Effects of Different Nitrogen Fertilizer Levels and Spacing on Phyllochron, Yield and Yield Components of Rice (*Oryza sativa* L.) under System of Rice Intensification (SRI)

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Abstract

The experiments were conducted to investigate the effects of different nitrogen levels and spacing on phyllochron until flag leaf and to determine interaction effects of different nitrogen fertilizer levels and spacing on the phyllochron, yield and yield components of rice under the system of rice intensification (SRI). Four levels of nitrogen fertilizer rate (0, 45, 85 and 125 kg N ha^{-1}) and three spacing (15 × 15, 20 × 20 and 25 × 25 cm) were laid out in 4 × 3 factorial in randomized complete block design with three replications in both dry and wet seasons. Higher number of leaves $hill^{-1}$ was observed in dry season as compared to those in wet season. Different mean values of phyllochrons were resulted from different levels of N applied and spacing in both seasons. In general, phyllochrons were shorter as increased of N applied. The wider spacing resulted the shorter phyllochrons. The highest nitrogen fertilizer rate N_3 (125 kg N ha^{-1}) and the widest spacing of S_3 (25 × 25 cm) gave the higher yield, yield components and agronomic parameters than the others. But, the maximum leaf area index (LAI), leaf dry weight (LDW), total dry matter (TDM) and crop growth rate (CGR) were produced by S_1 (15 × 15 cm) in both seasons. The combination effect of nitrogen fertilizer and spacing showed that the maximum yield was obtained from N_3S_3 (125 kg N ha^{-1} + (25 × 25 cm)) in both seasons. Therefore, the fertilizer rate 125 kg N ha^{-1} with spacing 25 × 25 cm should be used for rice to attain high grain yield under SRI.

Key words: rice, SRI, phyllochron, nitrogen, spacing

Introduction

System of rice intensification (SRI) methods provide the highest yield when young seedlings are transplanted, less than 15 days old and preferably only 8–12 days, i.e., before the start of the fourth phyllochron (Stoop et al. 2002). The vital physiological principle of SRI practices is to provide optimal growing conditions to individual rice plant so that tillering is maximized and phyllochron is shortened (Nemoto et al. 1995). Phyllochron is the time interval between the appearances of successive leaves on the main stem during the rice development (Itoh and Sano 2006). Phyllochron study is a suitable method to better understand the plant vegetative growth and helps simulation of plant growth. Phyllochron differs in a function of temperature, day length, nutrition, light intensity, planting density and humidity (Veeramani et al. 2012). Therefore, the knowledge of phyllochron is useful for characterizing plant development and determining when to apply management practices that depend on the crop developmental stage (Martínez-Eixarch et al. 2013). Nitrogen is the most limiting nutrient to rice growth and grain yield in almost all environments (Yoshida 1981). Therefore, proper nitrogen management is essential for optimizing rice grain yield (Fageria et al. 1997). Plant spacing is a vital production factor in transplanted rice (Bozorgi et al. 2011). Improper spacing decreased yield up to 20-30%. The optimum spacing ensures the plant to grow in their both aerial and underground parts through efficient utilization of solar radiation and nutrients (Mondal et al. 2013). Therefore, the present study was undertaken with the following objectives:

- to investigate the effects of different nitrogen fertilizer levels and spacing on phyllochron until flag leaf under the system of rice intensification (SRI) and
- to determine interaction effects of different

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nitrogen fertilizer levels and spacing on the phyllochron, yield and yield components of rice under SRI

Materials and Methods

The experiments were conducted at the low-land field of Department of Agronomy, State Agriculture Institute (SAI), Patheingyi during dry season from March to June 2017 and during wet season from July to November 2017. Four levels of nitrogen fertilizer rate (0, 45, 85 and 125 kg N ha^{-1}) and three spacing (15 × 15, 20 × 20 and 25 × 25 cm) were laid out in 4 × 3 factorial in randomized complete block design with three replications. Shwethweyin rice variety which was a widely cultivated variety in Patheingyi was used as a tested variety. Fourteen days old seedlings with one seedling $hill^{-1}$ were transplanted for SRI. In this experiment, phosphorus fertilizer (63 kg P_2O_5 ha^{-1}) was applied as basal. Potassium fertilizer was applied at the rate of 63 kg K_2O ha^{-1} in two equal split applications as basal and at panicle initiation stage (36 days after transplanting (DAT)). Nitrogen as urea was applied in three equal splits: one third at recovery stage (9 DAT), one third at active tillering stage (21 DAT) and the remaining one third at panicle initiation stage (36 DAT).

