Research Article

Effect of Source and Placement Timings of Nitrogen Fertilizers on Growth and Yield of Raya (*Brassica juncea* L.)

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Abstract | A field experiment was conducted to examine the efficacy of the source of N and its placement timings on growth and yield of raya. The experiment was laid out in the factorial arrangement within randomized complete block design (RCBD). Two sources of nitrogen i.e. urea and calcium ammonium nitrate (CAN) and three nitrogen placement timings i.e. ½ at rauni + ½ at flowering (T_1), ½ at sowing + ½ at flowering (T_2) and ½ at 1st irrigation + ½ at flowering (T_3) were included in the experiment. Treatments were replicated thrice. Data were collected for growth parameters and yield contributing traits. It was observed that source of nitrogen has no significant difference on growth or yield while the N placement timing significantly affects these traits. Results showed that most efficient N placement timing is split dose of fertilizer at T3 (½ at 1st irrigation and ½ at flowering) for either urea or CAN fertilizer.

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Introduction

There is an acute shortage of edible oil in Pakistan and has become the third largest importer of the edible oil in world. Seventy-five percent of total edible oil consumption depends on import (Ali et al., 2017). This import costs Rs. 284.546 billion (US$ 2.710 billion) during the year Rs. 2015-16. Winter rapeseed has become a crop of major agro-economic importance for edible oil after cottonseed with an annual production of 0.202 million tons (GOP, 2017). Rapeseed and mustards are rich source of oil and contains 44–46% good quality oil. Nitrogen (N), being an integral part of proteins (Saleem et al., 2009) plays important role in photosynthesis and several enzymatic biochemical and physiological reactions in plant metabolism (Balasubramaniyan and Palaniappan, 2001). Nitrogen deficiency results reduction in dry matter, crude protein and grain yield (Ashiono et al., 2005). Continuous supply of N is mandatory for good crop stand and yield and oil contents with better quality.

Nitrogen availability for optimum plant growth and development is very low in Pakistani soils due to low organic matter and high temperature (Saleem et al., 2009). So, a crop without application of nitrogenous fertilizer is quite impossible to grow well (Tisdale et al., 1990) but its effects on environment and high cost have drawn the attention of scientists to improve its efficiency (Lehrsch et al., 2000). Improvement in nitrogen use efficiency (NUE) is a major way to reduce nitrogen losses and its accumulation in plants (Moghaddam et al., 2007). High nitrogen fertilizer application rates decrease NUE and plant uptake due to its increased losses (Sowers et al., 1994). Identification and exploitation of strategies that enhance NUE is the need of hour to sustain crop productivity and environment protection.

Sources and time of application are considered as the factors affecting NUE and pathways of nitrogen loss from soil-plant system (Raun and Johnson, 1999). Right source of nitrogen fertilizer is more important for yield than its amount (Larson and Oldham, 2010). Ammonium, nitrate and urea are the predominant forms of nitrogen which are present in nitrogen fertilizer (Wood et al., 2010). Urea has high nitrogen contents (45-46%), low cost, and is rapidly converted into available form for plant uptake (Weiss et al., 2009). An alternative of urea is calcium ammonium nitrate (CAN) which is commercially developed to reduce nitrogen volatilization losses (Wood et al., 2010). CAN is also a better source as nitrogen fertilizer as it contains nitrogen in both ammonium and nitrate forms which results in high plant uptake (Weiss et al., 2009). Timing of fertilizer application is a low cost strategy to reduce nutrient losses (Gehl et al., 2005). Application of nitrogen fertilizer at the time when it is needed by the crop is most logical approach for improving nitrogen use efficiency (Larson and Oldham, 2010). Split application of nitrogen fertilizer at the time of crop need reduces nitrogen losses and improves the nutrient use efficiency of crop plants (Debele et al., 1994). Split application of nitrogen is more important because it provides nitrogen at different growth stages during crop development when it is required to plant for better NUE (Grant et al., 2012; Tadesse et al., 2013; Ma et al., 2015).

Keeping in view the all above findings, this study was conducted to investigate the efficacy of time and source of applied nitrogen on NUE and growth and yield of raya.

Materials and Methods

Present study was conducted at the experimental farm of Arid Zone Research Institute Bahawalpur during winter season 2015-2016. Soil sample were taken from 15 to 30 cm depth and soil analysis was carried out before the experiment (Table 1). Experiment was laid out in factorial arrangement with randomized complete block design in three replications. Two factors; sources of nitrogen (*i.e.* urea and calcium ammonium nitrate (CAN)) and three placement timings for each source (*i.e.* ½ at rauni + ½ at flowering (T_1), ½ at sowing + ½ at flowering (T_2), ½ at 1st irrigation and ½ at flowering (T_3) were taken. Net plot size was 3×5 m. Each plot had four rows and row to row distance was 75 cm whereas the row length was kept as 5 meters. Crop was sown in the third week of November, 2015 with the help of single row hand drill. Seed was sown at the rate of 6 kg ha^{-1}. Plant to plant distance was maintained 22.5 cm and surplus plants were thinned out at four leaf stage. A fertilizer dose of 60 kg phosphorus per ha was applied to all treatments and N were applied at the rate of 86 kg N per ha. Whole dose of P_2O_5 was applied at the time of sowing from the source of single supper phosphate (SSP) while recommended dose of nitrogen was applied as per treatment. All other agronomic practices like weeding and irrigations were kept normal and uniform for all treatments.

