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EFFECT OF NITROGEN SCHEDULING AND DOSES ON AEROBIC RICE

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Rice (*Oryza sativa*) is an important *kharif* cereal crop of Madhya Pradesh covering an area of 15.59 lakh hectares with production upto14.12 lakh tonnes. It is sown with different methods under upland and lowland conditions. The nitrogen requirement of rice plants is rather high and most of the Indian soils are very low in its content. The applied nitrogen is rapidly mineralized in soil and either absorbed by the rice crop in the ammonical form or escapes in gaseous state or leaches down into sub-soil layer beyond root-zone of the plants. Nitrogen is a key nutrient in determining the level of crop productivity. The efficiency of applied nitrogen is very low and varies from 20 to 25% in upland rice crop due to the oxidized condition prevailing in uplands and concomitant heavy nitrogen loss through percolating water (Sathiya *et al.*, 2008, Sharma, 2015). Hence, fractional (split) application of nitrogen in right amount and proportion, and when it is needed the most, seems to be a practical preposition. Splitting the application of nitrogen at the appropriate physiological growth stages of *kharif* crops increased its production efficiency compared to application of all the quantity of fertilizer-N at sowing (Sathiya and Ramesh, 2009). In view of the above facts, the present research on N-scheduling for aerobic rice was taken up.

The field experiment was conducted during *kharif* season in 2014 at the JNKVV College of Agriculture, Rewa (M.P.). The soil was sandy clay-loam in texture having pH 6.7, electrical conductivity 0.40 dS m^{-1}, organic carbon 6.6 g kg^{-1}, available N, P_2O_5 and K_2O 236, 18.5 and 352 kg ha^{-1}, respectively. The total rainfall during June to October was 814.2 mm. The treatments comprised two nitrogen levels (120 and 150 kg ha^{-1}) in the main- plots and six N-scheduling and dosages [**N-2** splits (1/2 basal + 1/2 PI stage), **N-2** splits (1/2, 10-12 DAE +1/2 PI stage), **N-3** splits (1/3 basal + 1/3 AT+ PI stage), **N-3** splits (1/3, 10-12 DAE + 1/3 AT +1/3 PI stage), **N-4** splits (1/4 basal + 1/4 AT stage + PI stage + ¼ at flowering stage) and **N-4** splits (1/4 DAE + 1/4 AT stage + PI stage + ¼ at flowering stage)] in the sub-plots. The experiment was laid out in split-plot design with three replications. The rice variety Pusa Sugandha-3 was sown on 4th July 2014 @ 50 kg seed ha^{-1} in rows 20 cm apart and keeping 10 cm distance between plants. The crop was grown as per recommended package of practices. An uniform dose of P_{60} K_{50} was applied in all the treatments. The crop was harvested on 25 October, 2014. Yield attributes and yields were recorded at maturity. The economics was calculated on the basis of prevailing market rates of inputs and produce.

The data (Table 1) reveal that all the yield -attributing characters were enhanced significantly due to increased supply of nitrogen upto 150 kg N ha^{-1}. The maximum panicles were recorded 274/m^2 with 150 kg N ha^{-1} as against 244/m^2 with 120 kg N ha^{-1}. There were 115 grains/panicle with 150 kg N over 75/panicle with 120 kg N ha^{-1}. Similarly the filled grains were 93/panicle as compared to 53/panicle with lower N level. The increased yield - attributes under 150 kg N ha^{-1} might be due to accelerated photosynthetic rate of plant growth and partitioning of photosynthates (assimilates) to the economic sink. These findings are in close agreement with those of Reddy *et al.* (2011), Reddy *et al.* (2013) and Kumar *et al.* (2015).

