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RESEARCH ARTICLE

Effect of nitrogen levels and its split application on physiological attributes of Indian mustard (*Brassica juncea* L.) in arid western Rajasthan

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SUMMARY

A field experiment was conducted during winter season of 2002-03 and 2003-04 to find out the effect of nitrogen levels and its split application on physiological attributes of Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson]. Application of increasing levels of nitrogen from 40 to 100 kg ha^{-1} significantly enhanced crop growth rate between sowing to 45 DAS, 45-90 DAS and 90 DAS to harvest, relative crop growth rate of mustard between 45-90 DAS and 90 DAS to harvest, net assimilation rate between 45 and 90 DAS and 90 DAS to harvest, leaf area index at 45, 90 DAS and at harvest and leaf area duration between 45-90 DAS and 90 DAS to harvest of Indian mustard. Further, application of nitrogen 1/3 as basal + 1/3 at I^{st} irrigation + 1/3 at II^{nd} irrigation being statistically at par with 1/2 at basal + 1/4 at I^{st} irrigation + 1/4 at II^{nd} irrigation brought a substantial improvement in CGR between 45-90 DAS and between 90 DAS to harvest, RGR between 90 DAS to harvest, leaf area index at harvest and leaf area duration between 90 DAS to harvest of mustard as compared to two equal splits *viz*., 1/2 at basal + 1/2 at I^{st} irrigation, DAP basal + 1/2 of rest at I^{st} irrigation + 1/2 of rest at II^{nd} irrigation and 100 per cent basal. However, significantly increase in crop growth rate of mustard between sowing to 45 DAS and leaf area index at 45 DAS was recorded due to nitrogen application as full basal over different split applications in mustard.

Key Words : Indian mustard, Nitrogen, Split application, Physiological attributes

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The world's arable land resources are finite and there is not much scope for significantly expending the area of land under cultivation. Hence, most of the increase in agricultural production will have to be obtained through increased productivity from the existing agricultural land. This can be achieved by improved management practices in general and fertilizer management practices in particular. Mustard is an important oilseed crop of India and stands next only to groundnut in term of both area and production.

Nitrogen is an indispensable element for optimum functioning of the crop and generally nitrogen fertilizer account for about half of the cost of cultivation for most of the crops (Prasad Babu and Sarkar, 2002). Urea is the most widely used source of nitrogen by farmers all over the world. Efficiency of nitrogen use by most of the crops ranges from 20-60 per cent and commonly averages around 50 per cent (Aulakh *et al.*, 1992). Low recovery of applied nitrogen by crops rise questions of the fate of the nitrogen that lost from soil-plant-system through runoff, leaching, denitrification and ammonia volatilization or made unavailable to the plant through biological immobilization. The soil of this region are deficient in organic matter, nitrogen and phosphorus content. These aspects of sustained crop production have received very

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little attention. Besides, the nitrogen levels, the time of application is also influenced the growth of mustard especially in light textured soils and high temperature. Thereafter, the present investigation was undertaken to find out the effect of nitrogen levels and its split application on growth attributes of Indian mustard.

MATERIAL AND METHODS

The experiment was conducted at College of Agriculture, Bikaner during winter season of 2002-03 and 2003-04. The soil was loamy sand and low in organic matter. The soil pH was 8.2. It was low in organic carbon (0.09 %), available nitrogen (113.13 kg ha^{-1}) and available phosphorus (12.01 kg ha^{-1}) and medium in potassium (200.04 kg ha^{-1}). The treatments comprised five levels of nitrogen (40, 60, 80, 100 and 120 kg N ha^{-1}) as main plot treatments and five split applications of nitrogen (100 per cent basal, 1/2 at basal + 1/2 at I^{st} irrigation, 1/3 as basal + 1/3 at I^{st} irrigation + 1/3 at II^{nd} irrigation , 1/2 at basal + 1/4 at I^{st} irrigation + 1/4 at II^{nd} irrigation and DAP basal + 1/2 of rest at I^{st} irrigation + 1/2 of rest at II^{nd} irrigation) as sub pot treatment and were laid out in split plot design with three replications. Nitrogen as per treatments was applied through urea after adjusting the nitrogen (13.7 kg N) supplied through DAP (applied for 35 kg P_2O_5 ha^{-1}). The calculated quantity of urea for different treatments was applied basal and remaining nitrogen was given at I^{st} and II^{nd} irrigation as per treatments 30 and 60 days after sowing, respectively. Indian mustard variety Bio –902 (Pusa Jaikisan) was sown at 30 cm row spacing using 4 kg seed ha^{-1} on 29th and 27th October in 2002 and 2003, respectively.

RESULTS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads:

Effect of nitrogen levels:

A significant increase in crop growth rate between sowing to 45 DAS, 45-90 DAS and 90 DAS to harvest, relative crop growth rate of mustard between 45-90 DAS and 90 DAS to harvest, net assimilation rate between 45 and 90 DAS and 90 DAS to harvest, leaf area index at 45, 90 DAS and at harvest and leaf area duration between 45-90 DAS and 90 DAS to harvest was observed with the increase in the levels of nitrogen from 40 to 100 kg N ha^{-1} during both the years and in pooled mean over the years (Table 1 and 2). However, application of nitrogen @ 100 kg N ha^{-1} was found to be at par with 120 kg N ha^{-1}.

