RESULTS AND DISCUSSION

The present investigation entitled “Evaluation of crop establishment techniques and fertility levels on growth and yield of rice (Oryza sativa L.)” was carried out during Kharif season of 2007 and 2009 at the Crop Research Farm, Department of Agronomy, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Deemed-to-be-University, Allahabad, to study the effect of different crop establishment techniques, fertility levels, and their interaction on growth and yield of rice. The results of the investigation regarding the influence of crop establishment techniques, fertility levels, and their interaction on growth and yield of rice have been presented in tables and bar-diagrams, wherever required. The findings have been divided into the following sub-headings:

A. Growth parameters

1. Plant height (cm)

2. Number of tillers hill\(^{-1}\)

3. Dry weight (g plant\(^{-1}\))

4. Crop growth rate (g m\(^{-2}\) day\(^{-1}\))

5. Relative growth rate (g g\(^{-1}\) day\(^{-1}\))
(B) Yield and yield attributes

6. Number of effective tillers hill$^{-1}$

7. Number of effective tillers m$^{-2}$

8. Number of panicles hill$^{-1}$

9. Length of panicle (cm)

10. Number of spikelets panicle$^{-1}$

11. Test weight (g)

12. Grain yield (t ha$^{-1}$)

13. Straw yield (t ha$^{-1}$)

14. Harvest index (%) 

C. Economics of different treatment combinations

A. Growth parameters

4.1 Plant height (cm)

The plant height as influenced by different crop establishment techniques, fertility levels, and their interaction, was recorded at 30, 60 and 90 DAT/DAS, and presented in Table 4.1.1, 4.1.2 and graphically illustrated in Fig. 4.1.

Effect of different crop establishment techniques, fertility levels, and their interaction on plant height at 30 DAT/DAS was non-significant. At 60 and 90
DAT/DAS, plant height was, however, significantly influenced, during both the years of experimentation (2007 and 2009).

At 30 DAT/DAS, maximum plant height (51.40 and 52.50 cm in 2007 and 2009, respectively) was recorded with C₅ (SRI technique) followed by 50.22 and 51.31 cm with C₁ (Integrated crop management). C₄ (Drum seeder) recorded the minimum (47.39 and 48.37 cm).

Fertility level F₃ (NPK 150: 75: 75 kg ha⁻¹) recorded maximum plant height (53.82 and 54.98 cm in 2007 and 2009, respectively) followed by 48.93 and 49.96 cm with F₂ (NPK 120: 60: 60 kg ha⁻¹). The minimum (45.20 and 46.18 cm) was found with F₁ (no fertilizer).

Treatment combination C₅ F₃ (SRI technique + NPK 150: 75: 75 kg ha⁻¹) recorded maximum plant height (57.33 and 58.55 cm in 2007 and 2009, respectively) followed by 55.00 and 56.17 cm with C₁ F₃ (ICM + NPK 150: 75: 75 kg ha⁻¹), whereas, the minimum (43.33 and 44.27 cm) was found with C₄ F₁ (drum seeder + no fertilizer). Similar trend was observed at 60 and 90 DAT/DAS also.

At 60 DAT/DAS, C₅ (SRI technique) recorded maximum plant height (79.79 and 81.57 cm in 2007 and 2009, respectively) followed by 78.24 and 79.98 cm with C₁ (ICM). C₄ (drum seeder) recorded the minimum (74.20 and 75.67 cm).

NPK 150: 75: 75 kg ha⁻¹ (Fertility level F₃) recorded maximum plant height (83.22 and 85.07 cm in 2007 and 2009, respectively) followed by 77.56 and 79.19 cm with F₂ (NPK 120: 60:60 kg ha⁻¹). F₁ (no fertilizer) recorded the minimum (70.20 and 71.73 cm).
Treatment combination C₃ F₃ (SRI technique + NPK 150: 75: 75 kg ha⁻¹) recorded maximum plant height (87.27 and 89.27 cm in 2007 and 2009, respectively) followed by 85.51 and 87.40 cm with C₁ F₃ (ICM + NPK 150: 75: 75 kg ha⁻¹) while the minimum (66.77 and 68.25 cm) was found with C₄ F₁ (drum seeder + no fertilizer). C₁ F₁ (ICM + no fertilizer), C₂ F₁ (line planting + no fertilizer), C₃ F₁ (farmers’ practice + no fertilizer); C₁ F₂ (ICM + NPK 120: 60: 60 kg ha⁻¹), C₂ F₂ (line planting + NPK 120: 60: 60 kg ha⁻¹); C₁ F₂ (ICM + NPK 120: 60: 60 kg ha⁻¹), C₃ F₂ (SRI + NPK 120: 60: 60 kg ha⁻¹); C₂ F₂ (line planting + NPK 120: 60: 60 kg ha⁻¹); C₃ F₂ (farmers’ practice + NPK 120: 60: 60 kg ha⁻¹); C₃ F₂ (farmers’ practice + NPK 120: 60: 60 kg ha⁻¹); C₄ F₂ (drum seeder + NPK 120: 60: 60 kg ha⁻¹); and C₅ F₂ (SRI + NPK 120: 60: 60 kg ha⁻¹), C₄ F₃ (drum seeder + NPK 150: 75: 75 kg ha⁻¹) were statistically at par during both the years.

