Agricultural Journal 2 (1): 38-45, 2007

Effect of Establishment Techniques and Nitrogen Management on the Leaf Nitrogen Concentration (LNC), Flowering, Nitrogen Use Efficiency and Quality of Rice Hybrid (*Oryza sativa* L.) ADTRH1

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Abstract: Field experiments were conducted during the *Kharif* season 2002 and 2003 at wetland research farm of Tamil Nadu Agricultural University, Coimbatore with the objective of developing suitable and efficient crop establishment techniques and to optimize the nutrient management strategy for rice hybrid ADTRH1. The experiments were laid out in split plot design replicated thrice with four crop establishment techniques in the main plot and seven N management practices were assigned in the sub-plots. The results revealed that the Leaf Nitrogen Concentration (LNC) was not significantly influenced by the crop establishment methods. Wet seeded rice crop registered earlier flowering of seven days as compared to the transplanted crop. Nitrogen use efficiency recorded significantly higher value by the seeding through all the holes (M_2) and it was on par with transplanting (M_1) and seeding through one out of two holes (M_3). Application of N based on Soil Test Crop Response (STCR) for a yield target of 7 t ha^{-1} registered significantly higher leaf nitrogen concentration and was comparable with N application in four splits plus green manure application @ 6.25 t ha^{-1}. The Nitrogen use efficiency was significantly higher with the N application based on Leaf Colour Chart (LCC) cv.4 whereas least NUE was registered with STCR based N application as compared to rest of treatments. The N management exerted significant variation in days to 50% flowering in both the years. Maximum number of days to 50% flowering was noticed with STCR based N application and minimum number of days was invariably noticed in control. The crop establishment methods did not cause significant variation in the quality parameters of hybrid rice. Significantly higher protein content was recorded with N application based on STCR and it was comparable with green manure 6.25 t ha^{-1} plus N application in four splits. Application of 100% N as organic manures recorded significantly higher amylase 27.20% and the lowest amylase content was observed in N application based on STCR.

Key words: Establishment techniques, leaf nitrogen concentration, hybrid rice, quality parameters

INTRODUCTION

The evolution of hybrid rice technology has generated high hopes in rice growing regions for meeting the food demands of the ever growing population. It is generally felt that a yield plateau has been reached in conventional rice varieties and any further increase in the productivity of rice warrants the breaking of this yield barrier. India is yet to fully exploit the hybrid rice technology which offers a 10-15% yield advantage over the best conventional inbred varieties[1,2]. Growing hybrid rice is a complex process since agronomic management of hybrid rice differs considerably from that of conventional inbred varieties in many respects. Agronomic inputs for realizing the full yield potential of hybrids are yet to be fully evaluated and optimized in various rice growing regions of Tamil Nadu. Of the many agronomic requirements for success in hybrid rice culture, plant density plays an important role which is an important aspect in wet seeding. Economy in seed rate of wet seeded rice had been made possible through the invention of drum seeder. The drum seeder enables sowing rice seeds in rows which facilitates easy manual weeding. Studies on effect of wet seeded short duration hybrid rice using drum seeder on various physiological parameters have not so far been taken up.

Nitrogen is the most limiting nutrient in irrigated rice system and grain yield is closely correlated with the total plant N accumulation. Nitrogen management is a vital strategy In hybrid rice production because of higher N

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demand and lower N use efficiency. In order to minimize N-fertilizer use and to maximize nitrogen fertilizer efficiency for enhancing rice yield, an innovative N management approach was introduced which estimate the leaf N concentration by the measurement of leaf greenness. Maintaining adequate leaf N concentration throughout the critical stages of crop growth was important to achieve higher NUE in terms of growth, yield and photosynthetic rate as reported by several scientists from rice growing countries[3-5]. Tenderness and cohesiveness of cooked rice is mostly governed by the total and insoluble amylose content[6]. In this context the present investigation was carried out to study the effect of different establishment methods and N management practices on the leaf nitrogen concentration, days to 50% flowering, nitrogen use efficiency and quality parameters of rice hybrid ADTRH1 under Tamil Nadu condition.