The splitting and timing of N application exerted significant influence on yield - attributing characters of aerobic rice. The S_4 treatment having N splitted thrice (1/3, 10-12 DAE + 1/3 AT +1/3 PI stages) proved the best and enhanced the yield- attributes upto maximum extent viz. 265 panicles/m^2, 116 grains /panicle and 89 filled grains/panicle and 27 unfilled grains/panicle. However the 1000-grain weight remained identical in all the N-scheduling treatments. The second best N-scheduling treatment was S_3 having 3 splits at 1/3 basal + 1/3 AT + 1/3 PI stages which gave 263 panicles/m^2, 100- **ANJIR**

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grains/panicle and 75 filled grains/panicle. On the other hand, S_1 treatment having 2 splits of N at 1/2 basal + 1/2 PI stage recorded significantly lowest 249 panicles/m^2, 76 grains/panicle and 52 filled grains/panicle. The best performance of S_4 and then S_3 (both having 3 N splits) on yield - attributes was exactly in accordance with the better crop growth under 1/3 N splitting at 10-12 DAE instead of basal application. The present results are in close agreement with those of Sathiya and Ramesh (2009), Singh *et al.* (2013) and Kumar *et al.* (2015). The treatment interactions were found significant in all the yield attributes except in 1000-grain weight (Table 2). The S_4 times N splits with N_{150} resulted in maximum 280 panicles/m^2, 156 grains/panicle, 121 filled grains/panicle and 35 unfilled grains/panicle.

Table 1: Yield attributes, yield and economics of aerobic rice as influenced by various treatments

Treatment	Panicles/m^2	Grains/ panicle	Filled grains/ panicle	Unfilled grains/ panicle	1000-grain weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)	Net income (Rs.ha^{-1})	B:C ratio
Nitrogen (kg ha^{-1})										
120	244	75	53	21	19	25.22	55.80	31	16289	1.70
150	274	115	93	22	22	28.19	73.52	28	21671	1.91
CD (P=0.05)	10.1	28.0	35.5	0.72	1.33	NS	NS	NS	-	-
Scheduling of N application										
S_1 2 splits (1/2 basal + 1/2 PI	249	76	52	24	20	23.00	52.83	31	13091	1.57
S_2 2 splits (1/2 10-12 DAE + 1/2 PI stage)	257	85	74	12	20	22.11	47.47	32	11353	1.49
S_3 3 splits (1/3 basal + 1/3 AT + 1/3 PI)	263	100	75	25	20	26.38	73.63	27	19427	1.83
S_4 3 splits (1/3 10-12 DAE + 1/3 AT + 1/3 PI)	265	116	89	27	21	34.62	83.43	30	31545	2.34
S_5 4 splits (1/4 basal + 1/4 AT + 1/4 PI + 1/4 flowering)	258	98	74	24	21	26.79	63.49	30	18673	1.79
S_6 4 splits (1/4 DAE + 1/4 AT + 1/4 PI + 1/4 flowering)	262	93	74	19	21	27.35	67.10	29	19791	1.83
CD P=0.05)	9.7	11.0	15.6	1.58	NS	6.3	12.7	2.89	-	-

DAE = Days after emergence, AT = Active tillering stage, PI=Panicle initiation stage