Plant height, number of tillers $hill^{-1}$ and SPAD values (Soil and Plant Analysis Development) from 5 sample hills (5 sample plants marked with sticks) were measured at weekly interval starting from 14 to 70 DAT. The number of leaves on the main culm, number of leaves $hill^{-1}$ and phyllochron were measured from the 4-leaf stage to the complete exertion of the flag leaf in 3-day intervals. Three sample plants were taken in each plot to measure total dry matter at 14-day intervals from 30 to 86 DAT. The grain yield was determined from a central 5 m^2 harvested area in each plot and was adjusted to 14% moisture content. The yield components data and panicle length were separately analyzed from 5 sample hills bordered with harvest area. Haun leaf, phyllochron, leaf area index (LAI) and crop growth rate (CGR) were calculated according to the following equation:

$$\text{Haun leaf} = \left[\frac{Ln}{L(n-1)}\right] + n - 1$$

Where; L_n = the length of the youngest leaf blade above the collar of subtending leaf,
$L_{(n-1)}$ = the length of the blade of the penultimate (subtending) leaf and
n = the total number of leaves that are visible on the main culm

(Haun 1973)

$$\text{Phyllochron (d leaf}^{-1}) = \frac{\text{Number of elapsed days between the two consecutive Haun leaves}}{\text{measurement difference between the two consecutive Haun leaf number measurements}}$$

(Wilhelm and McMaster 1995)

$$LAI = \frac{\text{Sum of the leaf area of all leaves}}{\text{Ground area of field where the leaves have been collected}}$$

(Yoshida 1981)

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \times \frac{1}{G_A}$$

Where; W_1 = Plant dry weight at time T_1, W_2 = Plant dry weight at time T_2, T_1 = Time unit at first harvest, T_2 = Time unit at next harvest and G_A= Ground area.

(Gardner et al. 1985)

The data were subjected to analysis of variance by Statistix (version 8.0) program and mean comparisons were performed by using Least Significant Difference (LSD) at 5 % level.

Results and Discussion

Yield and Yield Components

At different nitrogen fertilizer levels, grain yields and yield components of rice increased with increasing nitrogen application levels in both seasons (Table 1 and 2). N_3 (125 kg N ha^{-1}) gave the maximum grain yields in both seasons. Increase in grain yield with the application of 120 kg N ha^{-1} in rice was found by Majid (2012). In dry season, the maximum number of panicle $hill^{-1}$ was observed from N_2 which was not significantly different from N_3. In wet season, the maximum number of panicle $hill^{-1}$ was attained from N_3. The maximum number of panicle m^{-2} was produced by 120 kg N ha^{-1} (Bali et al. 1995). The maximum filled grain % was obtained from N_3 in dry season and N_2 in wet season. In both seasons, the maximum number of spikelets $panicle^{-1}$, 1000-grain weight, panicle length and harvest index were observed from N_3.

Among the different spacing, the widest spacing, S_3 (25 × 25 cm) gave the maximum grain yield, number of panicle $hill^{-1}$, number of spikelets $panicle^{-1}$, filled grain %, 1000-grain weight and panicle length in both seasons (Table 1 and 2). The maximum harvest index was produced by S_3 in dry season and S_2 in wet season. Karki (2009) described that 25 × 25 cm spacing produced higher grain yield. Baloch et al. 2002 found that the highest number of panicles $hill^{-1}$ was attained from 25 × 25

Table 1. Mean effects of nitrogen fertilizer rates and spacing on grain yield and yield components of rice during the dry season, 2017

Treatment	Grain yield (t ha^{-1})	No. of panicles hill^{-1}	No. of spike-lets panicle^{-1}	Filled grain %	1000-grain weight (g)	Panicle length (cm)	Harvest Index
Nitrogen fertilizer (N)							
N_0(Control)	3.12 c	11.44 c	75.13 b	74.89	18.94 c	18.36 d	0.43 c
N_1(45 kg N ha^{-1})	4.49 b	14.44 b	84.83 a	74.06	20.06 b	19.83 c	0.52 b
N_2(85 kg N ha^{-1})	5.22 a	16.89 a	85.38 a	74.78	20.61 ab	20.30 b	0.53 b
N_3(125 kg N ha^{-1})	5.38 a	16.33 a	87.77 a	77.91	21.50 a	20.82 a	0.57 a
LSD $_{0.05}$	0.25	1.33	7.66	7.27	1.03	0.35	0.01
Spacing (S)							
S_1(15 cm × 15 cm)	4.13 c	8.67 c	78.76 b	73.78	19.79 b	19.58 b	0.50 b
S_2(20 cm × 20 cm)	4.59 b	15.00 b	85.27 ab	73.11	19.79 b	19.88 ab	0.52 a
S_3(25 cm × 25 cm)	4.94 a	20.67 a	85.81 a	79.33	21.25 a	20.02 a	0.52 a
LSD $_{0.05}$	0.22	1.15	6.64	6.29	0.89	0.31	0.01
Pr>F							
N	<0.0001	<0.0001	0.0125	0.7025	0.0004	<0.0001	<0.0001
S	<0.0001	<0.0001	0.0700	0.1023	0.0029	0.0184	0.0137
N × S	0.0854	0.0203	0.5974	0.8370	0.1292	0.0251	0.0019
CV%	5.63	9.19	9.41	9.86	5.18	1.82	2.93