MATERIALS AND METHODS

Field experiments were conducted during *Kharif* (June-September) 2002 and 2003 at wetland farm of Tamil Nadu Agricultural University, Coimbatore to evaluate the effect of crop establishment methods with various N management practices in ADTRH1 rice hybrids. The soil of the experimental field was moderately drained, deep clay loam in texture and taxonomically classified as *Typic Haplustalf*. The soil was low in available N, medium in available P and high in available K. The experiment was laid out in a split plot design replicated thrice. The main plot consisted of four crop establishment techniques and sub-plot with seven levels of N management practices. The hybrid ADTRH1 grown in the experiment is short duration hybrid rice (110-115 days) suitable for *Kharif* season with long slender grain.

The details of the treatments and the notations used are as follows.

Main plots: Crop establishment techniques

M_1- Transplanting (15x10cm)

M_2- Drum seeding though all holes

M_3- Drum seeding through one out of every two holes

M_4- Drum seeding through one out of every three holes

Sub-plots: N managements

N_1- Control (without N)

N_2- 120 kg N ha^{-1} in four splits (1/6th N at 7DAT, 1/3rd at active tillering, 1/3rd at panicle initiation, 1/6th at first flowering)

N_3- Green manure application @ 6.25tha^{-1} +120 kg N ha^{-1} in four splits

N_4- 20 kg N ha^{-1} + N as per LCC cv.4

N_5 -N application as per LCC cv.4

N_6- 100% N through organic manures (50% N as green manure + 15% N as poultry manure + 20 % N as FYM + 15% N as neem cake)

N_7- Soil Test Crop Response (STCR) based N application for a yield target of 7 t ha^{-1}

The drum seeder holes were plugged with cellophane tape to impose the different seeding methods as described in M_3 and M_4 methods. Above ground biomass of *Sesbania aculeata* at the age of 40 days was harvested, weighed and applied to the respective plots as per treatment schedule. The green manure was spread uniformly and incorporated a week prior to transplanting. Seeds of hybrid ADTRH1 were treated with carbendazim at 2 g kg^{-1} of seeds against seed borne pathogens. After 24 h, the seeds were inoculated with Azospirillum @600 g ha^{-1} and the seeds were soaked in water for 24 h and incubated in dark for 12 h to induce sprouting. The drum seeder developed by the Department of Agricultural Engineering, TNAU,Coimbatore for row seeding of pre-germinated paddy seeds on puddle soil was used for direct seeding. This machine permits uniform seeding at fairly low seed rates of 50-100 kg ha^{-1}.The eight row drum seeder was used for this purpose and it requires 9 kg of pulling force to operate. The machine weighs 11 kg with seed capacity of 8 kg (2 kg/hopper). Seeding output per day is about 1.0 ha with seeding labour requirement of 14 man h ha^{-1}.The seed rate was optimized by seeding through one out of every two holes and seeding through one out of three holes. The ADTRH1 seeds of 20 kg were sown in the wet nursery for raising seeding on the same day of direct seeding in the main field. The seedlings raised were transplanted at 24 days after sowing. The seedlings were transplanted at one seedling $hill^{-1}$ adopting a spacing of 15×10 cm.The recommended dose of 120 kg N ha^{-1} for *Kharif* as per treatment was applied in equal splits on 30, 45, 70 and 95 DAS. Phosphorus at 50 kg ha^{-1} was applied basally to all the treatments. Potash @ 50 kg ha^{-1} was applied in three equal splits on 30, 45 and 70 DAS along with the first three splits of fertilizer N. In LCC based N management treatments, the LCC values were recorded as per the standard procedure at weekly interval starting from 14 DAT to flowering for transplanted crop. In case of drum seeding the LCC values were recorded at weekly interval from 21 DAS. Whenever the LCC values were found to be below the critical level of four, recommended quantity of fertilizer N was applied.

Leaf N concentration: Leaf N concentration was determined and expressed on oven dry basis (n Lg^{-1} kg^{-1})[7]. The average dry weight of four leaves was multiplied by nL to get total N leaf content.

Nitrogen use efficiency:

- Partial factor productivity (PFP) = $\frac{Y}{Nt}$

  Where, Y is the mean grain yield (kg ha^{-1}) and Nt is the total amount of N applied (kg ha^{-1} in treatment).

- Agronomic Efficiency (Ea) = $\frac{\Delta Y}{\Delta t}$

Where, Δ y is the incremental mean grain yield (kg ha^{-1}) for N applied treatment compared to control (Zero N) and Δ t is the total amount of N applied (kg ha^{-1}) in that treatment.

