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Effect of Soil and Foliar Application of Nitrogen on Morpho-Physiological, Growth Characters and Seed Yield of Rapeseed

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A B S T R A C T

A research work was conducted at the experimental field of SCS College of Agriculture, Assam Agricultural University, Dhubri, Assam during *Rabi* season of 2019-2020 to study the "effect of soil and foliar fertilization of nitrogen on morpho-physiological, growth characters and seed yield of rapeseed variety TS-46. The experiment comprised of ten treatments. Results revealed that there were significant differences among the treatments in terms of total leaf chlorophyll content, leaf area per plant, specific leaf weight (SLW), plant height, number of branches per plant, plant dry matter, number of siliquae per plant, number of seeds per siliqua and seed yield. Split application of nitrogen (recommended basal dose + foliar spray) significantly increased the morpho-physiological, growth characters and yield attributing parameters. Amongst all the treatments, T_{10} (Recommended dose of NPK + Foliar spray of 2% urea at 20 DAS and 40 DAS) proved to be the best followed by T_6 (Recommended dose of NPK + Foliar spray of 1% urea at 20 DAS and 40 DAS) and T_9 (Recommended dose of NPK + Foliar spray of 2% urea at 20 DAS). The treatments T_{10}, T_6 and T_9 recorded 57.36 %, 57.28% and 52.13%, respectively higher seed yield over T_1 (Control i.e. without fertilizers) and 26.65%, 26.52% and 17.65% respectively over T_2 (soil application of recommended dose of NPK alone).

Introduction

Rapeseed and mustard is the second most important edible oilseed crop after groundnut in India contributing 28.6% in the total oilseeds production and shared 27.8% in the oilseed economy of the country (Shekhawat *et al.*, 2012). In Assam, rapeseed and mustard is mainly grown as *Rabi* crop and the crop is sown during mid October to mid November. The productivity of rapeseed and mustard in Assam is 644 kg ha^{-1} (Anonymous, 2017-18) which is far below the national average of 1324 kg ha^{-1} (Anonymous, 2017-18). Availability of essential nutrient elements to the crop plant at an optimum amount and appropriate time are crucial for enhancing the seed yield. In Assam, poor nutrients management is one of the reasons for lower seed yield of rapeseed and mustard. Nitrogen

is one of the major elements required for growth and development of the crop plants. It is an important ingredient of various organic compounds such as chlorophyll, nucleic acids, amino acids, proteins, enzymes and hormones (Mingotte *et al.,* 2013). Hence, the efficient use of nitrogen is absolutely essential for higher yield of crop plants. The soil of Assam is acidic in nature (Medhi *et al.,* 2002). Of the total geographical area of Assam, 72.3% area is degraded acidic soils (with p^H<5.5) and 43.1%, 52.8% and 42.1% are low in available nitrogen, phosphorus and potassium content respectively (Bandypadhyay *et al.,* 2016). Although nitrogenous fertilizer is applied, about 50% of the fertilizer applied to the crop plant is partially lost through different mechanisms including leaching, volatilization and denitrification (Choudhury and Kennedy, 2005; Sinha *et al.,* 2018). However, such problems can be overcome by applying a portion of plants nutritional need with foliar fertilization. Jamal *et al.,* (2006) reported that the wastage of nutrients can be reduced by foliar applications of dilute solutions of nutrients to supplement the basal applications. Foliar fertilization can result in rapid utilization of nutrients to correct deficiencies that prevail during critical periods of growth. It is also more efficient in terms of absorption as nutrients are not subjected to different losses that occur with soil application. Keeping the above in view, a field experiment was conducted to study the effect of soil and foliar application of nitrogen on morpho-physiological, growth characters and seed yield of rapeseed.

