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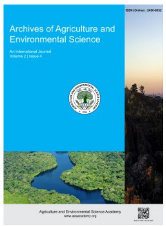

ORIGINAL RESEARCH ARTICLE

CrossMark

Growth analysis of short duration transplant *Aus* rice (*Oryza sativa* L. cv. Parija) under irrigated ecosystem

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ABSTRACT

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during April to July 2012 to examine the effect of plant spacing and nitrogen level on the growth performance of short duration transplant *Aus* rice (cv. Parija) under irrigated ecosystem. The experiment comprised four plants spacings *viz*., 20 cm × 20 cm, 20 cm × 15 cm, 20 cm × 10 cm and 15 cm × 15 cm and four nitrogen levels *viz.* 0, 35, 70 and 105 kg N ha^{-1}. The experiment was laid out in a Randomized Complete Block Design with three replications. Morpho-physiological characters, of transplant *Aus* rice (cv. *Parija*) significantly influenced by spacing of planting, nitrogen level and their interaction. At 60 DAT, the highest plant height (80.68 cm) was obtained at 20 cm × 15 cm spacing fertilized with 70 kg N ha^{-1} which was as good as 20 cm × 10 cm fertilizad with 35 kg N ha^{-1}. The maximum number of tillers hill^{-1} (15.16) was obtained at 20 cm × 20 cm spacing fertilized with 105 kg N ha^{-1}which was statistically at par with 20 cm × 15 cmfertilized with 70 kg N ha^{-1}. The highest total dry matter (8.92g) was obtained at the 20 cm × 15 cm spacing fertilized with higher dose of nitrogen (105 kg N ha^{-1}) and at 45-60 DAT, the highest crop growth rate (3.34) was obtained at 15 cm × 15 cm spacing fertilized with 35 kg N ha^{-1} while the lowest CGR (1.12) was recorded at the same spacing (15 cm × 15 cm) with control treatment. This study revealed that short duration transplant *Aus* rice cv. Parija can be cultivated at 20 cm × 15 cm or 15 cm × 15 cm spacing with 35 to 105 kg N ha^{-1}for proper growth.

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INTRODUCTION

Rice (*Oryza sativa* L.) is the most extensively cultivated crop in Bangladesh and the staple food for her people. In respect of area and production it ranks fourth among the rice producing countries of the world (FAO, 2009). There are three distinct growing seasons of rice namely, *Aus*, *Aman* and *Boro* in Bangladesh. *Aus* rice of the country covers an area of 1018623 ha with a production of 2288000 metric tons (BBS, 2016). *Aus* is the least productive season compared with other two seasons (BBS, 2016). Plant spacing is an important factor that needs to be considered in transplanted rice. The growth, yield and yield components of rice are also greatly influenced by plant spacing. Closer spacing hampered intercultural operation, more competition arises among the plant for nutrient, air and light as a result plant becomes weaker and thinner, consequently reduces dry matter accumulation and yield. Under wider plant spacing farmer could not get desired hill per unit area which ultimately reduces growth and as well as yield of rice. Proper spacing may help receive maximum light interceptions to enhance photosynthesis as like as growth and yield of rice (Jahan *et al*., 2017). Nitrogen is the most essential element in determining the growth and yield of rice production. Soil of Bangladesh is not properly enriched with different nutrients, especially nitrogen for growth and development of plant. Nitrogen is an essential macro element and it is being exhausted in many ways in the field. Plants growth is seriously hampered when lower dose of nitrogen is applied that hampered growth and drastically reduced yield (Ray *et al*., 2015). So, the selection of the most appropriate levels of nitrogen fertilizer is a major concern offering economic viability of the crop production. Therefore, the present study was conducted to find out the effect of plant spacing and nitrogen level on the growth performance of short duration transplant *Aus* rice (cv. *Parija*).