Table 1: *Soli Analysis of Experimental Site.*

Soil pH	8.1
EC	1.69 ds/m
Organic Matter	0.80 %
Phosphorus	6.4 ppm
Potassium	267 ppm
Soil Saturation	52 %
Soil Texture	Clay-Loam Soil

Crop was harvested at physiological maturity 3rd week of March in 2016. Observations of different growth parameters e.g. plant height (cm), number of silique per plant, silique length (cm), number of seeds per silique and number of branches per plant, were taken from ten randomly selected plants from each treatment and used for calculating their means. 1000-seed weight was worked out by calculating the weight of 100 seeds and multiplied with ten of 10 samples selected randomly from seed produce of each plot and their means were calculated. For seed yield all the plants were taken from each plot, siliques were separated, opened, shelled and weight was calculated in Kilograms per hectare. Treatment means were compared by using the least significant difference (LSD) test at 5% level of significance on ha^{-1} basis (Steel and Dickey, 1997) and correlation coefficients were determined by using computer software Statistix 8.1.

Table 2: *Effect of source of N (Urea and Calcium Ammonium Nitrate (CAN)) and time of application (½ at rauni + ½ at flowering (T1), ½ at sowing + ½ at flowering (T2), ½ at 1st irrigation and ½ at flowering (T3)) on Plant Height, Branches per Plant, Seliques per Plant, Selique Length, Seeds per Selique, 1000 Seed Weight and Total Seed Yield.*

Source	Time of Application	Plant Height (cm)	Branches per Plant	Seliques per Plant	Selique Length (cm)	Seeds per Selique	1000-Seed Weight (g)	Seed Yield (kg/ha)
Urea								
	T1	146.07^{D}	3.30^{C}	69.10^{D}	3.977^{A}	8.80^{B}	4.13^{BC}	1245.4^{B}
	T2	156.07^{BCD}	4.00^{B}	88.27^{B}	4.50^{A}	9.60^{AB}	4.33^{ABC}	1377.7^{A}
	T3	167.93^{A}	5.20^{A}	95.67^{A}	4.83^{A}	11.37^{A}	4.83^{A}	1401.0^{A}
CAN								
	T1	146.80^{CD}	3.80^{BC}	67.30^{D}	4.73^{A}	9.07^{B}	3.97^{BC}	1349.1^{A}
	T2	158.07^{ABC}	4.03^{B}	82.50^{C}	3.97^{A}	9.27^{B}	3.67^{C}	1352.1^{A}
	T3	167.13^{AB}	4.80^{A}	90.77^{AB}	4.43^{A}	10.57^{AB}	4.50^{AB}	1391.3^{A}

Note: *Any two means not sharing a letter in common differ significantly at $P \leq 0.05$*

Table 3: *Mean squares from analysis of variances for plant height, branches per plant, selique per plant, selique length, seeds per selique, 1000 seed weight and seed yield.*

Source of Variation	Plant Height (cm)	Branches per Plant	Seliques per Plant	Selique Length (cm)	Seeds per Selique	1000 Seed Weight	Seed Yield (kg/ha)
Source	1.869^{NS}	0.0089^{NS}	77.709**	0.0139^{NS}	0.3756^{NS}	0.6805^{NS}	2349.1^{NS}
Time	667.82**	3.2872**	982.46**	0.2539^{NS}	6.7356*	0.8272*	15337.7*
Source*Time	2.949^{NS}	0.3039^{NS}	6.52^{NS}	0.7672^{NS}	0.4289^{NS}	0.0972^{NS}	7459.3^{NS}
Error	41.731	0.1205	7.42	0.3336	1.0089	0.1412	3008.1
CV	4.11	8.29	3.31	13.11	10.27	8.87	4.05

** Correlation is significant at 0.05 level; ** Correlation is highly significant at 0.01 level; ^{NS} Correlation is non-significant at 0.05 level.*

Table 4: *Correlation (r) coefficients among yield contributing traits of Brassica.*

	PH	BPP	SPP	SL	SPS	SW	YLD
PH	1						
BPP	0.7817**	1					
SPP	0.7877**	0.7766**	1				
SL	0.0626^{NS}	0.3788^{NS}	0.2^{NS}	1			
SPS	0.6359**	0.6287**	0.6467**	0.1496^{NS}	1		
SW	0.2874^{NS}	0.5173*	0.5056*	0.2816^{NS}	0.5784*	1	
YLD	0.3810^{NS}	0.4826*	0.6011**	0.3050^{NS}	0.3480^{NS}	0.11123^{NS}	1

