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Effect of Levels and Time of Nitrogen Application on Yield and Economics of Rice

K. K. Ajmal[1*], M. Goverdhan[2], S. Sridevi[3] and K. Suresh[4]

[1]Dept. of Agronomy, College of Agriculture, GKVK, University of Agricultural Sciences, Bangalore, Karnataka (560 065), India
[2]Dept. of Agronomy, [3]Dept. of Soil Science and Agricultural Chemistry, [4]Dept. of Agronomy, Regional Agricultural Research Station, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telengana (500 030), India

Corresponding Author

K.K. Ajmal
e-mail: ajmalkk1994@gmail.com

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Abstract

A field experiment was conducted on yield and economics of rice during 2017 at Agriculture Research Institute, Rajensranagar. The study was conducted with 10 treatments and laid out in randomized block design with 3 replications. The soil of the experimental site was clay loam in texture, slightly alkaline in reaction, non-saline, low in organic carbon and available nitrogen, high in available phosphorous and potassium.Among the different time and dose of application of nitrogen, the highest panicle m^{-2} (309.3), panicle length (23.9 cm), number of filled grains $panicle^{-1}$ (103.2),number of total grains $panicle^{-1}$ (118.1), test weight (23.9 g), grain yield (4514 kg ha^{-1}), straw yield (5470 kg ha^{-1}) and B: C ratio (1.99)were recorded highest with application of 160 kg N ha^{-1} 25% each at sowing, 20 DAS, 40 DAS and 60 DAS compared to the other treatments. However, growth recorded with 160 kg in 4 equal splits was found to be on par with the growth in the treatments having 160 and 140 kg N ha^{-1}applied at various splits and with application of 120 kg N ha^{-1} in 4 equal splits at sowing, 20 DAS, 40 DAS and 60 DAS. The lowest observation wasfoundin the farmer's practice with the application of nitrogen at 120 kg ha^{-1} N in 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS.

Keywords: Rice nitrogen application, yield, economics

1. Introduction

Rice is the most important cereal crop grown throughout the world and provides staple food for more than 2 billion people in Asia (Anil et al., 2015). More than 90% of the world's rice is grown and consumed in Asia, wherein 60% of the world's population lives (Ajmal et al., 2022). It has been cultivated in 114 countries across the world. It is expected that by 2025, the world will need about 760 mt of rice in order to meet the demand for the growing population (Kamruzzaman et al., 2013).

There are 3principal systems of rice cultivation wet, semi dry and dry. In wet system, the crop is grown under wet conditions from seed to seed (Avasthe, 2009, Dar et al., 2000). This system requires huge amount of water for the specific operations. It is estimated that rice will consume 5000 L water for producing 1 kg of rice grain (Hussain et al., 2013). In dry system seeds are sown in non-puddled aerated dry soil by broadcasting or line sowing or drilling under supplementary irrigation and grown as rainfed crop (Hebbar et al., 2017). The low and unstable yields of aerobic rice were mainly due to water scarcity and nutrient stresses. The lower soil moisture content in aerobic rice cultivation therefore reduces nutrient supply to the roots and results in the lower rate of plant uptake (Siddiq et al., 2011)

In semi dry system, seeds are sown in ploughed dry soil with monsoon rains same as aerobic rice and when the monsoon become active the field is impounded in with canal water of a project or bore water and continued as wet land crop (Raj et al., 2014, Lakshmi Bai et al., 2014). Semi dry system reduces the cost of cultivation by omitting the preparatory operation like puddling, levelling, bund formation and transplantation (Singh and Tripathi, 2007). Fertilizer being an expensive and precious input, determination of an appropriate dose and method of application would reduce the cost of production and enhance the productivity, and consequently increase the profits under given situations (Rawal et al., 2017, Ahmed et al., 2016, Chaudary et al., 2011). A crop production system with high yield targets cannot be sustained unless balanced nutrient inputs are supplied to soil against nutrient removal by crops. Nitrogen (N) is the most limiting nutrient for rice production and is required more consistently and in larger amounts than other nutrients(Rao et al., 2014, Chaudary et al., 2013, Pasha and Reddy, 2007).It is estimated that 1 kg of nitrogen is required to produce 15–20 kg of grains (Mahajan et al., 2011, Singh et al., 2007). The low N use efficiency has been mainly due to its rapid mineralization and proneness to losses like denitrification, leaching and volatilization through different pathways before it is utilized by the crop (Thind et al., 2018, Patel et al., 2018, Nayak et al., 2015, Mallareddy and Padmaja, 2013). Semi-dry rice requires more precise nitrogen management technology because it will go through both lowland and upland conditions during their growth stages. Initial slow growth with required nitrogen may be helpful as it enables to have longer time for conversion to wet. It can be achieved by split application of nitrogen at different growth stages (Sathiya et al., 2008, Sharma et al., 2007). Hence our hypothesis of present study effect of levels and time of nitrogen application of yield and economics of rice.