Materials and Methods

The investigation was carried out at the farm of SCS College of Agriculture, Assam Agricultural University, Dhubri, Assam during *Rabi* season of 2019-2020. Soil samples were collected randomly from 0-15 cm depth prior to experimentation and estimated for various soil parameters. The soil was acidic (pH 5.34) in nature with low in available N (270.12 $kgha^{-1}$), medium in P_2O_5 (27.35 $kgha^{-1}$) and K_2O (235.27 $kgha^{-1}$) content. The experimental design adopted was Randomized Block Design (RBD) with 3 replications. The rapeseed variety TS-46 was selected for the study. The experiments comprised of ten treatments *viz*. T_1: Control (Without fertilizers), T_2: Recommended dose (RD) of NPK, T_3: Recommended dose of PK + Foliar spray of 1% urea at 20 days after sowing (DAS), T_4: Recommended dose of PK + Foliar spray of 1% urea at 20 DAS and 40 DAS, T_5: Recommended dose of NPK + Foliar spray of 1% urea at 20 DAS, T_6: Recommended dose of NPK + Foliar spray of 1% urea at 20 DAS and 40 DAS, T_7: Recommended dose of PK + Foliar spray of 2% urea at 20 DAS, T_8: Recommended dose of PK + Foliar spray of 2% urea at 20 DAS and 40 DAS, T_9: Recommended dose of NPK + Foliar spray of 2% urea at 20 DAS, T_{10}: Recommended dose of NPK + Foliar spray of 2% urea at 20 DAS and 40 DAS. The recommended dose of N, P_2O_5 (P) and K_2O (K) @ 40:35:15 kg/ha respectively for rapeseed was applied as per the treatment combinations.

Plant height was recorded at physiological maturity stage from the surface of the soil to the apex of the plant and expressed in centimeters. Total number of branches per plant was recorded at harvesting stage. For estimating total plant dry matter at harvest, the previously tagged plants were carefully uprooted from the soil, washed thoroughly under running tap water to remove all kinds of clinging particles from plant parts. Plants were then dried in hot air oven at 70^oC until the plant material attains a constant weight. Then the dried samples were weighed and weights are expressed in grams. Leaf area was recorded with the help of CI-203 Laser leaf area meter and expressed in square

centimeters per plant at flowering stage. Specific leaf weight (SLW) is the ratio of total leaf dry weight per unit of leaf area. It was calculated following the method of Radford (1967) at flowering stage and expressed in mg cm^{-2}.

$$SLW = \frac{\text{Total leaf dry weight}}{\text{Area of leaf}} (\text{mg cm}^{-2})$$

The total chlorophyll content in leaf tissue were estimated by non-maceration method using Dimethyl Sulphoxide (DMSO) as suggested by Hiscox and Israelstam (1979) using the following formula.

Total chlorophyll = (20.2 x D_{645}) + (8.02 x D_{663}) x (V / 1000 x W) mg g^{-1} fwt

Where,

D_{645} = Absorbance at 645 nm
D_{663} = Absorbance at 663 nm
V = Volume of DMSO in ml
W = Fresh weight of sample taken in g

Total number of siliquae per plant at harvest was recorded from already tagged plants from each plot. Number of seeds per siliqua was recorded from tagged plants. The seed obtained from each plot after threshing, cleaning and sun drying were weighed and the seed yield per hectare was calculated and expressed in kilograms per hectare. The data were statistically analyzed (Sahu and Das, 2014) and results are discussed below.

Results and Discussion

Morpho-physiological characters

Significant difference was observed among the nitrogen fertilizer treatments in terms of total leaf chlorophyll content, leaf area per plant and specific leaf weight (Table 1). Total leaf chlorophyll content was found to be highest in the treatment T_{10} (RD of NPK + Foliar spray of 2% urea at 20 DAS and 40 DAS) followed by T_6 (RD of NPK + Foliar spray of 1% urea at 20 DAS and 40 DAS) and T_9 (RD of NPK + Foliar spray of 2% urea at 20 DAS). Chlorophylls are green pigments that reflect the plant photosynthetic capacity. Green leaf area is considered to be one of the photosynthetic determinants in crop plants (Kaur *et al.,* 2015). Crop growth depends on adequate formation of leaf area for efficient interception of light (Wilson, 1981). Leaf area per plant differed significantly among the treatments. The treatment T_{10} (RD of NPK + Foliar spray of 2% urea at 20 DAS and 40 DAS) recorded the highest value followed by T_6 (RD of NPK + Foliar spray of 1% urea at 20 DAS and 40 DAS) and T_9 (RD of NPK + Foliar spray of 2% urea at 20 DAS). Leaf thickness is expressed as specific leaf weight. Specific leaf weight refers to dry mass of tissue per unit leaf area. Thicker leaves would have more number of mesophyll cells with high density of chlorophyll and therefore, have a greater photosynthetic capacity than thinner leaves (Craufurd *et al.,* 1999). Thick leaves are associated with high yielding capacities of mung bean and mash bean cultivars were reported by Sharma (2015). Specific leaf weight, a measure of thickness of leaf, has been reported to have a strong positive correlation with leaf photosynthesis in soybean as reported by Bowes *et al.,* (1972).

