended dose of nitrogen with single spray of water regarded as control

T_6- 75% of recommended dose of nitrogen with single spray of 2% urea solution at 20 days after sowing

T_7-75% of recommended dose of nitrogen with two sprays of 2% urea solution 20 and 40 days after sowing

T_8- 75% of recommended dose of nitrogen with three sprays of 2% urea solution 20, 40 and 60 days after sowing

T_9- 50% of recommended dose of nitrogen with single spray of water regarded as control

T_{10}- 50% of recommended dose of nitrogen with single spray of 2% urea solution at 20 days after sowing

T_{11}- 50% of recommended dose of nitrogen with two sprays of 2% urea solution 20 and 40 days after sowing

T_{12}- 50% of recommended dose of nitrogen with three sprays of 2% urea solution 20, 40 and 60 days after sowing

Results and Discussion

Growth indices

A consistent increase in plant height was found with advancement of crop growth, however it was not significant at harvest. Among various nitrogen levels, 75% of recommended dose of nitrogen recorded highest plant height as compared to the rest two nitrogen levels *i.e.*, recommended and 50% of recommended dose of nitrogen. The minimum value was recorded for 50% of recommended dose of nitrogen. The effect of nitrogen application was pronounced when it was increased from 60 to 90 kg ha^{-1}. However, further increase in dose decreased plant height. Among foliar sprays two sprays of 2% urea solution resulted in higher plant height, as compared to water spray regarded as control. Foliar sprays increased plant height upto two sprays. Further application of urea solution as foliar could not increase plant height. Single spray of water regarded as control recorded minimum plant height as no nitrogen supplementation was given to this treatment in form of urea solution.

Cell division and cell expansion are the two key physiological processes responsible for growth. For these two, nitrogen is of prime requirement. Probably nitrogen supplementation through foliar application resulted in better growth. Similar results have also been reported by Laghari *et al.,* (2014) in sunflower and Bhowmick (2006) in linseed. Stanley and Basavarajappa (2014) also recorded significantly higher plant height in sesame with application of nitrogen in two equal splits and urea @1.5% foliar spray.

Dry matter accumulation

The dry matter increased with advancement of the growth stage and was recorded maximum at harvest. Various nitrogen levels and foliar sprays significantly influenced the dry matter accumulation of plants. Highest dry matter accumulation was found on application of 75% of the recommended dose of nitrogen as compared to 50%. On increasing dose of nitrogen from 75% of the recommended dose to recommended there was decline in the dry matter accumulation. However this decrease was not significant. Dry matter accumulation is function of metabolic activities required for growth and development. Nitrogen is required for these activities to occur in the plant system.

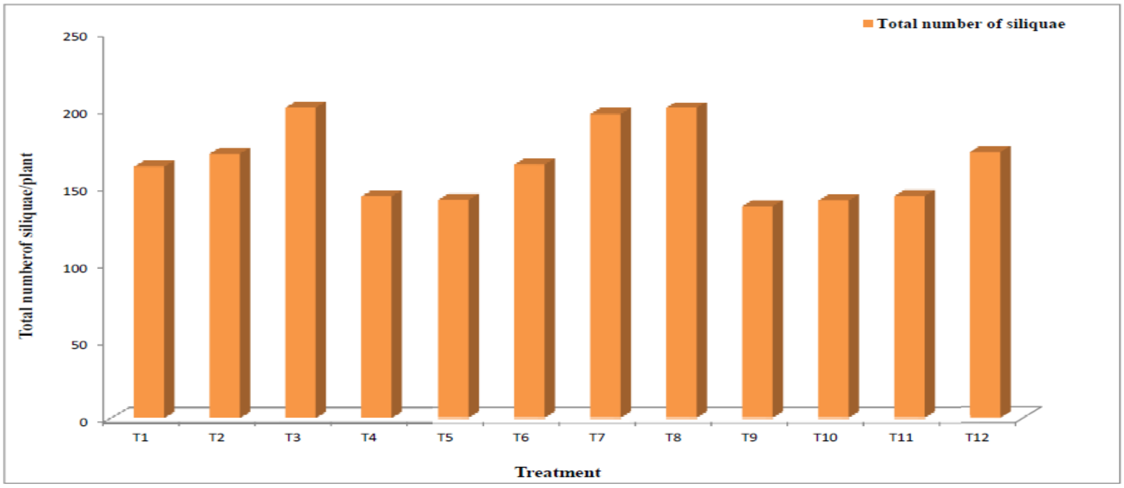
Increasing nitrogen application from 50% of the recommended dose to 75% increased these activities and hence dry matter accumulation. Among foliar sprays, two sprays of 2% urea solution proved superior treatment over others. Interaction effect of nitrogen levels and foliar sprays on dry matter accumulation was found significant. Two foliar sprays of urea increased the dry matter accumulation with 75% of the recommended dose of nitrogen which was more than that of recommended dose but the difference was not significant.