MATERIALS AND METHODS

Study area and experimental design

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from April to July 2012 to study the effect of spacing of planting and nitrogen level on the growth performance of short duration transplant *Aus* rice (cv. *Parija*) under irrigated ecosystem. This experiment was located at $24^0 75'$ N latitude and $90^0 50'$ E longitude having an altitude of 18m above the mean sea level. The experimental site belongs to the Sonatala series of Old Brahmaputra Floodplain Agroecological Zone (AEZ -9) having non-calcareous dark grey floodplain soils (UNDP and FAO, 2009). The experiment field was medium high land having sandy loam with low organic matter content and pH 6.8. The experiment comprised four spacings *viz*., 20 cm × 20 cm, 20 cm × 15 cm, 20 cm × 10 cm and 15 cm × 15 cm and four nitrogen levels *viz*., 0, 35, 70 and 105 kg N ha^{-1}. The experiment was laid out in a Randomized Complete Block Design with three replications. The net size of each unit plot was 4.0 m × 2.5 m.

Selection of rice variety and preparation of nursery

A short duration local variety of *Aus* rice cv. Parija was used in this experiment. The sprouted seeds were broadcasted uniformly in a well prepared nursery bed on 15 April, 2012. The land was first opened with a tractor driven plough, ploughing followed by laddering were done with a country plough and a ladder. Weeds and stubbles were removed from the field as much as possible after leveling. The lands were finally prepared and the plots were laid out on 4 May, 2012. In addition to nitrogen a basal dose each of triple super phosphate, muriate of potash, gypsum and zinc sulphate at the rate of 90, 60, 38 and 8 kg ha^{-1}, respectively were applied in all plots. Nitrogen fertilizer in the form of urea was applied as per treatment used in the experiment in two equal splits at 10 DAT and 30 DAT. All the plots were transplanted on 5 May, 2012 using 3-4 seedlings hill$^{-1.}$ Constant water depth of 5 -7 cm was maintained in the experimental field throughout the growing period. The experimental plots were irrigated and drained out as and when necessary during the growing period of the crop. The crops was found infested with some weeds and were controlled by hand weeding. To control insects, 10 kg of granular Carbofuran-5G per hectare were applied during the first top-dressed of urea; liquid insecticides were applied during the second top-dress and during the milking stage of the panicle to save the crop from stem borer and rice bug insects.

Determination of plant parameters

Growth parameter such as plant height, no of tillers hill^{-1}, total dry matter production hill^{-1} etc. were determined at 15, 30, 45 and 60 DAT. Five hills were marked by bamboo stick excluding boarder rows to collect data on plant height and tiller number. Plant height was measured with the tallest tiller from the selected hills which gave average plant height.

To determine total dry matter, four hills were taken from the outside of harvest area and excluding boarder rows at 15, 30, 45 and 60 DAT. The roots of each plant were removed, then the plants were washed with tap water and the destructive plant samples were packed in labeled brown paper bags and dried in the oven at 85±5°c for 72 hours until constant weight was reached. The samples were weighed carefully after oven drying to measure the dry weight of plant.

Crop growth rate (CGR): Increase of materials per unit of time.

$$\mathrm{CGR} = \frac{1}{\mathrm{A}} \times \frac{\mathrm{W_2 - W_1}}{\mathrm{T_2 - T_1}} (\mathrm{mg\ day^{-1}\ hill^{-1}})$$

Statistical analysis of data

Recorded data were analyzed statistically using analysis of variance (ANOVA) technique and the differences among treatment means were adjudged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant height

The height of the plant was significantly affected by plant spacing (Table 1). At 15 days after transplanting (DAT) the tallest plant (25.62 cm) was obtained at plant spacing 20 cm ×10 cm which was statistically identical to 20 cm × 15 cm plant spacing (25.41 cm) and the shortest one (20.75 cm) was obtained at widest spacing 20 cm × 20 cm. The tallest plant (46.83 cm) was obtained at widest spacing 20 cm × 20 cm which was statistically identical to 20 cm × 15 cm plant spacing at 30 DAT and the lowest one (40.34 cm) was obtained at closest spacing 15 cm × 15 cm. At 45 DAT, the tallest plant height (66.35 cm) was obtained at widest plant spacing 20 cm × 20 cm and the lowest one (60.79 cm) was obtained at closest spacing 15 cm × 15 cm. At 60 DAT, the tallest plant height (78.31 cm) was obtained at plant spacing 20 cm × 10 cm and the lowest one (78.31 cm) was obtained at plant spacing 15 cm × 15 cm. Plant height of transplant *Aus* rice increased with increased growth duration up to 60 DAT (Table 1). Remarkable differences among different levels of nitrogen were found at all dates of sampling. The tallest plant was obtained when fertilized with 105 kg N ha^{-1} and the lowest one recorded in control at all sampling. Plant height increased due to application of nitrogen was reported elsewhere (Salahuddin *et al*, 2009 and Kirtannia *et al*., 2013). The interaction effect of different plant spacing and nitrogen levels had significant effect on plant height (Table 2). At 15 DAT, the highest plant height (27.23 cm) was obtained at the spacing 20 cm × 10 cm with 105 kg N ha^{-1} and the lowest plant height