Means followed by the same letter within the column are not significantly different at 5% level.

Table 2. Mean effects of nitrogen fertilizer rate and spacing on grain yield and yield components of rice during the wet season, 2017

Treatment	Grain yield ($t\ ha^{-1}$)	No. of panicles $hill^{-1}$	No. of spike-lets $panicle^{-1}$	Filled grain %	1000-grain weight (g)	Panicle length (cm)	Harvest Index
Nitrogen fertilizer (N)							
N_0(Control)	2.87 c	12.00 c	74.78 c	72.33 c	18.61 b	18.64 c	0.42 c
N_1(45 kg N ha^{-1})	3.93 b	13.78 b	79.11 b	75.44 bc	19.89 a	19.77 b	0.51 b
N_2(85 kg N ha^{-1})	4.49 a	14.22 ab	85.00 a	79.22 a	20.11 a	20.23 b	0.52 b
N_3(125 kg N ha^{-1})	4.62 a	14.67 a	85.89 a	76.78 ab	20.33 a	21.10 a	0.55 a
$LSD_{0.05}$	0.24	0.65	2.18	3.26	0.57	0.64	0.02
Spacing (S)							
S_1(15 cm × 15 cm)	3.48 c	7.00 c	79.75 b	74.58 b	19.17 b	19.59 b	0.49
S_2(20 cm × 20 cm)	3.91 b	13.42 b	79.83 b	74.33 b	19.29 b	19.89 ab	0.51
S_3(25 cm × 25 cm)	4.54 a	20.58 a	84.00 a	78.92 a	20.75 a	20.33 a	0.50
$LSD_{0.05}$	0.21	0.57	1.89	2.83	0.49	0.56	0.02
Pr>F							
N	<0.0001	<0.0001	<0.0001	0.0023	<0.0001	<0.0001	<0.0001
S	<0.0001	<0.0001	0.0001	0.0040	<0.0001	0.0367	0.1378
N × S	0.0008	0.0002	0.1065	0.0541	0.0131	0.4079	0.1888
CV%	6.16	4.89	2.75	4.40	2.96	3.29	3.74

Means followed by the same letter within the column are not significantly different at 5% level.

cm spacing in transplanted rice.

There were not interaction between nitrogen and spacing on yield during dry season. But, in wet season, there was a significant interaction on grain yield between nitrogen fertilization and spacing. However, in both seasons, the maximum yield of rice were observed from N_3S_3. There were interaction between nitrogen and spacing on grain yield (Salahuddin et al. 2009).

Agronomic Characters

In both seasons, there was highly significant difference in plant height among different nitrogen fertilizer levels (Table 3 and 4). Plant heights were gradually increased as affected by nitrogen applied. Among spacing, there was no significant difference in plant height (Table 3 and 4). There was highly significant difference in number of tillers hill^{-1} at both different nitrogen fertilizer levels and spacing (Table 3 and 4). The number of tillers hill^{-1} increased with increased nitrogen application. Salahuddin et al. (2009) observed that the number of tillers hill^{-1} increased with the increasing nitrogen applied up to 200 kg N ha^{-1}. The number of tillers hill^{-1} was superior at the widest spacing of S_3. Sultana et al. (2012) discovered the highest number of effective tillers per hill with 25 cm row spacing in rice. SPAD value resulted from nitrogen applied were significantly higher than that of control (N_0) (Table 3 and 4). The maximum SPAD value was attained from S_3 among different spacing. The more nitrogen applied, the more leaf area index (LAI), leaf dry weight (LDW), total dry matter (TDM) and crop growth rate (CGR) of rice resulted (Table 3 and 4). LDW value of higher nitrogen fertilizer levels was higher than those of lower levels (Azarpour et al. 2014). The maximum LAI, LDW, TDM and CGR were resulted from S_1.