Increasing the number of foliar sprays from two to three for recommended and 75% of the recommended dose of nitrogen dry matter accumulation did not increase. This might be due to sufficient amount of nitrogen available for the uptake of plant from soil. The plants responded to increasing number of 2% urea solution spray in case of 50% of the recommended dose of nitrogen due to insufficient nitrogen applied as soil application. Foliar application supplemented nitrogen requirement of plants, although not significant when third spray was given. In case of single spray of water i.e. control, plants had to completely depend on soil applied nitrogen for their requirement therefore, dry matter accumulation was corresponding to it. Dry matter accumulation is function of metabolic activities occurring in the plant system for which nitrogen is of prime importance. This was exhibited in treatments where the plants were solely dependent on soil applied nitrogen. Ngezimana and Agenbag (2013) reported increase in dry matter with increase in nitrogen application. Odeleye *et al.,* (2007) also observed highest value for dry weight with two foliar sprays when nitrogen, phosphorus, potassium and magnesium were applied as foliar. Siddiqui *et al.,* (2008) also reported that soil plus foliar application of nitrogen, phosphorus and sulphur increased dry weight per plant by 27.3 %.

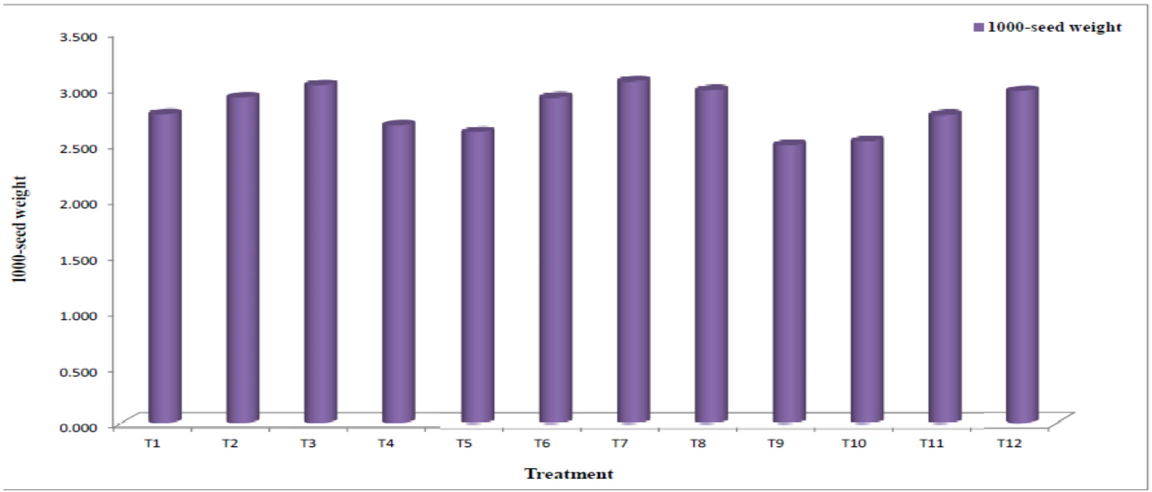
Growth Indices

Treatment	**Plant height (cm) at harvest**	**Dry matter accumulation plant^{-1} (g) at harvest**
Nitrogen (kg ha^{-1})		
120	191.2	21.9
90	191.1	22.9
60	186.4	19.4
CD (P=0.05)	NS	2.7
Foliar sprays		
0	188.5	18.4
1	191.8	20.2
2	192.8	24.9
3	190.2	22.1
CD (P=0.05)	NS	2.8