Apparent Recovery of N (AR): Apparent recovery of N was computed as per the formula given below.

$$AR\ (\%) = \frac{\text{Uptake of N in fertilized plot (kg ha}^{-1}\text{)- Uptake of N in unfertilized plot (kg ha}^{-1}\text{)}}{\text{Quantity of N applied(kg ha}^{-1}\text{)}}$$

Chemical analysis

Amylose: The amylose content of rice for the hybrid was estimated after hydrolysis and expressed in percentage [24].

Protein content: The protein content was estimated by Microkjeldahl method[8].

RESULTS AND DISCUSSION

Leaf Nitrogen Concentration (LNC): The leaf nitrogen concentration is an important parameter to judge the photosynthetic rate and its efficiency for the conversion of photosynthates from source to sink. LNC and leaf Co_2 assimilation rate has a close relationship reflecting on the crop growth and yield parameters. In the present investigation, the Leaf Nitrogen Concentration (LNC) estimated at 40, 60 and 80 DAS revealed that there is no significant variation between the crop establishment techniques at all the stages of the crop in both the seasons% Table 1. However LNC was numerically higher in seeding through one of three holes (M_4) followed by M_3, M_1 and M_2.The lower plant density in this treatment might have increased the uptake of nutrients due to less competition resulting in higher LNC compared to other treatments. In general, the results have shown that the maximum leaf nitrogen concentration occurs at 40 DAS in ADTRH1 and thereafter starts declining %Table 1. Similar results of highest leaf nitrogen concentration have been reported to occur around active tillering stage[5].As far as N management is concerned, the highest LNC was recorded with N application of 120 kg ha^{-1} plus green manure 6.25 t ha^{-1}(N_3).The higher LNC under these two N regimes exhibited the fact that higher the LNC consequently will influence the grain yield. The application of higher quantity of N in STCR based application (N_7) resulted in increased N uptake by the hybrids and the continuous supply of N through decomposition of green manure might have resulted in maintaining adequate leaf N throughout growing period in N_3 treatment. This is in accordance with the observation of earlier worker[3]. The solar radiation use efficiency for Co_2 assimilation depended on N concentration in leaves and new leaf area was developed only when there was adequate leaf N present. Lower LNC was registered in control plot and this results fall in line with the observation of lower LNC in no 'N' applied (control)[10].

Days to 50% flowering: The different crop establishment methods and N management practices exerted a considerable variation on the days to 50% flowering in both the years of the study. Maximum number of days to 50% flowering during both the years was registered in transplanting method (M_1) was 91.34 and the minimum days to 50% flowering was noticed in seeding through one out of two holes(M_3) was 85.15. The drum seeding establishment technique had a minimum of 5.39 and maximum of 7.12 days earlier flowering as compared to transplanting. The delay in flower emergence by a maximum of 7.12 days in transplanted crop might be due to transplanting shock experienced by the seedlings in the third week% Table 2. Impairing of the seedling physiological activity due to uprooting might also be the reason for delayed flowering under transplanting method compared to direct seeding of rice[11]. Delayed flowering by 6-9 days and 3 days to maturity has been reported depending upon the environmental conditions like method of nursery preparation and age of seedlings[12]. Similar result of enhanced early crop establishment by direct seeding through drum seeder and reduced crop duration by two weeks compared to transplanting methods[13].

In the drum seeding treatment, the different seed rates has a marginal influence on days to 50% flowering due to variation in plant density. Seeding through all the holes

Table 1: Influence of crop establishment methods and 'N' management on leaf nitrogen concentration (g kg^{-1}) of ADTRH 1

	Leaf Nitrogen Concentration(g kg^{-1})					
	Kharif 2002			*Kharif* 2003		
Treatments	40DAS	60DAS	80DAS	40DAS	60DAS	80DAS
Establishment methods						
M_1	29.64	22.68	18.97	29.01	23.09	18.76
M_2	29.47	22.55	18.86	28.84	22.96	18.65
M_3	29.88	22.87	19.12	29.26	23.28	18.92
M_4	30.49	23.31	19.50	29.87	23.73	19.28
CD(0.05)	NS	NS	NS	NS	NS	NS
N Management						
N_1	21.38	16.62	14.58	20.61	16.89	14.28
N_2	28.88	23.08	18.36	29.08	23.49	19.67
N_3	36.41	28.10	22.35	36.16	28.57	21.78
N_4	29.77	22.21	19.28	28.19	22.63	18.82
N_5	28.68	21.51	18.98	27.98	21.91	18.53
N_6	25.58	19.49	17.20	24.86	19.88	16.82
N_7	38.40	28.97	23.03	37.80	29.45	22.44
CD(0.05)	1.94	1.21	1.07	1.68	1.29	1.05