The number of leaves on the main culm and leaves hill^{-1} were significantly affected by N application (Table 3 and 4). The maximum number of leaves on the main culm and leaves hill^{-1} were produced by N_3. Among spacing, the maximum number of leaves on the main culm and leaves hill^{-1} were observed from S_3. The maximum number of leaves plant^{-1} was produced by 25 × 25 cm spacing (Karki 2009). Higher number of leaves hill^{-1} was observed in dry season as compared to those in wet season.

Phyllochron

In different rates of nitrogen fertilizer of dry season, there was significantly different in phyllochron at all leaf numbers on the main culm except leaf number 13 (Table 5). According to the results of the experiment, phyllochrons applied different nitrogen fertilizers levels were significantly shorter than that of N_0. At leaf number 7, 11, 12, 13, 14, 15 and 18, shorter phyllochrons were obtained from N_3. In wet season, significant differences in phyllochrons among the different nitrogen fertilizer were observed from leaf number 7, 8, 9, 10, 11 and 16 (Table 6). At leaf number 5, 7, 8, 9, 10, 13 and 15, shorter phyllochrons were obtained from N_3. Phyllochron was short with increasing nitrogen (Hokmalipour 2011).

In dry season, there was significantly different among spacing in phyllochron at 7, 9, 10, 12, 15 and 18 leaf numbers on the main culm (Table 5). At leaf number 7, 9, 10, 16, 17 and 18, phyllochrons were short in the widest spacing S_3. In wet season, there was significantly different among spacing in phyllochron at 6 and 7 leaf numbers on the main culm (Table 6). At leaf number 7, 8, 9, 12, 13, 15 and 16, phyllochron in S_3 was shorter than S_1 and S_2. With increasing plant density, phyllochron length was long (Nemoto et al. 1995 and Hokmalipour et al. 2010). In general, phyllochrons were shorter as increased of N applied. The wider spacing resulted the shorter phyllochron. Interaction was found between different rates of nitrogen fertilizers and spacing in both seasons (Table 5 and 6). The shortest phyllochron length was attained from the highest nitrogen fertilizer level and the lowest plant density (Hokmalipour et al. 2010).

Conclusion

According to the result of this study, higher number of leaves hill^{-1} was observed in dry season as compared to those in wet season. Different mean values of phyllochrons were resulted from different levels of N applied and spacing in both seasons. In general, phyllochrons were shorter as increased of N applied. The wider spacing resulted the shorter phyllochron. Shorter phyllochron increases the number of leaves and tillers at vegetative stage. Consequently, increase number of panicles may contribute rice yield. The highest nitrogen fertilizer rate (N_3) and the widest spacing (S_3) gave better growth performance, yield and yield components than the others. So, N_3S_3 should be used for Shwethweyin rice variety to attain high yield. Therefore, further phyllochron studies on other different rice varieties in relation with management practices are useful research in rice.

Table 3. Mean effects of nitrogen fertilizer rate and spacing on agronomic characters and plant growth of rice during dry season, 2017

Treatment	Plant height (cm)	No. tiller hill^{-1}	SPAD value	LAI At (86 DAT)	LDW At (86 DAT)	TDM At (86 DAT)	CGR (72-86DAT)	leaves on the main culm(No.)	leaves hill^{-1} (No.)
Nitrogen fertilizer (N)									
N_0(Control)	65.87 c	14.67 c	35.84 c	0.90 d	191.54 d	825.00 d	28.92 b	16.11 c	51.44 c
N_1(45 kg N ha^{-1})	74.27 b	18.00 b	40.07 b	1.78 c	255.04 c	967.20 c	20.97 c	17.56 b	66.44 b
N_2(85 kg N ha^{-1})	80.67 a	19.22 ab	43.17 a	2.14 b	273.76 b	1157.40 b	29.20 b	20.67 a	73.56 a
N_3(125 kg N ha^{-1})	81.77 a	19.89 a	43.84 a	2.58 a	324.31 a	1333.8 a	40.12 a	20.78 a	77.00 a
LSD $_{0.05}$	4.09	1.38	0.89	0.25	12.53	35.00	2.87	0.47	3.56
Spacing (S)									
S1(15 cm × 15 cm)	76.20 ab	12.92 c	39.92 b	2.58 a	290.09 a	1244.30 a	30.95	18.08 b	60.92 b
S_2(20 cm × 20 cm)	77.23 a	17.92 b	40.93 a	1.77 b	271.18 b	1056.20 b	28.55	19.00 a	70.42 a
S_3(25 cm × 25 cm)	73.50 b	23.00 a	41.35 a	1.20 c	222.22 c	912.00 c	29.92	19.25 a	70.00 a
LSD $_{0.05}$	3.54	1.20	0.77	0.21	10.85	30.31	2.49	0.41	3.08
Pr>F									
N	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
S	0.1021	<0.0001	0.0027	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
N × S	0.4858	0.2933	0.0202	0.0002	<0.0001	<0.0001	<0.0001	0.0131	0.5795
CV%	5.53	7.88	2.24	13.61	4.91	3.34	9.85	2.57	5.42