(18.81cm) was obtained at the widest spacing (20 cm × 20 cm) with control treatment. The interaction of different spacing and nitrogen levels did not produce any significant effect on plant height at 30 DAT. At 45 DAT, the highest plant height was obtained at the widest spacing (20 cm × 20 cm) with 105 kg N ha^{-1} and the lowest one (69.46 cm) was obtained at spacing 20 cm × 20 cm with control application. At 60 DAT, the highest plant height (80.68 cm) was obtained at spacing 20 cm × 15 cm fertilized with 70 kg N ha^{-1} and the lowest plant height (68.69 cm) was obtained at closest spacing (15 cm × 15 cm) with control nitrogen.

Tillering pattern

Spacing had significant effect on the number of tillers hill^{-1} (Table 1). At 15 DAT, the maximum number of tillers hill^{-1} (4.84) was observed at spacing 20 cm × 10 cm and the minimum one (4.37) was observed at spacing 15 cm × 15 cm. At 30 DAT, the maximum number of tillers hill^{-1} was obtained at the widest spacing 20 cm × 20 cm which was statistically identical to spacing 20 cm × 15 cm and 20 cm ×10 cm while the minimum number of tillers hill^{-1} (6.46) was obtained at the closest spacing (15 cm × 15cm). At 45 DAT, the maximum number of tillers hill^{-1} (11.72)was observed at widest spacing 20 cm × 20 cm and the minimum number of tillers hill^{-1} (9.00) obtained at the closest spacing (15 cm × 15 cm). At 60 DAT, the maximum number of tillers hill^{-1}(12.89)was observed at the spacing 20 cm × 15 cm and the minimum number of tillers hill^{-1}(9.88) was obtained at the closest spacing (15 cm × 15 cm). The reason might be wide spaced plants received more nutrients; moisture and light thus produced higher number of tillers hill^{-1}. Wider spacing produced maximum number of total tillers than closer spacing in rice was reported elsewhere (Mobasser *et al*., 2007 and Ray *et al*., 2015). Tillering pattern of transplant *Aus* rice (cv. Parija) at different spacing over time were gradually increased by gradual elevation of nitrogen fertilizer. Maximum tillers hill^{-1} (13.89) was produced at 60 DAT (Table 3). Number of tillers increased with increased levels of nitrogen and highest number of tillers were obtained when 105 kg N ha^{-1} was applied and lowest from control treatment at all sampling dates. Similar result was observed from the findings of Sharma and Mishra (1986).The interaction effect between plant spacing and nitrogen levels was found to be significant at 30 and 60 DAT but insignificant at 15 and 45 DAT (Table 2). The maximum number of tillers hill^{-1}(10.98) and (15.16) was obtained at the widest spacing (20 cm × 20 cm) fertilized with 105 kg N ha^{-1} and the minimum number of tillers hill^{-1}(4.23) and (6.95) was obtained at the closest spacing (15 cm × 15 cm) with control treatment at 30 DAT and 60 DAT. The growth stage effect was pronounced by decreasing number of tillers hill^{-1} during flowering stage and post flowering stage might be due to senescence of tillers at later stages of growth. The significantly highest tillers was obtained by 20 cm × 20 cm plant spacing fertilized with 105 kg N ha^{-1}. The lowest number of tillers hill^{-1} was found always by the control treatment with closest spacing.