Table 2: Effect of crop establishment methods and N management on days to 50% flowering of ADTRH 1

	Kharif 2002					*Kharif* 2003				
Treatments	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
N_1	88.83	81.58	82.49	83.12	84.00	88.57	81.44	82.53	82.80	83.83
N_2	91.54	84.75	85.38	86.11	86.94	91.13	84.15	84.69	85.51	86.37
N_3	92.46	85.28	86.63	87.07	87.86	92.68	85.42	86.87	87.23	88.05
N_4	91.67	84.41	85.59	86.32	87.00	90.95	83.51	85.14	85.51	86.28
N_5	91.62	84.74	85.20	86.12	86.92	90.77	84.41	84.87	85.68	86.43
N_6	90.76	83.42	84.33	85.25	85.94	90.13	84.05	84.60	85.41	86.05
N_7	92.52	85.38	86.44	87.67	88.00	93.58	86.23	87.59	88.59	89.00
Mean	91.34	84.22	85.15	85.95		91.11	84.17	85.18	85.82	

Data not statistically anlaysed

esulted in early flowering compared to the seeding through one out of three holes due to higher plant density. The early flowering due to higher plant density was reported earlier[14]. Increased number of days to 50% flowering was noticed with N application based on STCR. The increased quantity of N application through STCR resulted in uniform supply of N throughout the crop growth period tends to increase the number of days taken to 50% flowering. Prolonging the number of days for flowering with adequate N nutrition in rice has been reported[15,16]. Similar results of delayed 50% flowering due to higher N application were reported earlier[17].

Nitrogen Use Efficiency (NUE)

Agronomic efficiency: Agronomic efficiency which is an indicator of grain produced per kg of applied N showed wide variation from 17.20 to 22.52% during both the years of study. Among the crop establishment techniques, the highest agronomic use efficiency was registered with the seeding through all the holes (M_2) and the lowest agronomic use efficiency was recorded in seeding through one out of three holes (M_4)% Table 3. The obvious reason for this, is the sub-optimal plant density in the seeding through one out of three holes due to lower seed rate resulted in underutilization of applied nitrogen subjecting to various losses and ultimately causing reduction in NUE. Similar result of lower NUE of 18.94% with lower seed rate of 12 kg ha^{-1} in wet seeding of rice as against 36.01% NUE with seed rate of 24 kg ha^{-1} was reported[18]. With increase in N level, the rate of response or the rate of change in production increased with decreasing rate. This is in conformity with the observations made by earlier research workers on N management[19,20]. In the present study, higher values are associated with the application of N through LCC measurements matching the peak demand of the crop and the highest agronomic efficiency of 22.52 was registered with the N application based on LCC cv.4. In the LCC value based N management, basal dose of N was skipped, which might have reduced the losses of applied N during the early stages and resulted in higher agronomic efficiency. This is in agreement with the earlier observation[21]. Moreover, the quantity of N applied was also less in this treatment which indicated that the response of rice is high at low N supply and medium to low at high N addition. The fact is supported by the findings that the agronomic efficiency is reduced at higher N rates. This is expected because cereal crops like rice may show linear response at low fertilizer input and a quadratic response thereafter. The application of N based

Table 3: Effect of crop establishment methods and N management on agronomic efficiency (kg (kg N^{-1}) of ADTRH 1

	Kharif 2002					*Kharif* 2003				
Treatments	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
N_1	-	-	-	-	-	-	-	-	-	-
N_2	21.83	22.39	21.52	15.12	20.22	21.43	22.10	20.90	15.00	19.86
N_3	20.44	20.80	20.25	12.61	18.53	19.39	19.85	19.37	12.95	17.89
N_4	21.96	22.46	21.70	15.24	20.34	21.35	21.84	21.54	15.03	19.94
N_5	24.32	24.57	24.25	16.95	22.52	23.12	23.28	22.86	17.00	21.56
N_6	-	-	-	-	-	-	-	-	-	-
N_7	19.26	19.38	19.08	12.39	17.53	18.68	19.30	18.68	12.12	17.20
Mean	21.56	21.92	21.36	14.47		20.79	21.27	20.67	14.42	