Means followed by the same letter within the column are not significantly different at 5% level.

Table 4. Mean effects of nitrogen fertilizer rate and spacing on agronomic characters and plant growth of rice during wet season, 2017

Treatment	Plant height (cm)	No. tiller $hill^{-1}$	SPAD value	LAI At (86 DAT)	LDW At (86 DAT)	TDM At (86 DAT)	CGR (72-86DAT)	leaves on the main culm(No.)	leaves $hill^{-1}$ (No.)
Nitrogen fertilizer (N)									
N_0(Control)	67.24 c	15.56 b	36.17 c	0.54 c	209.53 c	808.40 d	31.44 c	12.00 c	33.44 c
N_1(45 kg N ha^{-1})	75.67 b	17.44 a	41.34 b	1.38 b	259.32 b	1125.80 c	40.84 b	13.33 b	45.00 b
N_2(85 kg N ha^{-1})	80.78 a	18.11 a	41.70 b	1.63 a	353.77 a	1318.00 b	50.00 a	14.67 a	48.89 a
N_3(125 kg N ha^{-1})	82.29 a	18.22 a	42.93 a	1.74 a	355.36 a	1431.7 a	47.88 a	15.11 a	49.44 a
LSD $_{0.05}$	2.78	1.14	1.07	0.21	18.34	27.44	2.43	0.53	3.08
Spacing (S)									
S1(15 cm × 15 cm)	78.10 a	11.50 c	40.07	1.99 a	372.18 a	1469.00 a	48.20 a	13.58	42.83 b
S_2(20 cm × 20 cm)	75.75 ab	16.67 b	40.62	1.15 b	299.31 b	1188.60 b	47.97 a	13.75	43.75ab
S_3(25 cm × 25 cm)	75.63 b	23.83 a	40.93	0.83 c	212.00 c	855.30 c	31.56 b	14.00	46.00 a
LSD $_{0.05}$	2.41	0.99	0.93	0.18	15.88	23.76	2.11	0.46	2.66
Pr>F									
N	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
S	0.0784	<0.0001	0.1749	<0.0001	<0.0001	<0.0001	<0.0001	0.1885	0.0594
N × S	0.2134	0.0547	0.2910	0.0006	<0.0001	<0.0001	<0.0001	0.1452	0.2601
CV%	3.72	6.72	2.70	15.90	6.37	2.40	5.85	3.93	7.12

Means followed by the same letter within the column are not significantly different at 5% level.

Table 5. Mean effects of nitrogen fertilizer rate and spacing on phyllochron of each leaf on the main culm of rice during the dry season, 2017