Total dry matter (TDM) production

Significant effect of spacing on total dry matter production hill^{-1} was observed at 15, 30, 45 and 60 DAT (Table 3). The highest TDM hill^{-1} was obtained at 20 cm × 15 cm plant spacing at all sampling dates. The lowest TDM hill^{-1} was obtained at the closest spacing (15 cm × 15 cm) at 60 DAT. The lowest TDM hill^{-1} was obtained at the spacing 20 cm × 10 cm at 15, 30 and 45 DAT. The result was agreement with that of Murty and Murty (1980). Tyeb *et al.* (2013) reported that rice crop produced higher dry matter when transplanted at 25 cm × 15 cm spacing the value decreased when transplanted in 20 cm × 10 cm plant spacing. Nitrogen levels had significant effect on the production of total dry matter (TDM) hill^{-1} (Table 3). Total dry matter production by plants increased progressively with the advancement of growth stages of transplant *Aus* rice and it was also increased gradually with increased levels of nitrogen up to 70 kg N ha^{-1} and declined thereafter. The highest TDM hill^{-1} was obtained when 70 kg N ha^{-1} was applied and the lowest one was obtained when fertilized with 35 kg N ha^{-1} at all sampling dates but at 60 DAT, the lowest TDM (5.63) hill^{-1}was obtained with control application of N. Total dry matter production hill^{-1} increased due to application of higher dose of nitrogen (Ray *et al*., 2015) where application of 80 kg N ha^{-1}produced higher dry matter hill^{-1}.The interaction effect between plant spacing and nitrogen levels was significant at 60 DAT but insignificant at 15, 30 and 45 DAT (Table 4). The highest total dry matter (8.92) was observed at the spacing 20 cm × 15 cm fertilized with higher dose of nitrogen 105 kg N ha^{-1} and the lowest one (1.12) was found at the closest spacing (15 cm × 15 cm) with control application of nitrogen at 60 DAT.

Crop growth rate (CGR)

The effect of plant spacing in different crop growth rate (CGR) was significant at 15-30 DAT and 45-60 DAT but not in 30-45 DAT. At 45-60 DAT, the highest CGR (2.68) was obtained at the spacing 20 cm × 10 cm and the lowest CGR (2.01) was obtained at the wider spacing (20 cm × 20 cm) (Table 3). Plant spacing influenced the CGR at various growth stage of rice (Tyeb *et al*., 2013). The effect of nitrogen level in different crop growth rate (CGR) was significant at (45-60) DAT but not in (15-30) DAT and (30-45) DAT (Table 3). At 45-60 DAT, the highest CGR (2.56) was obtained when fertilized with 35 kg N ha^{-1} and the lowest one (1.86) obtained with control application. Ray *et al.* (2015) reported that CGR varied due to rate of nitrogen application. The interaction effect between plant spacing and nitrogen levels was significant at 15-30 DAT and 45-60 DAT but not significant at 30-45 DAT (Table 4). At 15-30 DAT, the highest CGR (1.34) was found at the widest spacing (20 cm × 20 cm) with control application and the lowest CGR (0.56) was found at the closest spacing (15 cm × 15 cm) with control application. At 45-60 DAT, The highest CGR (3.34) was obtained at the closest spacing (15 cm × 15 cm) fertilized with 35 kg N ha^{-1}and the lowest CGR (1.12) was obtained at 15 cm × 15 cm with control application.

Table 1. Effect of plant spacing and level of nitrogen on plant height and number of tillers hill^{-1} at different days after transplanting.

	Plant height (cm)				Number of tillers hill^{-1}			
	15 DAT	30 DAT	45 DAT	60 DAT	15 DAT	30 DAT	45 DAT	60 DAT
Plant spacing (cm x cm)								
20 cm × 20 cm	20.75c	46.83a	66.35a	76.71b	4.62ab	8.25a	11.72a	12.80a
20 cm ×15 cm	25.41a	46.40a	64.29b	75.91b	4.53ab	8.01a	10.87b	12.89a
20 cm × 10 cm	25.62a	41.01b	62.79c	78.31a	4.84a	7.67a	10.28b	10.80b
15 cm × 15 cm	24.16b	40.34b	60.79d	69.58c	4.37b	6.46b	9.00c	9.88c
CV(%)	4.45	3.17	2.49	2.01	8.61	11.9	7.93	8.12
Level of sig.	*	**	**	**	*	**	**	**
Nitrogen level (kg ha^{-1})								
0	22.82b	42.56b	60.89b	72.01c	4.21c	5.86c	8.74c	8.43d
35	24.07a	43.83a	64.34a	74.68b	4.50bc	7.81b	10.07b	11.42c
70	24.38a	43.93a	63.88a	76.86a	4.70ab	7.69b	11.22a	12.63b
105	24.66a	44.26a	65.13a	76.96a	4.96a	9.02a	11.84a	13.89a
CV(%)	4.45	3.17	2.49	2.01	8.61	11.9	7.93	8.12
Level of sig.	**	*	**	**	**	**	**	**