The treatments differed significantly in terms of specific leaf weight in the present study. Highest value for specific leaf weight was observed in T_6 (RD of NPK + Foliar spray of 1% urea at 20 DAS and 40 DAS) followed by T_{10} (RD of NPK + Foliar spray of 2% urea at 20 DAS and 40 DAS) and T_9 (RD of NPK + Foliar spray of 2% urea at 20 DAS). The treatments T_{10} and T_9 were statistically *at par* with T_6 in terms of specific leaf weight.

Table.1 Effect of soil and foliar application of nitrogen on morpho-physiological and growth characters of rapeseed

Treatment	Morpho-physiological characters			Growth characters		
	Total leaf chlorophyll ($mgg^{-1}fw$)	Leaf area (cm^2plant^{-1})	Specific leaf weight ($mgcm^{-2}$)	Plant height (cm)	Number of Branches per plant	Total plant dry matter ($g\ plant^{-1}$)
T_1: Control (Without fertilizers)	2.87	300.75	3.33	49.22	4.00	7.38
T_2: RD of NPK	4.31	435.86	4.47	59.99	6.60	10.73
T_3: RD of PK + Foliar spray of 1% urea at 20 DAS	3.45	311.03	3.76	57.89	5.80	9.27
T_4: RD of PK + Foliar spray of 1% urea at 20 DAS and 40 DAS	4.10	323.98	3.94	59.47	6.07	9.87
T_5: RD of NPK + Foliar spray of 1% urea at 20 DAS	4.75	445.55	4.68	69.85	8.20	11.54
T_6: RD of NPK + Foliar spray of 1% urea at 20 DAS and 40 DAS	5.11	449.96	5.96	67.80	8.60	13.27
T_7: RD of PK + Foliar spray of 2% urea at 20 DAS	3.66	316.73	3.69	58.73	5.47	9.51
T_8: RD of PK + Foliar spray of 2% urea at 20 DAS and 40 DAS	3.98	428.18	4.12	60.12	5.47	10.05
T_9: RD of NPK + Foliar spray of 2% urea at 20 DAS	4.87	446.43	4.77	67.73	8.27	11.61
T_{10}: RD of NPK + Foliar spray of 2% urea at 20 DAS and 40 DAS	5.23	451.25	5.41	68.79	8.53	14.01
SEm ±	0.351	6.951	0.367	2.533	0.696	0.754
CD (5%)	1.051	20.811	1.100	7.585	2.083	2.257

Table.2 Effect of soil and foliar application of nitrogen on yield attributing parameters and seed yield of rapeseed

Treatment	Number of siliquae per plant	Number of seeds per siliqua	Seed yield ($kg\ ha^{-1}$)
T_1: Control (Without fertilizers)	63.27	13.07	306.60
T_2: RD of NPK	90.13	16.47	527.40
T_3: RD of PK + Foliar spray of 1% urea at 20 DAS	74.40	15.20	350.70
T_4: RD of PK + Foliar spray of 1% urea at 20 DAS and 40 DAS	80.60	16.13	415.80
T_5: RD of NPK + Foliar spray of 1% urea at 20 DAS	93.67	17.00	630.00
T_6: RD of NPK + Foliar spray of 1% urea at 20 DAS and 40 DAS	102.13	18.73	717.84
T_7: RD of PK + Foliar spray of 2% urea at 20 DAS	76.80	16.60	405.70
T_8: RD of PK + Foliar spray of 2% urea at 20 DAS and 40 DAS	85.00	16.87	464.10
T_9: RD of NPK + Foliar spray of 2% urea at 20 DAS	94.20	17.47	640.50
T_{10}: RD of NPK + Foliar spray of 2% urea at 20 DAS and 40 DAS	104.80	18.30	719.06
SEm±	3.595	0.884	8.299
CD (5%)	10.763	2.648	24.848

Split application of nitrogen (recommended basal dose + foliar spray) registered higher values for total leaf chlorophyll content, leaf area per plant and specific leaf weight compared to that of control and soil application alone. Nitrogen is an essential component of many metabolically important compounds *viz*. chlorophyll, amino acids, proteins and nucleic acids (Jamal *et al.*, 2006). The lower values for these parameters with soil application of NPK alone over split fertilization might be due to unavailability of some portion of soil applied nitrogen to plant due to leaching losses, volatilization and denitrification. Dejoux *et al.*, (2003) reported that up to 50% of the applied nitrogen may be lost through leaching, decomposition and volatilization. However, the loss of nutrients can be reduced by foliar applications of dilute solutions of nutrients to supplement the basal applications (Jamal *et al.*, 2006). Foliar application is also more efficient in terms of absorption as nutrients are not subjected to different losses that occur with soil application. Siddiqui *et al.*, (2008) reported that soil and foliar application of nutrients improved the performance of rapeseed-mustard genotypes with respect to growth characteristics and physico-biochemical parameters.