Treatment	Number of leaf on the main culm													
	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Phyllochron (Days leaf^{-1})													
Nitrogen fertilizer (N)														
N_0(Control)	4.25 a	3.40 a	3.20 a	2.83 b	6.01 a	5.36 a	2.94 a	3.39 a	3.43	3.31 a	5.12 a	3.72 a	3.67 a	3.00 a
N_1(45 kg N ha^{-1})	3.51 b	2.85 b	3.21 a	3.35 a	4.77 b	3.53 b	2.98 a	3.21 ab	3.07	3.64 a	3.42 b	3.21 ab	2.79 b	3.13 a
N_2(85 kg N ha^{-1})	3.46 b	2.43 c	2.92 ab	2.90 b	3.11 c	3.36 b	2.73 ab	2.80 bc	2.88	2.47 b	2.67 c	2.66 b	2.50 b	2.46 b
N_3(125 kg N ha^{-1})	3.61 b	2.71 bc	2.52 b	2.89 b	3.18 c	3.48 b	2.39 b	2.57 c	2.78	2.24 b	2.35 c	2.76 b	2.58 b	2.37 b
LSD $_{0.05}$	0.50	0.32	0.54	0.40	0.59	0.74	0.41	0.52	0.68	0.53	0.68	0.60	0.43	0.40
Spacing (S)														
S_1(15 cm × 15 cm)	3.78	2.73	3.16 a	2.98	4.78 a	4.31 a	2.65	3.32 a	2.94	3.07 a	3.97 a	3.20	3.04	3.23 a
S_2(20 cm × 20 cm)	3.67	2.87	3.14 a	2.90	4.13 b	4.02 ab	2.87	2.51 b	3.25	2.60 b	2.79 b	3.18	2.93	2.56 b
S_3(25 cm × 25 cm)	3.67	2.96	2.59 b	3.10	3.89 b	3.47 b	2.76	3.16 a	2.94	3.07 a	3.41 a	2.88	2.68	2.44 b
LSD $_{0.05}$	0.43	0.28	0.46	0.35	0.51	0.64	0.35	0.45	0.59	0.46	0.59	0.52	0.37	0.35
Pr>F														
N	0.0121	<0.0001	0.0479	0.0505	<0.0001	<0.0001	0.0253	0.0138	0.2304	<0.0001	<0.0001	0.0049	<0.0001	0.0011
S	0.8293	0.2603	0.0284	0.4776	0.0044	0.0404	0.4598	0.0028	0.4532	0.0704	0.0016	0.3783	0.1464	0.0002
N × S	0.2879	0.1010	0.5401	0.3917	0.0010	0.3266	0.0126	0.2945	0.2856	0.0196	0.0017	0.0170	0.0450	0.0326
CV%	13.76	11.50	18.46	13.63	14.18	19.36	15.13	17.80	22.78	18.69	20.56	19.74	15.20	14.98

Means followed by the same letter within the column are not significantly different at 5% level.

Table 6. Mean effects of nitrogen fertilizer rate and spacing on phyllochron of each leaf on the main culm of rice during the wet season, 2017

Treatment	Number of leaf on the main culm											
	5	6	7	8	9	10	11	12	13	14	15	16
Nitrogen fertilizer (N)	Phyllochron (Days leaf^{-1})											
N_0(Control)	3.44 a	2.51 a	8.60 a	10.73 a	4.27	4.84 a	5.28 a	5.56	6.25	5.76 a	2.80	5.00 a
N_1(45 kg N ha^{-1})	3.12 ab	2.04 b	4.94 b	4.78 b	4.13	4.26 ab	4.06 b	5.81	5.76	5.94 a	2.91	3.65 b
N_2(85 kg N ha^{-1})	3.01 ab	2.23 ab	3.70 c	3.58 c	3.51	3.84 b	3.56 b	5.28	5.40	4.46 b	3.04	3.06 b
N_3(125 kg N ha^{-1})	2.81 b	2.24 ab	3.29 c	3.57 c	3.32	3.58 b	3.58 b	5.90	5.33	4.99 ab	2.80	3.25 b
LSD $_{0.05}$	0.52	0.32	1.09	1.13	0.75	0.72	0.64	0.93	1.18	1.20	0.28	0.73
Spacing (S)												
S_1(15 cm × 15 cm)	2.98	2.36 a	5.26 b	5.73	4.01	4.37	3.80	5.79	6.00 a	5.11	2.90	3.62
S_2(20 cm × 20 cm)	3.02	2.04 b	6.38 a	5.68	3.89	4.00	4.20	5.64	6.09 a	5.24	2.91	3.99
S_3(25 cm × 25 cm)	3.29	2.36 a	3.76 c	5.59	3.52	4.02	4.35	5.48	4.97 b	5.51	2.86	3.61
LSD $_{0.05}$	0.45	0.28	0.94	0.98	0.65	0.63	0.56	0.81	1.02	1.04	0.25	0.63
Pr>F												
N	0.1182	0.0455	<0.0001	<0.0001	0.0406	0.0092	<0.0001	0.5196	0.3813	0.0628	0.2724	<0.0001
S	0.3240	0.0362	<0.0001	0.9561	0.2821	0.4155	0.1268	0.7306	0.0600	0.7271	0.9182	0.3749
N × S	0.5430	0.3640	<0.0001	0.0170	0.6404	0.6907	0.2586	0.0212	0.2336	0.9218	0.0618	0.0398
CV%	17.23	14.74	21.67	20.35	20.15	17.93	15.91	16.95	21.21	23.22	10.04	19.99

Means followed by the same letter within the column are not significantly different at 5% level.

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