Mean values in a column having the same letter do not differ significantly as per DMRT; DAT- Days after transplanting; ** Significant at 1% level, * Significant at 5% level.

Table 2. Interaction effect of spacing of planting and nitrogen levels on plant height and number of total tillers hill^{-1} at different days after transplanting.

Interaction (Plant spacing× N level)	Plant height				Number of tillers hill^{-1}			
	15 DAT	30 DAT	45 DAT	60 DAT	15 DAT	30 DAT	45 DAT	60 DAT
$S_1 \times N_0$	18.81f	45.76	60.38f	74.81d	4.14	5.80f	9.40	8.76h
$S_1 \times N_1$	20.95e	45.97	66.96ab	76.14cd	4.53	7.00def	11.72	12.68de
$S_1 \times N_2$	20.96e	47.29	68.61a	77.29bcd	4.70	9.20bc	12.60	14.59abc
$S_1 \times N_3$	22.26de	48.28	69.46a	78.59abc	5.12	10.98a	13.15	15.16a
$S_2 \times N_0$	24.77bc	44.23	63.47cde	68.75e	4.11	6.34ef	9.32	9.30gh
$S_2 \times N_1$	26.34ab	46.59	64.89bc	76.10cd	4.48	10.30ab	10.48	13.21bcd
$S_2 \times N_2$	25.31abc	46.45	64.63bc	78.12abc	4.62	7.30def	11.52	14.22a-d
$S_2 \times N_3$	25.22bc	48.34	64.18bcd	80.68a	4.92	8.10cd	12.15	14.82ab
$S_3 \times N_0$	23.46cd	40.97	63.10c-f	75.80cd	4.38	7.05def	8.17	8.69h
$S_3 \times N_1$	25.34abc	41.82	63.35c-f	77.29bcd	4.73	6.95def	9.80	10.51fg
$S_3 \times N_2$	26.43ab	40.78	61.38def	80.67a	5.07	7.27def	11.25	11.12ef
$S_3 \times N_3$	27.23a	40.47	63.34c-f	79.48ab	5.19	9.39bc	11.88	12.89cd
$S_4 \times N_0$	24.23c	39.28	56.60g	68.69e	4.20	4.23g	8.06	6.95i
$S_4 \times N_1$	23.64cd	40.95	62.14c-f	69.20e	4.27	7.00def	8.27	9.27gh
$S_4 \times N_2$	24.83bc	41.18	60.91ef	71.35e	4.39	7.00def	9.51	10.58fg
$S_4 \times N_3$	23.93cd	39.94	63.53cde	69.10e	4.62	7.60de	10.17	12.70de
CV(%)	4.45	3.17	2.49	2.01	8.61	11.9	7.93	8.12
Level of significance	*	NS	**	**	NS	**	NS	*

Mean values in a column having the same letter do not differ significantly as per DMRT; ** Significant at 1% level, * significant at 5% level, NS- Not significant.

Table 3. Effect of plant spacing and level of nitrogen on total dry matter production and crop growth rate at different days after transplanting.