The data (Table 1) further indicate that grain and straw yield as well as harvest index of aerobic rice did not influence due to fertility levels. However, grain yield was higher (28.19 q ha^{-1}) with 150 kg N ha^{-1} as against 25.22 q ha^{-1} with 120 kg N ha^{-1}. Similarly straw yield was also higher (73.52 q ha^{-1}) as against 55.80 q ha^{-1} with lower N level. The harvest index was higher (31%) with lower N level over 28% with higher N level. The lower N level produced comparatively less straw over grain resulting into harvest index. The increased grain and straw yield due to increase N supply was exactly in accordance with the yield attributing characters recorded under increased supply of nitrogen. Consequently the net income values (Rs.21671 ha^{-1}) and B:C ratio (1.91) were found maximum due to increased supply of nitrogen upto 150 kg ha^{-1}. This net income was higher by Rs.5382 ha^{-1} as against lower dose of nitrogen supply. The beneficial effect of higher dose of nitrogen (150 kg ha^{-1}) has also been reported by Reddy *et al.* (2011), Reddy *et al.* (2013) and Sharma (2013). As regards with the N-scheduling treatments, S_4 having 3 N splits (1/3 10-12 DAE + 1/3 AT + 1/3 PI stage) recorded significantly higher grain and straw yield i.e. 34.62 and 83.43 q ha^{-1}, respectively over all the remaining N-scheduling treatments. This was however, followed by 3 to 4 times N splitting treatments producing identical grain and straw yield. On the other hand, S_1 and S_2 having 2 times N splits recorded the lowest productivity parameters. These productivity parameters are exactly in accordance with the yield- attributing parameters recorded from these treatments. The beneficial effect of 2 to 4 splitting of N for increased rice yield has also been reported by Sathiya and Ramesh (2009), Singh *et al.* (2013) and Kumar *et al.* (2015).

Table 2: Yield attributes of aerobic rice as influenced by N levels x N splitting interactions

Scheduling of N application		Panicles/m^2		Grains/panicle		Filled grains/panicle		Unfilled grains/panicle	
		N_{120}	N_{150}	N_{120}	N_{150}	N_{120}	N_{150}	N_{120}	N_{150}
S_1	2 splits (1/2 basal + 1/2 PI)	233	264	73	79	46	58	27	21
S_2	2 splits (1/2 10-12 DAE + 1/2 PI)	236	277	77	92	57	90	20	3
S_3	3 splits (1/3 basal + 1/3 AT + 1/3 PI)	246	280	70	129	41	108	29	21
S_4	3 splits (1/3 10-12 DAE + 1/3 AT + 1/3 PI)	245	284	77	156	57	121	20	35
S_5	4 splits (1/4 basal + 1/4 AT + 1/4 PI + 1/4 flowering)	246	270	81	115	63	86	18	29
S_6	4 splits (1/4 DAE + 1/4 AT + 1/4 PI + 1/4 flowering)	256	267	69	118	55	94	14	24
	C D P=0.05)	13.71		15.69		22.10		2.23	

The economical gain was also found according to the grain yield under different N-scheduling treatments. Accordingly, S_4 having 3 N splits resulted in maximum net income (Rs.31545 ha^{-1}) as well as B:C ratio (2.34). This was almost equally followed by 3 to 4 times N splitting (Rs.18673 to Rs.19791 ha^{-1}) and B:C ratio (1.79 to 1.83). The minimum net income (Rs.11353 ha^{-1}) and B:C ratio (1.49) was recorded from S_2 treatment having 2 splits of N application. This was, however, followed by S_1 giving lower income (Rs.13091 ha^{-1}) and B:C ratio (1.57).

From our study, it may be concluded that the application of 150 kg N ha^{-1} in 3 splits (1/3 at 10-12 DAE + 1/3 AT + 1/3 at PI stages) proved the most remunerative for growing aerobic rice var. Pusa Sugandha-3.

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RESPONSE OF INDIAN MUSTARD TO LEVELS OF FERTILITY AND SULPHUR AFTER RICE