Data not statistically anlaysed

Table 4: Partial factor productivity (kg (kg N^{-1}) of ADTRH 1 as influenced by Crop establishment methods and N management

	Kharif 2002					*Kharif* 2003				
Treatments	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
N_1	-	-	-	-	-	-	-	-	-	-
N_2	52.33	53.31	51.73	40.42	49.45	50.20	51.44	49.23	38.58	47.36
N_3	41.71	42.37	41.32	30.28	38.92	39.46	40.32	39.25	29.41	37.11
N_4	51.25	52.14	50.70	39.52	48.40	48.97	50.00	48.74	37.67	46.34
N_5	59.18	59.90	58.77	45.86	55.93	56.00	56.82	55.71	43.95	53.12
N_6	43.55	45.04	41.60	37.32	41.88	42.27	43.93	40.77	36.82	40.95
N_7	32.62	32.79	31.42	28.88	32.89	36.76	37.74	36.49	26.94	34.48
Mean	47.77	47.59	45.97			45.61	46.71	45.03	35.56	

Data not statistically anlaysed

on STCR registered lower nitrogen use efficiency because of higher dose of N application. Similar finding of lower agronomic use efficiency 7.05% for CoRH2 was recorded by application of 225 kg N ha^{-1} as against 13.5% for 150 kg N ha^{-1}[22]. The lower NUE of 9.5% at 250 kg N ha^{-1} was noticed[23]. The results is online with report of lower NUE of 21.26% with STCR based N application as against 31.5% with 150 kg N ha^{-1}[24].

Partial factor productivity (Pfp): Partial factor productivity, which indicates the efficiency of absorption of applied N, decreased at higher levels of fertilizer. Partial factor productivity in the course of investigation ranges from as low as 26.94 to as high as 59.90 9% Table 4. Among the crop establishment techniques, the highest partial factor productivity was observed in the seeding through one out of every three holes (M_4) in both the years of investigation. The partial factor productivity was lower in the seeding through one out of three holes because of poor plant density as against the seeding through all the holes with higher plant density. Similar result of lower partial factor productivity of 31.5 was recorded with 33 hills m^{-2} density whereas Pfp of 33.5 recorded with 66 hills m^{-2} density was reported [125].It reflects both agronomic use efficiency and the balance between the indigenous soil N supply and applied N. Similar results of higher values with LCC based N management in both the years was noticed[20]. This higher values in LCC based N management proved that these technologies will serve as a standard fertilizer prescription programme for hybrid rice than conventional application of N at prefixed growth stages. The fact is supported by the findings of higher partial factor productivity under the LCC treatment compared to recommended N application[26]. The lowest value of partial factor productivity was registered in N application based on STCR. Similar results of lower Pfp of 27.87 were reported in STCR based N application as against 68.16 in SPAD based N application[10].

Apparent N recovery: The apparent N recovery as influenced by different establishment methods and N management showed wide variation from 20.90 to 42.74% during both the years of study. The highest apparent recovery of N was recorded in the seeding through all the holes which was closely followed by the transplanting method and seeding through one out of two holes in both the years of experimentation % Table 5. The optimum seed rate resulting in higher plant density in all the above methods and consequent increased uptake of N applied by different N management resulted in higher N recovery. The lowest N recovery was observed in the seeding through one out of three holes due to sub-optimal plant density. The fact of lowest recovery fraction in wet seeded rice with12 kg ha^{-1} seed rate was earlier observed[18]. The different N management practices results reflected more or less similar pattern of agronomic efficiency. Here too, low N supply registered more values than high levels of N, once again proving the superiority of N application based on LCC measurements in terms of NUE. Similar results of higher N recovery at lowest N supply were reported[27]. The lowest apparent N recovery was recorded in 100% N application through organic manures.