	Total dry matter (g hill^{-1})				Crop growth rate (CGR)		
	15 DAT	30 DAT	45 DAT	60 DAT	15-30	30-45	45-60
Plant spacing (cm x cm)							
20 cm × 20 cm	1.74b	3.34a	4.33a	7.34b	1.07a	0.66	2.01c
20 cm × 15 cm	1.97a	3.49a	4.47a	8.10a	1.02ab	0.65	2.42ab
20 cm × 10 cm	1.17c	2.39b	3.41b	7.42b	0.81b	0.68	2.68a
15 cm × 15 cm	1.30c	2.51b	3.43b	6.68c	0.81b	0.61	2.16bc
CV(%)	14.26	11.9	9.31	7.32	9.03	12.53	8.07
Level of sig.	**	**	**	**	*	NS	**
Nitrogen level (kg ha^{-1})							
0	1.33b	2.72b	3.67b	6.46c	1.07a	0.66	2.01c
35	1.10c	2.42c	3.35c	7.19b	1.02ab	0.65	2.42ab
70	1.91a	3.34a	4.35a	8.08a	0.81b	0.68	2.68a
105	1.84a	3.27a	4.27a	7.83a	0.81b	0.61	2.16bc
CV(%)	14.26	11.9	9.31	7.32	9.03	12.53	8.07
Level of sig.	**	**	**	**	*	NS	**

Mean values in a column having the same letter do not differ significantly as per DMRT; ** Significant at 1% level, * Significant at 5% level.

Table 4. Interaction effect of spacing of planting and nitrogen levels on total dry matter production and crop growth rate at different days after transplanting.

Interaction	Total dry matter (g hill^{-1})				Crop growth rate (CGR)		
	15 DAT	30 DAT	45 DAT	60 DAT	15-30	30-45	45-60
$S_1 \times N_0$	1.40	3.42	4.44	6.65fg	1.34a	0.68	1.47fg
$S_1 \times N_1$	1.27	3.03	3.98	7.36c-f	1.17abc	0.63	2.25b-f
$S_1 \times N_2$	2.22	3.52	4.47	8.12a-d	0.86a-d	0.64	2.43b-e
$S_1 \times N_3$	2.07	3.40	4.42	7.24c-f	0.89a-d	0.68	1.88ef
$S_2 \times N_0$	1.77	3.00	3.98	7.07ef	0.82bcd	0.65	2.06c-f
$S_2 \times N_1$	1.47	2.64	3.53	7.61c-f	0.78bcd	0.60	2.72a-d
$S_2 \times N_2$	2.33	4.26	5.34	8.80ab	1.29ab	0.72	2.31b-e
$S_2 \times N_3$	2.30	4.07	5.04	8.92a	1.18abc	0.65	2.58a-e
$S_3 \times N_0$	0.73	2.21	3.16	7.32c-f	0.98a-d	0.64	2.77abc
$S_3 \times N_1$	0.82	2.03	3.03	5.90g	0.80bcd	0.67	1.91def
$S_3 \times N_2$	1.55	2.64	3.64	8.18a-d	0.73cd	0.67	3.03ab
$S_3 \times N_3$	1.59	2.68	3.78	8.27abc	0.72cd	0.74	2.99ab
$S_4 \times N_0$	1.40	2.24	3.11	4.79h	0.56d	0.58	1.12g
$S_4 \times N_1$	0.85	1.97	2.86	7.87b-e	0.75cd	0.60	3.34a
$S_4 \times N_2$	1.54	2.92	3.94	7.19def	0.92a-d	0.68	2.17c-f
$S_4 \times N_3$	1.41	2.93	3.83	6.87ef	1.01a-d	0.60	2.03c-f
CV(%)	14.26	11.9	9.31	7.32	9.03	12.53	8.07
Level of sig.	NS	NS	NS	**	*	NS	**

Mean values in a column having the same letter do not differ significantly as per DMRT; ** significant at 1% level, * significant at 5% level, NS Not significant.

Conclusion

The present investigation concluded that the highest plant height was obtained at 20 cm × 15 cm spacing fertilized with 70 kg N ha^{-1} while the maximum number of tillers hill^{-1}was obtained at 20 cm × 20 cm spacing when fertilized with 105 kg N ha^{-1}. The highest total dry matter production hill^{-1}was obtained at the 20 cm × 15 cm spacing fertilized with higher dose of nitrogen (105 kg N ha^{-1}) and at 45-60 DAT, the highest crop growth rate was obtained at 15 cm × 15 cm spacing fertilized with 35 kg N ha^{-1} while the lowest CGRwas recorded at the same spacing (15 cm × 15 cm) with control nitrogen. Therefore, short duration transplant *Aus* rice cv. *Parija* can be cultivated at 20 cm × 15 cm or 15 cm × 15 cm planting spacing with 35 to 105 kg N ha^{-1} for proper growth.

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