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Indian mustard (*Brassica juncea* L.) is an important rabi oilseed crop of India next to groundnut and soybean. It is grown on 21% of the total oilseed area and producing 23% of the total oil seed production in the country. Its area, production and productivity in the country is 6.7 million ha, 8.0 million tonnes and 1188 kgha^{-1}, respectively (GO1, 2013-14). In Uttar Pradesh, mustard is grown on an area of 10.26 lakh ha with total production of 11.29 lakh tonnes. The average productivity of mustard in the state is 1100 kg ha^{-1} (Mustard seed survey Report, 2014-15) which is considered to be low. Among the various agronomic practices, use of sub-optimum and imbalanced fertilization are responsible for low productivity of mustard. Use of optimum fertilization is the key factor in increasing the productivity which can be realized with the judicious application of plant nutrients to mustard crop. Continuous cropping coupled with use of high yielding varieties of mustard exhausted the soil fertility not only in respect of macro-nutrients but also micro-nutrients. The increase use of sulphur free N, P and K fertilizers with organic manures affected the reserve of the sulphur in most of the soils resulting in higher depletion of these nutrients thereby limiting the soil productivity (Wani and Akhter, 2009). In recent years, sulphur seems to be a vital nutrient and is now widely accepted as the fourth major plant nutrient along with N, P and K. Application of sulphur influences the seed yield and oil content of the mustard as it involves in synthesis of essential sulphur containing amino acids like cysteine, cystine and methionine. Therefore, an attempt was made to assess the response of mustard to level of fertility and sulphur in irrigated condition.

A field experiment was carried out during winter (*rabi*) season of 2011-12 at Instructional Research Farm of Narendra Deva University of Agriculture and Technology, Faizabad. The experimental site was situated at 26^{0}18'N latitude and 82^{0}12' longitude with an elevation of 113m above mean sea level under sub-tropical zone of Indo-Gangetic Plains. The soil of the site was silty-loam in texture having pH 8.3, EC 0.31 dSm^{-1}, low in organic C (3.2g kg^{-1}) and available N (136.5), P (8.5), K (178.5) and S (6.8) kg ha^{-1}. The experiment was laid out in randomized block design with three replications. The treatment comprised of four levels of fertility (75,100, 125 and 150% of recommended dose of N P and K), and four levels of sulphur (0, 20, 40 and 60 kg S ha^{-1}). The recommended dose of fertilizer for mustard was 120-60-60 kg NPK ha^{-1}. The half dose of N and full dose of P, K and S was applied as per treatment before sowing of the crop. The remaining N was applied after first irrigation at branching. Mustard variety 'NDR 8501' was sown on 13th November 2011 at 30 cm rows apart, and harvested on 25 February 2012. Plant population of experimental crops was maintained by thinning two weeks after germination. The crop received post-sowing irrigation at branching and flowering stage. All recommended package of practices were followed for raising experimental crop. Data collected on various parameters of crop were subjected to statistical analysis as per standard procedure. Oil content was determined by Soxhlet ether extraction method.

The results revealed that mustard crop responded to fertility levels from 75% to 150% RDF in terms of plant height, branches plant^{-1} and yield attributes except test weight (Table-1). However, significant response in these parameters was obtained upto 125% RDF. Improvement in growth and yield parameters was mainly attributed to better nutritional rhizospheric environment for crop. Our findings confirm the results of Yadav et al (2010) and Solanki and Sharma (2016). Mustard crop received 100% RDF recorded significantly the highest test weight (5.40 gm) and reduce with increasing fertility levels.The mustard seed yield increased significantly with corresponding increase in fertility from 75% to 150% RDF,

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Table 1: Effect of fertility and sulphur levels on yield attributes, yield, quality and economics of mustard