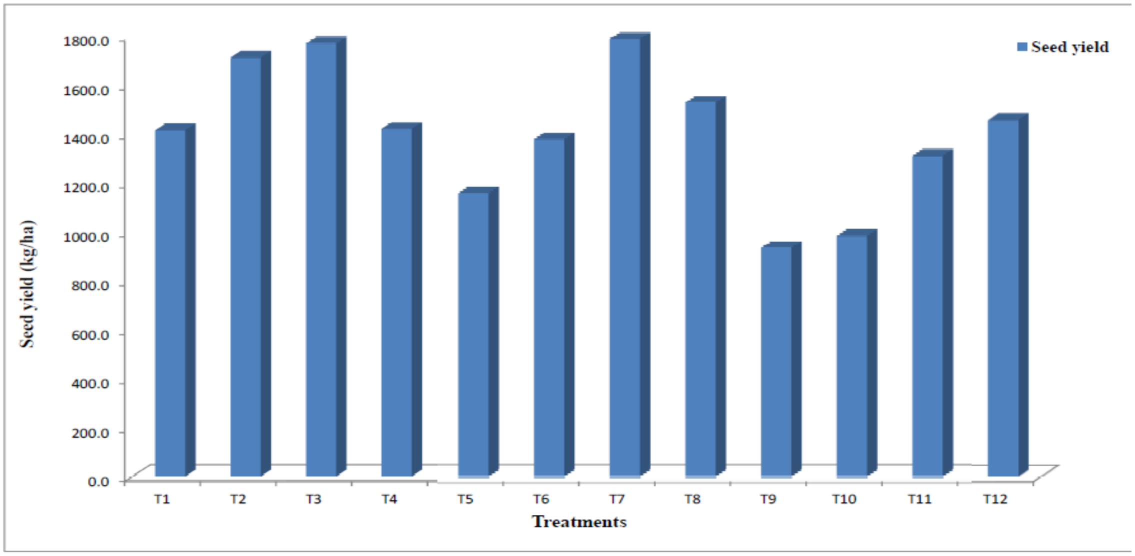
Yield attributes



Oil content and oil yield



Treatment	Branches plant^{-1}	Siliquae plant^{-1}	1000-seed weight (g)	Seed yield (kg ha^{-1})	Oil content (%)	Oil yield (kg ha^{-1})
Nitrogen (kg ha^{-1})						
120	10.9	169.8	2.9	1579	38.3	567.3
90	11.5	176.0	2.9	1464	38.6	572.5
60	9.8	148.6	2.7	1171	39.8	470.1
CD (P=0.05)	NS	21.0	NS	151	NS	36.5
Foliar sprays						
0	9.7	147.2	2.6	1159	39.9	459.1
1	10.2	158.9	2.8	1357	39.2	500.0
2	11.9	180.8	3.0	1623	38.5	616.7
3	10.9	172.3	2.9	1469	38.8	570.8
CD (P=0.05)	1.2	18.7	0.2	171	NS	75.6



Yield attributes

Among various yield attributes, nitrogen levels influenced significantly total number of siliquae plant^{-1} only. It was found highest for 90 kg nitrogen per hectare. Foliar sprays of 2% urea solution influenced the yield attributes significantly. All the yield attributes viz. total number of branches plant^{-1}, total number of siliquae plant^{-1} and 1000-seed weight was found maximum for two foliar sprays, how however they remained on a par with three foliar sprays. It might be because two foliar sprays would have sufficed the supply of nitrogen to the plants for production of enough photosynthates to put forth more branches which led to production of more number of siliquae/plant. The result confirms the finding of Keivanrad and Zandi (2012). 1000-seed weight is a function of metabolic activities and sink-source balance of the plant. Two foliar sprays supplemented plants with nitrogen and also proved efficient to maintain sink-source relationship. That is why this treatment resulted in highest 1000-seed weight. Control and single foliar spray could not supply the plant with sufficient nitrogen for development of seed therefore, resulted in relatively lower values for 1000-seed weight. Positive effect of nitrogen levels on 1000-seed weight has also been reported by Khan (1996). Reddy *et al.,* (1989) found similar results in groundnut with foliar application of phosphorus. The findings of the present study are also in conformity with the results of Walker *et al.*, (1984).

Seed yield

Different nitrogen levels significantly influenced the seed yield. Seed yield was found maximum for 120 kg nitrogen per hectare, however it remained on a par with that of 90 kg/ha. Increase in yield with increase in nitrogen has also been reported by Thakur *et al.,* (2005). Among the foliar sprays, two sprays of 2% urea solution resulted in maximum seed yield.

Seed yield is a function of yield attributes of the plant. All the yield attributes were recorded higher with 75% of recommended dose of nitrogen. Among the foliar sprays two sprays of 2% urea solution proved better. Also the combination of these two, recorded highest values for yield attributes. Correspondingly seed yield was found highest in the combination of 75% of recommended dose of nitrogen and two sprays of 2% urea solution. Halvey *et al.,* (1987) also found significant increase in yield of peanut with foliar application of nitrogen, phosphorus, potassium and sulphur. Khan *et al.,* (1993) reported similar findings in mustard with foliar application of nitrogen and phosphorus.

Oil content and oil yield

Different nitrogen levels and foliar sprays could not influence the oil content in Indian mustard significantly. Although the effect of any of the factors of treatment was not significant, a decreasing trend in oil content was observed with increase in the dose of nitrogen. The result confirms the finding of Hocking *et al.,* (1997) and Brennan *et al.*, (2000) who concluded the oil concentration of canola seed remained unaffected by N rate. Increasing nitrogen application either as basal or foliar led to more meristematic growth. More meristematic growth due to higher supply of nitrogen caused diversion of photosynthates more in production of more structural protein for new tissues rather contributing to oil in seeds. 90 kg/ha resulted in maximum value for oil yield. Among foliar sprays, two sprays of 2% urea solution at 20 and 40 days after sowing resulted in highest oil yield. Oil yield is function of oil content and seed yield. Lower content of oil in seeds was offset by higher seed yield in treatments which supplied nitrogen adequately. Oil yield corresponding to seed yield has also been reported by Kumar (1986).

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How to cite this article:

Rajni Sinha, M.S. Negi, B.S. Mahapatra and Anil Shukla. 2018. Managing Nitrogen Requirements through Foliar Application of Nitrogen in Mustard (*Brassica juncea* L. *Czernj*. and *Cosson*.). *Int.J.Curr.Microbiol.App.Sci.* 7(04): 3761-3768.
doi: https://doi.org/10.20546/ijcmas.2018.704.423