Growth Characters

The growth characters *viz*. plant height, number of branches per plant and total plant dry matter differed significantly due to different nitrogen treatments (Table 1)**.** Among all the treatments, the treatment T_5 (RD of NPK + Foliar spray of 1% urea at 20 DAS) showed the highest value for plant height followed by T_{10} (RD of NPK + Foliar spray of 2% urea at 20 DAS and 40 DAS) and T_6 (RD of NPK + Foliar spray of 1% urea at 20 DAS and 40 DAS). Highest number of branches per plant was observed in the treatment T_6 (RD of NPK + Foliar spray of 1% urea at 20 DAS and 40 DAS) followed by T_{10} (RD of NPK + Foliar spray of 2% urea at 20 DAS and 40 DAS) and T_9 (RD of NPK + Foliar spray of 2% urea at 20 DAS). In terms of total plant dry matter, the treatment T_{10} (RD of NPK + Foliar spray of 2% urea at 20 DAS and 40 DAS) registered the highest value followed by T_6 (RD of NPK + Foliar spray of 1% urea at 20 DAS and 40 DAS) and T_9 (RD of NPK + Foliar spray of 2% urea at 20 DAS).

In the present study, the recommended basal dose of nitrogen along with foliar spray significantly increased the plant height, number of branches per plant and total plant dry matter over control and soil application of NPK alone. Foliar nutrition is a more economic way to supplement the plants' nutrients for more efficient utilization (Girma *et al.*, 2007). During critical stages of plant growth foliar fertilization with nitrogen can directly deliver the nutrient to the plant tissues. The higher values for these parameters with split fertilization might be due to the efficiency in utilization of nitrogen for photosynthesis, cell division, cell enlargement and tissue and organ formation as nitrogen is an essential component of many metabolically important compounds *viz.* chlorophyll, amino acids, proteins and nucleic acids. Sinha *et al.*, (2018) reported that soil plus foliar application of nitrogen improves plant height, number of branches per plant and dry matter accumulation in mustard.

Yield attributes and seed yield

The yield attributes *viz*. number of siliquae per plant, number of seeds per siliqua and seed yield differed significantly due to different nitrogen treatments (Table 2). In terms of number of siliquae per plant, the treatment T_{10} (RD of NPK + Foliar spray of 2% urea at 20 DAS and 40 DAS) recorded the highest value followed by T_6 (RD of NPK +

Foliar spray of 1% urea at 20 DAS and 40 DAS) and T_9 (RD of NPK + Foliar spray of 2% urea at 20 DAS). The highest number of seeds per siliqua was found in the treatment T_6 (RD of NPK + Foliar spray of 1% urea at 20 DAS and 40 DAS) followed by T_{10} (RD of NPK + Foliar spray of 2% urea at 20 DAS and 40 DAS) and T_9 (RD of NPK + Foliar spray of 2% urea at 20 DAS). Out of all treatments, the highest seed yield was recorded in the treatment T_{10} (RD of NPK + Foliar spray of 2% urea at 20 DAS and 40 DAS) followed by T_6 (RD of NPK + Foliar spray of 1% urea at 20 DAS and 40 DAS) and T_9 (RD of NPK + Foliar spray of 2% urea at 20 DAS).

Among all the treatments, the treatment T_{10} registered the highest seed yield which might be due to highest number of siliquae per plant in that treatment. The treatment T_6 although recorded the highest value for seeds per siliqua could not registered highest seed yield which might be due to lower number of siliquae per plant. However, the seed yield in the treatment T_6 was found to be statistically *at par* with T_{10}. Siddiqui *et al.,* (2008) reported that soil and foliar application of nitrogen improved siliquae number per plant, seeds number per siliqua, 1000-seed weight, seed yield per hectare, oil content, and oil yield per hectare and fatty acid composition in oil of rapeseed-mustard genotypes. Jamal *et al.,* (2006) also reported that the grain yield of wheat increased when NPK was applied both through soil and foliar sprays.

From the present investigation it can be concluded that both soil and foliar application of nitrogen improved overall performance of the rapeseed in respect to morpho-physiological, growth as well yield attributes and seed yield. Application of recommended dose of NPK as basal along with spraying of 2% urea at 20 DAS and 40 DAS was found to be the best amongst the nitrogen treatments under rainfed condition of Dhubri district of Assam.

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