Treatment	Plant height	Branches plant^{-1}	Siliquae plant^{-1}	Siliquae length (cm)	Seeds siliqua^{-1}	Test weight (g)	Seed yield (qha^{-1})	Stover yield (qha^{-1})	Harvest index (%)	Oil content (%)	Oil yield (qha^{-1})	Net return (Rs ha^{-1})	B:C ratio
Fertility levels													
75% RDF	153.3	6.11	263	4.71	9.98	4.32	14.09	44.11	24.28	40.00	5.64	33190	1.61
100% RDF	169.0	6.63	321	6.04	12.03	5.04	16.54	51.77	24.25	39.42	6.52	33531	1.86
125% RDF	182.2	7.75	348	6.15	12.83	4.94	18.93	59.22	24.21	39.02	7.39	48674	2.06
150% RDF	191.4	8.34	351	6.19	13.04	4.90	19.18	60.09	24.31	38.70	7.37	48112	1.91
SEm±.	4.27	0.30	8.4	0.04	0.25	0.10	0.29	1.39	0.56	0.45	0.14		
CD (P=0.05)	12.34	0.75	24.2	0.10	0.71	0.26	0.83	4.05	NS	1.12	0.35		
Sulphur levels (kg ha^{-1})													
Control	165.3	5.82	275	5.10	10.48	4.32	14.71	45.99	24.24	37.97	5.58	35768	1.75
20	178.3	6.84	288	5.64	11.30	4.60	16.54	52.45	24.01	38.75	6.40	41202	1.86
40	191.4	7.83	360	6.10	13.31	5.01	18.43	57.93	24.20	39.64	7.30	46668	1.97
60	197.5	8.44	376	6.18	13.68	5.28	19.05	58.83	24.60	40.52	7.68	47433	1.86
SEm ±	4.27	0.30	8.4	0.04	0.25	0.11	0.29	1.39	0.56	0.45	0.14		
CD (P=0.05)	12.34	0.75	24.2	0.10	0.71	0.31	0.83	4.05	NS	1.12	0.35		

however, difference between 125% and 150% RDF was on par. The per cent increase in seed yield due to application of 150% RDF was recorded to be 36.1, 15.9 and 1.3 over 75, 100 and 125% respectively. Primarily grain yield is a function of cumulative effect of yield attributing character, the higher value of these attributes can be assigned as the most probable reason for significantly higher seed yield. These results are in close conformity with those of Meena et al (2013). The harvest index was not affected significantly due to level of fertility. Stover yield was also recorded higher with increasing fertility levels from 75% to 150% RDF. It might be due to improvement in biomass plant^{-1} and increase in various morphological parameters like plant height and branches plant^{-1}. The oil content (%) of mustard was reduced due to application fertility level which might be due dilution effect owing to higher biomass production per unit area. Application of 125% RDF recorded the highest oil yield (7.39 qha^{-1}) and further increase in fertility level could not improved oil yield owing to reduction in oil content (%). The net return (Rs. 48674ha^{-1}) and B:C ratio (2.06) was highest with 125% RDF.

Plant height, branches plant^{-1} and yield attributes were increased significantly with application of sulphur from 20 kg to 60 kgha^{-1} over control however, significant improvement was recorded only upto 40 kgSha^{-1}, however, maximum value of growth parameters was recorded with 60 kg Sha^{-1}.Application of sulphur from 20-60 kg S ha^{-1}increased significantly the seed yield however, difference between 40 and 60 kgSha^{-1} was on par. The percent increase in seed yield due to 60 kg S ha^{-1} was recorded to be 3.3, 15.1, and 29.5 over 40 kgSha^{-1}, 20 kg S ha^{-1} and control, respectively. The increase in seed yield was mainly ascribed to improvement in growth and yield attributes with sulphur application in addition to its multiple roles and metabolism as essential constituent of amino acid and also improvement in vegetative structure production of reproductive structure and assimilates thereby maintaining balanced source-sink in plant (Kumar *et al 2009*). These results are supported with the findings of Singh *et al (2013*) and Solanki and Sharma (2016). The oil content (%) and oil yield was improved significantly with application of sulphur from 20 to 60 kg ha^{-1} as compared to no sulphur application. The maximum oil content (40.52%) and seed yield (19.05 qha^{-1}) was recorded with 60 kg S ha^{-1}. The maximum net returns (Rs. 47433 ha^{-1}) was recorded with the application of 60 kg S ha^{-1} followed by 40, 20 kgSha^{-1} and control. This is because of higher seed and stover yield with above treatment. These results are in accordance to the findings of Kumar *et al.* (2009) and Singh *et al.* (2015). However, B:C ratio was recorded highest (1.97) with 40 kgSha^{-1} due to proportionately lesser cost with higher seed and stover yield with this treatment.

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