Application of 100 kg N ha^{-1} recorded an increase of 27.61, 15.71 and 6.71 per cent crop growth rate between sowing to 45 DAS, 52.24, 23.40 and 10.36 per cent crop growth rate between 45-90 DAS, 125.12, 45.56 and 16.35 per cent crop growth rate between 90 DAS to harvest, 7.14, 1.95 and 0.73 per cent relative crop growth rate between 45-90 DAS, 51.07, 20.08 and 7.25 per cent relative crop growth rate between 90 DAS to harvest, 8.62, 2.34 and 0.85 per cent net assimilation rate between 45-90 DAS, 52.76, 20.84 and

Table 1 : Effect of nitrogen levels and their split application on crop growth rate, relative growth rate and net assimilation rate during different periodical growth stages of mustard (pooled data of 2002-03 and 2003-04)

Treatments	CGR (g day^{-1} m^{-2})			RGR (mg g^{-1} day^{-1})		NAR (mg dm^{-2} day^{-1})	
	Sowing - 45 DAS	45 DAS- 90 DAS	90 DAS - at harvest	45 DAS - 90 DAS	90 DAS- at harvest	45 DAS- 90 DAS	90 DAS- at harvest
Nitrogen levels (kg ha^{-1})							
N_{40}	1.333	7.298	1.839	18.06	1.86	4.220	1.283
N_{60}	1.470	9.004	2.844	18.98	2.34	4.479	1.622
N_{80}	1.600	10.068	3.558	19.21	2.62	4.545	1.820
N_{100}	1.701	10.885	4.140	19.35	2.81	4.584	1.960
N_{120}	1.733	11.111	4.264	19.36	2.83	4.588	1.974
S.E.±	0.020	0.127	0.065	0.030	0.026	0.006	0.007
C.D. (P = 0.05)	0.060	0.382	0.196	0.091	0.079	0.017	0.022
Split application of N							
Basal 100 %	1.769	8.482	0.997	16.91	0.86	3.895	0.591
1/2 Basal + 1/2 at I^{st} irrigation	1.606	9.551	3.457	18.66	2.66	4.385	1.849
1/3 Basal + 1/3 at I^{st} irrigation + 1/3 at II^{nd} irrigation	1.489	10.416	4.397	20.02	3.13	4.777	2.175
1/2 Basal + 1/4 at I^{st} irrigation + 1/4 at II^{nd} irrigation	1.604	10.268	3.897	19.28	2.81	4.562	1.955
DAP basal[1] + 1/2 of rest[2] at I^{st} irrigation + 1/2 of rest at II^{nd} irrigation	1.368	9.649	3.896	20.09	3.00	4.797	2.090
S.E.±	0.019	0.127	0.058	0.026	0.025	0.005	0.006
C.D. (P = 0.05)	0.053	0.357	0.163	0.073	0.070	0.014	0.016

I^{st} irrigation at 30 DAS, II^{nd} irrigation at 60 DAS, DAS = Days after sowing
[1] = 13.7 kg N ha^{-1} through DAP, [2] = Nitrogen remaining after adjustment of 13.7 kg N ha^{-1}

7.69 per cent net assimilation rate between 90 DAS to harvest, 27.60, 15.69 and 6.26 per cent leaf area index at 45 DAS, 45.92, 20.14 and 7.83 per cent leaf area index at 90 DAS, 55.67, 24.05 and 9.29 per cent leaf area index at harvest, 38.69, 27.95 and 7.25 per cent leaf area duration between 45-90 DAS and 48.65, 21.25 and 8.25 per cent leaf area duration between 90 DAS to harvest over 40, 60 and 80 kg N ha^{-1}, respectively.

In general, the overall improvement in growth of mustard with increased nitrogen could be ascribed to its pivotal role in several physiological and biochemical processes which are of vital importance for growth and development of plant. The increased N supply increased the leaf area which might have accelerated the photosynthetic rate, thereby, increasing the supply of carbohydrates to the plant (Khanpara *et al.,* 1993) which might have been attributed to significantly higher. Beneficial effect of nitrogen addition on growth parameters have also been reported in mustard by Shukla *et al.* (2001), Garg *et al.* (2001), Kumar *et al.* (2001) at Ludhiana and Tripathi *et al.* (2002) at Kanpur in Indian mustard.

Effect of split application of nitrogen:

It is further evident from data (Table 1 and 2) that application of nitrogen as 100 % basal significantly improved the crop growth rate of mustard between sowing to 45 DAS and leaf area index at 45 DAS. Nitrogen application as 100 per cent basal increased 10.15, 18.80, 10.28 and 29.31 per cent CGR between sowing to 45 DAS and 10.12,18.75,10.24 and 29.25 per cent leaf area index at 45 DAS over various split applications *viz*., 1/2 as basal + 1/2 at I^{st} irrigation, 1/3 at basal + 1/3 at I^{st} irrigation + 1/3 at II^{nd} irrigation, 1/2 as basal + 1/4 at I^{st} irrigation + 1/4 at II^{nd} irrigation and DAP basal + 1/2 of rest at I^{st} irrigation + 1/2 of rest at II^{nd} irrigation, respectively.