2. Materials and Methods

The study was conducted during *kharif* (July–November, 2017) at Agricultural Research Institute, Professor JayashankarTelangana State Agricultural University (PJTSAU), Rajendranagar,Hyderabad, Telengana State, India.Theclimate of Hyderabad is classified as dry tropical and semi-arid. The study was conducted with 10 treatments and laid out in randomized block design with 3 replications. The treatments comprised of three doses of nitrogen (120, 140 and 160 kg ha^{-1}) and 3 schedules of nitrogen application (25% each at sowing, 20 DAS, 40 DAS and 60 DAS, 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30 at 60 DAS,10% at sowing, 10% at 20 DAS, 40% at 40DAS and 40% at 60 DAS.) and were evaluated against the farmers practice (120 kg ha^{-1} N at 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS). The soil of the experimental site was clay loam in texture, slightly alkaline in reaction, non-saline, low in organic carbon and available nitrogen, high in available phosphorous and potassium.The crop was sown in non-puddle field by giving one pre sowing irrigation and grown as aerobic crop up to 40 DAS and there after converted to wet and 2–5 cm standing water was maintained. The test variety grown was JGL-18047 (Bathukamma) of medium slender grain type with duration of 120–125 days.

Nitrogen was applied accordingly experimental specification in the form of urea at four splits application with different doses (120, 140 and 160 kg ha ^{1}). Phosphorous @ 60 kg ha^{-1} in the form of SSP and potassium @40 kg ha^{-1} in the form of MOPwere applied at the time of sowing as basal. Data recorded on various parameters during investigation was statistically analysed following the analysis of variance (ANOVA) technique for randomized block design as suggested by Panse and Sukhatme (1978). The statistical significance was tested with F-test value at 0.05 level of probability.

3. Results and Discussion

3.1. Effect of nitrogen dose and time of application on yield attributes

3.1.1. Number of panicles m^{-2}

Among the different doses and schedules of application, the highestnumber of panicle m^{-2} (309.3) was recorded with the application of the 160 kg N ha^{-1} N in 4 equalsplits at sowing, 20, 40 and 60 DAS than the other lower doses of fertilizers. This might be due to the application of the higher dose of nitrogen, which increased their vegetative growth by conversion of the source to sink are high compared to the other doses of fertilizer doses. Application of nitrogen in equal doses at different growth stages full filled their requirement satisfactorily than other time of application. However, this was on par with the lower doses of 120 and 140 kg N ha^{-1} when applied 25% each in 4 equal splits of at sowing, 20, 40 and 60 DAS (T_2 and T_5), the doses of 140 and 160 kg N ha^{-1} when applied in 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS (T_7 and T_{10}) and the doses of 140 and 160 kg N ha^{-1} applied in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS (T_6 and T_9) . The lowest number of panicle m^{-2} (249.3) was recorded in the farmer's practise (T_1 (249.3) with the application of the 120 kg ha^{-1} N at 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS). This might be due to the insufficient dose of nitrogen in the initial crop growth stage and non-synchronous application of fertilizers failed to meet the required demand for the growth and development.Similarly, highest number panicle m^{-2} reported in 160 kg N ha^{-1}but were found to be on par with 120 kg N ha^{-1} in dry seeded rice under medium deep black soils at Raichur (Reddy et al., 2017, Siddiq et al., 2011, Ajmal et al., 2022).

3.1.2. Panicle length (cm)

Maximum panicle length was recorded with application of the 160 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS were highest (23.9 cm) compared to the other treatments. It was on par with treatments having 160 and 140 kg N ha^{-1} applied at various splits and with T_2 (application of 120 kg N ha^{-1} N in 4 equal splits at sowing, 20, 40 and 60 DAS). Shortest panicle height (19.2 cm) was recorded in the treatment, T_1- application of the 120 kg ha^{-1} N at 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS and this was found to be significantly inferior with all the doses of (120, 140 and 160 kg N ha^{-1}) when applied 25% each in 4 equal splits of at sowing, 20, 40 and 60 DAS (T_2, T_5, and T_8), all the higher doses of 140 and 160 kg N ha^{-1} applied in 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS (T_7 and T_{10}) and T_9- 160 kg N ha^{-1} applied in 4 splits 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS. Similar result was noticed by Sharma et al. (2007), Ahmed et al., 2016 in aerobic rice.