Table 5: Effect of crop establishment methods and N management on apparent recovery of nitrogen (%) of ADTRH 1

	Kharif 2002					*Kharif* 2003				
Treatments	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
N_1	-	-	-	-	-	-	-	-	-	-
N_2	38.89	39.29	38.43	23.55	35.04	38.26	38.77	39.02	26.25	35.57
N_3	37.89	39.03	36.70	23.85	34.36	35.10	35.93	36.02	21.72	32.19
N_4	39.19	40.44	38.80	24.30	35.68	38.97	39.49	39.64	27.46	36.49
N_5	42.36	42.74	41.84	26.33	38.31	41.43	42.89	42.28	31.46	39.51
N_6	26.92	29.61	26.22	18.66	25.35	24.09	25.48	25.63	22.38	24.39
N_7	35.52	35.72	35.21	22.62	32.27	33.28	32.87	33.55	20.90	30.15
Mean	36.79	37.80	36.20	23.22		35.19	35.90	36.02	25.08	

Data not statistically anlaysed

Table 6: Influence of crop establishment methods and N management practices on Protein (%) and Amylose content (%) of ADTRH1

	Kharif 2002		*Kharif* 2003	
Treatments	Protein content	Amylose content	Protein content	Amylose content
Establishment methods				
M_1	6.60	25.50	6.60	25.20
M_2	6.60	25.80	6.50	25.50
M_3	6.70	26.03	6.60	25.80
M_4	6.70	25.74	6.60	25.50
CD(0.05)	NS	NS	NS	NS
N Management				
N_1	6.10	24.90	6.10	24.50
N_2	6.50	26.80	6.50	26.70
N_3	7.30	24.00	7.20	23.70
N_4	6.50	26.70	6.40	26.30
N_5	6.40	27.00	6.40	27.10
N_6	6.40	27.20	6.30	26.80
N_7	7.30	23.80	7.20	23.50
CD(0.05)	0.26	1.00	0.22	0.94

Chemical properties of rice

Amylase content: Rice quality is determined to a major extent by the amylase content since it is a major source of carbohydrate in most of human diet. The amylase content was not significantly influenced by the crop establishment methods during both the years. However, there was a significant variation in the amylase content due to N management practices. Application of 100% N through organic sources (N_6) recorded highest amylase content 27.20% and it was on par with N application based on LCC cv.4 (N_3) and 120 kg N ha^{-1} as urea in four equal splits (N_2)% Table 6. The least amylase content %23.80% was observed in the N application based on STCR (N_7) and it was on par with four split N application plus green manure (N_3). Since the protein and carbohydrate contents are negatively correlated, an increase in the protein content was associated with a corresponding decrease in the amylase content as was evident with the present study by the higher amylase contents under lower levels of applied N. Higher amylase content in the 100% N application through organic manure was due to proper N nutrition and favourable soil conditions which ensured the nutrient supply to the crop and improved the quality of rice grain. The result is online with the report that application of FYM increased the amylase content compared to control[29].The negative relationship between nitrogen content and amylase content was also documented[30].

Crude protein content: The N management practices had significant influence on the protein content in both the seasons. The N application based on STCR (N_7) registered highest protein content (7.30 and 7.20) and it was on par with four split of N application plus green manure (N_3)% Table.6. The least protein content %6.1% was recorded in control (N_1) during both the years % Table 6. An appreciable increase in protein content of rice grain was observed with the application of N based on STCR and N application in four splits plus green manure @ 6.25 t ha^{-1} is quite natural because an increase in the N application by this two management practices and consequent absorption by the plant resulted in enhanced protein content of the sink. The increase in protein content with the increase in nitrogen is in confirmation with the earlier findings[22]. The increased grain protein concentration is due to higher absorption of mineral N and its assimilation by the plants as observed by higher crop N uptake[32]. It was also confirmed that grain protein content generally increased with increasing N rate[28].

CONCLUSION

The present study concludes that seeding through one out of every three holes using drum seeder along with N application based on Soil Test Crop Response (STCR) registered significantly higher leaf nitrogen concentration. Days to 50% flowering were early by seven days in wet seeded crop as compared to transplanted crop. Seeding through all the holes in combination with N application based on LCC cv.4 registered higher Nitrogen Use Efficiency. Crop establishment methods did not cause significant variation in the quality characters whereas significantly higher protein content was recorded with STCR based N application and higher amylase content with 100% N application through organic manures.

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