Further, nitrogen in three equal splits as 1/3 as basal + 1/3 at I^{st} irrigation + 1/3 at II^{nd} irrigation being statistically at par with 1/2 at basal + 1/4 at I^{st} irrigation + 1/4 at II^{nd} irrigation significantly increased CGR between 45-90 DAS and between 90 DAS to harvest, RGR between 90 DAS to harvest, leaf area index at harvest and leaf area duration between 90 DAS to harvest over all other split treatments and full basal.

However, nitrogen application as DAP basal + 1/2 of rest at I^{st} irrigation + 1/2 of rest at II^{nd} irrigation, being statistically at par with three equal splits *viz*., 1/3 as basal + 1/3 at I^{st} irrigation + 1/3 at II^{nd} irrigation resulted significantly higher RGR between 45-90 DAS and between 90 DAS to harvest, net assimilation rate during 45-90 DAS and between 90 DAS to harvest over all other split treatments and full basal.

The magnitude of increase was recorded in order of 12.60, 22.80, 21.05 and 13.75 per cent CGR between 45-90 DAS, 246.74, 341.02, 290.87 and 290.77 per cent CGR between 90 DAS to harvest, 10.35, 18.39, 14.01 and 18.80 per cent RGR between 45-90 DAS, 209.30, 263.95, 226.74 and 248.83 per cent RGR between 90 DAS to harvest, 12.58, 22.64, 17.12 and 23.15 per cent net assimilation rate during 45-90 DAS, 212.85, 268.02, 230.79 and 253.63 net assimilation rate during 90 DAS to harvest, 23.32, 35.92, 32.56 and 24.72 per cent leaf area index at harvest, 6.81, 8.30, 9.53 and 6.90 per cent leaf area duration between 45-90 DAS and 12.75, 21.43, 20.34 and 12.12 per cent leaf area duration between 90 DAS to harvest with the treatments of 1/2 at basal

Table 2 : Effect of nitrogen levels and their split application on leaf area index and Leaf area duration (days) during different periodical growth stages of mustard (pooled data of 2002-03 and 2003-04)

	Leaf area index			Leaf area duration (days)	
	45 DAS	90 DAS	At harvest	45-90 DAS	90 DAS- at harvest
Nitrogen levels (kg ha^{-1})					
N_{40}	2.00	3.07	1.19	114.02	63.91
N_{60}	2.20	3.73	1.49	133.47	78.35
N_{80}	2.40	4.16	1.69	147.44	87.76
N_{100}	2.55	4.48	1.85	158.14	95.00
N_{120}	2.60	4.57	1.89	161.28	96.98
S.E.±	0.027	0.053	0.025	2.017	1.367
C.D. (P = 0.05)	0.081	0.159	0.074	6.047	4.098
Split application of N					
Basal 100 %	2.65	3.65	1.32	134.39	74.47
1/2 Basal + 1/2 at I^{st} irrigation	2.41	3.97	1.62	143.54	83.97
1/3 Basal + 1/3 at I^{st} irrigation + 1/3 at II^{nd} irrigation	2.23	4.24	1.79	145.55	90.43
1/2 Basal + 1/4 at I^{st} irrigation + 1/4 at II^{nd} irrigation	2.40	4.23	1.75	147.21	89.62
DAP basal[1] + 1/2 of rest[2] at I^{st} irrigation + 1/2 of rest at II^{nd} irrigation	2.05	3.92	1.64	143.67	83.50
S.E.±	0.027	0.053	0.023	1.798	1.243
C.D. (P = 0.05)	0.075	0.148	0.065	5.060	3.498

I^{st} irrigation at 30 DAS, II^{nd} irrigation at 60 DAS, DAS = Days after sowing

[1] = 13.7 kg N ha^{-1} through DAP, [2] = Nitrogen remaining after adjustment of 13.7 kg N ha^{-1}

+ 1/2 at Ist irrigation, 1/3 as basal + 1/3 at Ist irrigation + 1/3 at IInd irrigation, 1/2 at basal + 1/4 at Ist irrigation + 1/4 at IInd irrigation and DAP basal + 1/2 of rest at Ist irrigation + 1/2 of rest at IInd irrigation, respectively over nitrogen application as full basal.

Leaching and volatilization losses of nitrogen particularly under loamy sand soil result in low availability of nitrogen at basal application which might be due to unable to fulfill the supply of nitrogen at critical growth stage of plants. Hence, the marked improvement in growth parameters, due to split application of nitrogen could be ascribed to rational utilization of N at its critical growth stages which play a potential role in modifying plant environment *vis-à-vis* better growth and development of the crop. Similar findings were also reported by Mohapatra (1993) in mustard, Ahmed *et al.* (1999) at Pakistan in mustard, Behrens *et al.* (2001) and Tamagno *et al.* (2001) at Argentina in rapeseed.

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