3.1.3. Number of filled grains panicle^{-1}

Highest filled grains panicle^{-1} (103.2) was noticed with application of 160 kg N ha^{-1} in 4 equal splits at sowing, 20, 40 and 60 DAS (T_8) which was on par with the lower doses of 120 and 140 kg N ha^{-1} when applied in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS (T_2 and T_5), the doses of 140 and 160 kg N ha^{-1} applied in 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS (T_7 and T_{10}) and also applied in 4 splits 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40%

at 60 DAS (T_6 and T_9). Lowest number of filled grains panicle^{-1} (84.4) was recorded in treatment T_1 (application of 120 kg N ha^{-1} at 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS). This might be due to less conversion of sink to source in lower doses when unequal split application was employed compared to the equal split application(Lakshmi Bai et al., 2014). Hussain et al. (2013) also obtained similar findings.

3.1.4. Number of unfilled grains panicle^{-1}

Number of unfilled grains are increased with increase in the fertilizer doses. Highest number of unfilled grain panicle^{-1} (15.3) was observed in the treatment T_9 (160 kg N ha^{-1} in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS). It was found to be on par with other treatments with 160 kg N ha^{-1} (T_8 and T_{10}). Hussain et al. (2013) also found increase in unfilled grains panicle^{-1} from 80–140 kg N ha^{-1} in aman rice in silty clay loams soil at Gazipur. Lowest number of unfilled grains were recorded with application of nitrogen @ 120 kg ha^{-1} in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS (T_2- 8.6).

3.1.5. Total number of grains panicle^{-1}

Number of total grains panicle was found to increase with increase in dose of nitrogen application. Highest total grains panicle^{-1} (108.1) was noticed in T_8-application of 160 kg N ha^{-1} in 4 equal splits at sowing, 20, 40 and 60 DAS. However, it was found to be at par with the lower doses of 120 and 140 kg N ha^{-1} when applied in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS (T_2 and T_5), the doses of 140 and 160 kg N ha^{-1} when applied as 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS (T_7 and T_{10}) or applied in 4 splits 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS (T_6 and T_9). Lowest number of total grains panicle^{-1} (95.9) was recorded in treatment T_1 (application of 120 kg N ha^{-1} N at 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS).

3.1.6. Sterility percentage (%)

Spikelet sterility has significant effect on the dose and time of application in the semi dry rice. Highest spikelet sterility percentage was noticed (13.5%) with application of 160 kg ha^{-1} N in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS (T_9). The other treatments with 160 kg N ha^{-1} but applied in different proportions (T_{10} and T_8) were also found to be par with T_9. Lowest spikelet sterility (8.0%) was recorded in the treatment T_2 i.e., with 120 kg ha^{-1} N in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS. All other treatments except T_4 (120 kg ha^{-1} N in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS) recorded a significantly higher spikelet sterility. Similar observations were noticed by Ragavendra et al. (2017), Lakshmi Bai et al., 2014.

3.1.7. Test weight (g)

Highest test weight (23.9 g) was recorded in 160 kg N ha^{-1} 4 equal splits at sowing, 20, 40 and 60 DAS compared to other dose and time of application of fertilizers. Lowest test weight (23.5 g) was recorded in the farmer's practice (T_1- application of 120 kg N ha^{-1} N at 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS) application. Even though there is slight increase in the test weight by increasing doses of nitrogen the differences are non-significant in nature. With respect to different splits of application of nitrogen, highest test weight was noticed with the application of the nitrogen in 4 equal splits at sowing, 20, 40 and 60 DAS compared to the other split applications of nitrogen. Test weight a genetic character specific to the variety, was not found to be not influenced by time of application and the crop (Thind et al., 2018, Lakshmi Bai et al., 2014).