** Correlation is significant at 0.05 level; ** Correlation is highly significant at 0.01 level; ^{NS} Correlation is non-significant at 0.05 level.*

Results and Discussion

Nitrogen is an important component of plant metabolism. Nitrogen application affects almost all growth parameters especially plants height. There was a significant difference in the crop height when nitrogen fertilizer was applied in splits at different timing as shown in Table 2, while the sources of nitrogen not significantly affected crop height. Maximum crop height (167.93 cm for urea and 167.13 cm for CAN) was observed at T3 (½ at 1st irrigation + ½ at flowering). This could be due to the availability of nitrogen at the right time of growth. However, lowest crop height (146.07 cm for urea and 146.80 for CAN) was observed at harvest in case of T1 (½ at rauni + ½ at flowering). Our results are at par with the results of other related studies (Cheema et al., 2001; Chen et al., 2004; Hassan et al., 2010).

Number of branches per plant is an important trait that directly contributes in total yield. Different nitrogen placement times showed significant difference in the branches per plant when source of nitrogen fertilizer was either urea or CAN. Maximum number branches were observed (5.20 for urea and 4.80 for CAN fertilizer) when applied in split doses at (½ at 1st irrigation + ½ at flowering) as shown in Table 2, while lowest branches per plant (3.43) was observed when Urea was applied in case of (½ at rauni + ½ at flowering). This could be due to the loss of nitrogen by leaching down and unavailability at the right stage of the crop. No significant difference was observed for sources of nitrogen. These results are supported by the work of Cheema et al. (2001) and Chen et al. (2004).

There was a significant difference in the number of siliques per plant when nitrogen fertilizer was applied under different placement times as shown in Table 2. Source of nitrogen were not significantly affecting this trait. Number of siliques were maximum (95.67) when urea fertilizer was applied in at T3 (½ at 1st irrigation + ½ at flowering) while, lowest siliques per plant (67.30) were observed when CAN was applied in T1 (½ at rauni + ½ at flowering). Following results are supported in other studies as well (Cheema et al., 2001; Muhammad et al., 2007).

There was no significant difference in the silique length when nitrogen fertilizer was applied in splits either from urea or CAN as shown in Table 2. It was maximum (4.83 cm) when fertilizers were applied in split (½ at sowing + ½ at flowering). Same results were observed in the work of Cheema et al. (2001) and Chen et al. (2004) which are at par with our fidings.

Number of seeds per silique is an important agronomic trait. It is not significantly affected when different Nitrogen sources were used, while various application timing of these fertilizers affected the number of seeds per silique. Maximum number of seeds per silique (11.37 for urea and 10.57 for CAN) was observed when fertilizers were applied at various time of placement at T3 (½ at 1st irrigation + ½ at flowering). These results are different from the results of Öztürk (2010) who found non-significant difference in application time. While our results were supported by the work of Cheema et al. (2001) and Muhammad et al. (2007).

1000-seed weight was not significantly affected by the source of nitrogen. However, it was greatly influenced by the timing of application of fertilizer. Maximum 1000-seed weight (4.83 g for urea and 4.50 g for CAN) was observed when fertilizers were applied at T3 (½ at 1st irrigation + ½ at flowering). Least 1000-seed weight was observed when CAN was applied at T2 (½ at sowing + ½ at flowering). These results were supported by the work of Cheema et al., 2001 and Muhammad et al., 2007.

There was a significant difference in the crop yield when Urea fertilizer was applied under different nitrogen placement times. It was maximum (1401.0 tons/ha) when urea fertilizer was applied under split application at T3 (½ at first irrigation + ½ at flowering). While lowest crop yield (1245.4 tons/ha) was observed when Urea was applied in case of T1 (½ at rauni + ½ at flowering). While no significant effect of CAN fertilizer was observed under different placement timing. These results are in line with the work of Cheema et al. (2001); Chen et al. (2004); Muhammad et al. (2007); Hassan et al. (2010) and Tariq et al. (2013).

Correlation coefficient between growth and yield contributing traits were calculated (Table 4). It was observed that number of branches per plant and selique per plant showed significantly positive correlation with yield. While the other parameters like plant hight and seed weight showed positive correlation but not significantly different for yield increase.

Conclusions

From the all above findings both of the N source were proved equally efficient for seed yield and many growth parameters. However, N placement timing significantly effects the yield and other growth traits. It was observed that the most efficient timing of nitrogen placement is when half of the amount is applied at 1st irrigation and ½ at flowering for raya.

Author's contributions

M.M. Yousaf conceived the idea and provide technical support in this study. M. Hussain, M.J. Shah and B. Ahmad planned and executed the experiment in field. M.M. Raza helped in data collection and analysis. M. Zeshan collected the data, done statistical analysis and wrote the manuscript.

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