3.2. *Effect of nitrogen dose and time of application on yield of semi dry rice*

3.2.1. Effect on grain yield

Grain yield was found to be significantly influenced by the different dose and time of application of the nitrogen. Grain yield increased from lower dose to higher dose of N application. Highest grain yield (4569 kg ha^{-1}) was recorded with application of the 160 kg N ha^{-1} in 4 equal splits at sowing, 20, 40 and 60 DAS (T_8). However it was found to be on par with application of lower doses of 120 and 140 kg N ha^{-1} (T_2 and T_5) when applied in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS, and also the doses of 140 and 160 kg N ha^{-1} when applied in various splits (T_6, T_7, T_9 and T_{10}) . Application of 120 kg N ha^{-1} at 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS has recorded the lowest grain yield (3676 kg ha^{-1}) compared to other treatments. It was found to be significantly inferior than all other treatments having140 and 160 kg N ha^{-1} and application of 120 kg N ha^{-1} in 4 equal splits at sowing, 20, 40 and 60 DAS (T_2). Similar results were noticed by Anil et al. (2015), Mandana et al. (2014), Hebbar et al. (2017), Mahajan et al. (2011) Ramulu et al. (2016), Rao et al. (2014).

3.2.2. Straw yield (kg ha^{-1})

The application of the higher dose of fertilizers had increased the vegetative growth and dry matter accumulation thereby the straw yield. The straw yield was found to be increased with increase in the nitrogen fertilizer dose. Highest straw yield (5828 kg ha^{-1}) was recorded with application of 160 kg N ha^{-1} in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS (T_8). However, it was found to be on par with all the doses of (120 and140 kg N ha^{-1}) when applied 25% each in 4 equal splits of at sowing, 20, 40 and 60 DAS (T_2 and T_5). The treatments with 140 and 160 kg N ha^{-1} applied as 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS (T_7 and T_{10}) and applied in 4 splits 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS (T_6 and T_9). Lowest straw yield (4871 kg ha^{-1}) was observed in farmer's practice (T_1application of 120 kg N ha^{-1} in 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS). Similarly, Straw yield recorded with 120 kg N ha^{-1} was on par with that of 160 kg N ha^{-1} in dry seeded rice grown in silty loamy soil at U.P. (Singh and Tripathi, 2007). Kumar and Singh (2016), Murthy et al. (2015) andPatelet al. (2018) also observed similar results (Table 1).

Table 1: Yield attributes of semi dry rice as influenced by dose and time of nitrogen application

T. No.	Yield attributes						
	Panicle m^{-2}	Panicle length (cm)	No. of filled grains $panicle^{-1}$	No. of unfilled grains $panicle^{-1}$	Total No. of grains $panicle^{-1}$	Sterility percentage (%)	Test weight (g)
T_1	249.3	19.2	84.4	10.5	95.9	10.9	23.5
T_2	292.0	22.2	99.2	8.6	107.8	8.0	23.7
T_3	261.3	20.1	88.8	9.5	101.3	9.4	23.5
T_4	272.3	21.2	90.3	9.3	102.6	9.0	23.5
T_5	301.3	23.0	100.2	10.8	111.0	9.7	23.7
T_6	281.3	21.2	97.3	11.2	107.5	10.4	23.6
T_7	288.0	22.1	98.0	11.1	108.1	10.3	23.7
T_8	309.3	23.9	103.2	14.9	118.1	12.6	23.9
T_9	290.7	22.3	98.0	15.3	113.3	13.5	23.8
T_{10}	301.3	23.4	100.4	15.1	115.5	13.1	23.8
SEm±	11.7	0.9	4.1	0.4	4.2	0.4	0.3
CD (p=0.05)	34.1	2.8	12.2	1.2	12.7	1.3	NS

T_1: Farmer's practice (120 kg ha^{-1} N in 3 splits of 12% at sowing, 44% at 40 DAS and 44% at 60 DAS); T_2: 120 kg N ha^{-1} in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS; T_3: 120 kg ha^{-1} N in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS; T_4: 120 kg N ha^{-1} in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS; T_5: 140 kg N ha^{-1} in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS; T_6: 140 kg N ha^{-1} in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS; T_7: 140 kg N ha^{-1} in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS; T_8: 160 kg N ha^{-1} in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS; T_9: 160 kg N ha^{-1} in 4 splits of 10% at sowing, 10% at 20 DAS, 40% at 40 DAS and 40% at 60 DAS; T_{10}: 160 kg ha^{-1} N in 4 splits of 20% at sowing, 20 at 20 DAS, 30% at 40 DAS and 30% at 60 DAS

3.2.3. Harvest index (%)

Harvest index has not shown any significant difference due to nitrogen levels and time of application. However, among different doses of application the harvest index (44.5) was observed to be the highest with application of 140 kg N ha^{-1} in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS. Among different time of application, the highest harvest index was recorded with application of Nitrogen in 4 splits of 20% at sowing, 20% at 20 DAS, 30% at 40 DAS and 30% at 60 DAS. Lowest harvest index (42.9) was recorded in farmer's practices (T_1-application of 120 kg N ha^{-1} in 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS). Increasing nitrogen level beyond a limit did not increase the harvest index, probably there was not a drastic increase in grain yield in relation toincrease in biological yield(Rawal et al., 2017) (Table 2).

Table 2: Yield (kg ha^{-1}) and harvest index (%) of semi dry rice as influenced by dose and time of nitrogen application

T. No.	Yield attributes		Harvest index (%)
	Grain	Straw	
T_1	3676	4841	42.9
T_2	4350	5512	44.1
T_3	3961	5061	43.8
T_4	4046	5178	43.9
T_5	4514	5651	44.4
T_6	4370	5470	44.4
T_7	4447	5540	44.5
T_8	4569	5828	44.0
T_9	4403	5739	43.4
T_{10}	4504	5812	43.2
SEm±	171.4	210.0	0.7
CD (p=0.05)	508.0	624.1	NS

3.3. Effect of nitrogen dose and time of application on economics of semi dry rice

Data pertaining to the cost of cultivation, gross returns, net returns and B: C ratio of various treatments in the experiment was showed in Table 3.

3.3.1. Cost of cultivation (₹ ha^{-1})

Highest cost of cultivation (₹ 40,047 ha^{-1}) was noticed in the treatments with 160 kg N ha^{-1} applied at various splits (T_8, T_9 and T_{10}). Application of higher dose of fertilizers resulted in growth of more weed flora than lower doses and required extra man power for weeding. Lowest cost of cultivation (₹ 37026 ha^{-1}) was found in application of 120 kg N ha^{-1} applied

Table 3: Economics of semi dry rice as influenced by dose and time of nitrogen application

T. No.	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C Ratio
T_1	37026	64224	27198	1.73
T_2	37026	75693	38667	2.04
T_3	37026	68987	31961	1.86
T_4	37026	70948	33922	1.92
T_5	39786	78444	38658	1.97
T_6	39786	75940	36154	1.91
T_7	39786	77238	37452	1.94
T_8	40047	79561	39514	1.99
T_9	40047	76855	36808	1.92
T_{10}	40047	78530	38483	1.96

1 US$= 80.76 INR Average harvesting month value

in various splits (T_1, T_2, T_3 and T_4).

3.3.2. Gross returns (₹ ha^{-1})

Highest gross returns (₹ 79,561 ha^{-1}) were obtained from T_8 treatment (application of 160 kg N ha^{-1} in 4 equal splits at sowing, 20, 40 and 60 DAS). Lowest gross returns (₹ 64,224 ha^{-1}) was recorded in farmer's practice (T_1- application with of nitrogen at 120 kg ha^{-1} N in 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS).

3.3.3. Net returns (₹ ha^{-1})

The treatment with application of 160 kg N ha^{-1} in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS had given the highest net returns (₹ 39,514 ha^{-1})compared to other treatments and was closely followed by the treatment T_2 (120 kg N ha^{-1} in 4 equal splits of 25% each at sowing, 20, 40 and 60 DAS) with ₹ 38,667 ha^{-1}. Lowest gross returns (₹ 27,198 ha^{-1}) was noticed in farmer's practice (T_1- application with of nitrogen at 120 kg ha^{-1} N in 3 splits with 12% at sowing, 44% at 40 DAS and 44% at 60 DAS). Application of nitrogen in irregular splits was found to be uneconomical than equal splits.

3.3.4. B:C ratio

Highest B:C ratio was realised from the treatment T_2 -application of 120 kg N ha^{-1} in 4 equal splits at sowing, 20, 40 and 60 DAS (2.04) compared to other higher doses and schedules of application. Application of extra doses of nitrogen did not increase the B:C ratio compared to the optimum doses. Lowest B:C ratio was noticed in farmer's practice (1.73). Gupta et al. (2011) also observed the highest B:C ratio with application of 120 kg N ha^{-1} compared to the 150 and 180 kg N ha^{-1} in loamy sandy soil at Ludhiana.

4. Conclusion

Yield attributes and yield were found higher in application of the 160 kg N ha^{-1} in four equal splits 25% each at sowing, 20, 40 and 60 DAS but it was on par with lower doses. Therefore,application of the 120 kg N ha^{-1} in four equal splits 25% each at sowing, 20, 40 and 60 DAS were found to be the optimum for semidry rice grown in clay loam soil.

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