C₅ (SRI) recorded maximum plant height at 90 DAT/DAS (104.55 and 106.58 cm in 2007 and 2009, respectively) followed by 103.20 and 105.17 cm with C₁ (ICM). C₄ (drum seeder) recorded the minimum (97.03 and 98.88 cm).

NPK 150: 75: 75 kg ha⁻¹ (fertility level F₃) recorded maximum plant height (108.57 and 110.67 cm in 2007 and 2009, respectively) followed by 101.28 and 103.19 cm with F₂ (NPK 150: 75: 75 kg ha⁻¹). F₁ (no fertilizer) recorded the minimum (93.77 and 95.56 cm).

Interacting treatment combination C₅ F₃ (SRI + NPK 150: 75: 75 kg ha⁻¹) recorded maximum plant height (112.67 and 114.89 cm in 2007 and 2009, respectively) followed by 110.55 and 112.67 cm with C₁ F₃ (ICM + NPK 150: 75: 75 kg ha⁻¹), whereas, the minimum (87.77 and 89.44 cm) was recorded with C₄ F₁ (drum seeder + no fertilizer). C₁ F₁ (ICM + no fertilizer), C₅ F₁ (SRI + no fertilizer); C₁ F₂
(ICM + NPK 120: 60: 60 kg ha$^{-1}$), C$_2$ F$_2$ (line planting + NPK 120: 60: 60 kg ha$^{-1}$); C$_1$ F$_2$ (ICM + NPK 120: 60: 60 kg ha$^{-1}$), C$_3$ F$_2$ (SRI + NPK 120: 60: 60 kg ha$^{-1}$); and C$_3$ F$_2$ (SRI + NPK 120: 60: 60 kg ha$^{-1}$), C$_4$ F$_3$ (drum seeder + NPK 150: 75: 75 kg ha$^{-1}$) were statistically at par during both the years.

SRI technique of crop establishment produced tallest plants closely followed by ICM, whereas, minimum height of plants was recorded with drum seeder during both the years of experimentation. The plant height gradually increased at successive growth stages with increase in fertility level. Maximum plant height was recorded with NPK 150: 75: 75 kg ha$^{-1}$ followed by NPK 120: 60: 60 kg ha$^{-1}$. Minimum plant height was recorded in the plots in which no fertilizer was applied. Combination of SRI and also produced tallest plants during both the years of experimentation.

Abundant supply and availability of nitrogen, phosphorus and potassium in balanced combination as well as availability of sufficient light and spacing between the plants might have helped the plants to attain more vigour thereby increasing the plant height than lower level NPK or no fertilizer. Higher nitrogen levels also significantly increased the plant height because of enough availability of nitrogen at growing stages.

These findings are in close conformity with the results reported by Singh and Jain (2000), Pandey et al. (2001), Prasad et al. (2001), Kundu and Kundu (2002), Lenin and Rangaswamy (2002), Gobi et al. (2006) and Mankotia et al. (2006).
4.2 Number of tillers hill$^{-1}$

The number of tillers hill$^{-1}$ as influenced by different crop establishment techniques, fertility levels and their interaction, recorded at 30, 60 and 90 DAT/DAS are presented in Table 4.2.1, 4.2.2 and graphically shown in Fig. 4.2.

Different crop establishment techniques, fertility levels and their interaction had non-significant effect on number of tillers hill$^{-1}$ at 30 DAT/DAS. At 60 and 90 DAT/DAS, the crop establishment techniques, fertility levels and their interaction significantly influenced the number of tillers hill$^{-1}$.

At 30 DAT/DAS, C$_5$ (SRI technique) recorded maximum number of tillers hill$^{-1}$ (15.24 and 15.81 in 2007 and 2009, respectively) followed by 14.27 and 14.78 with C$_1$ (ICM) and C$_4$ (drum seeder) recorded the minimum (12.90 and 13.39).

NPK 150: 75: 75 kg ha$^{-1}$ (Fertility level F$_3$) recorded maximum number of tillers hill$^{-1}$ (16.09 and 16.69 in 2007 and 2009, respectively) followed by 13.97 and 14.50 with F$_2$ (NPK 120: 60: 60 kg ha$^{-1}$). The minimum (11.66 and 12.09) was recorded with F$_1$ (no fertilizer).

Treatment combination C$_5$ F$_3$ (SRI + NPK 150: 75: 75 kg ha$^{-1}$) recorded maximum number of tillers hill$^{-1}$ (17.88 and 18.55) followed by 16.21 and 16.80 with C$_1$ F$_3$ (ICM + NPK 150: 75: 75 kg ha$^{-1}$), whereas, the minimum (10.17 and 10.54) was found with C$_4$ F$_1$ (drum seeder + no fertilizer). Similar trend was observed at 60 and 90 DAT/DAS also.
SRI (C₅) recorded maximum number of tillers hill⁻¹ (31.00 and 32.15 in 2007 and 2009, respectively) at 60 DAT/DAS followed by 29.15 and 30.24 with C₁ (ICM). C₄ (drum seeder) recorded the minimum (25.58 and 26.52).

F₃ (NPK 150: 75: 75 kg ha⁻¹) recorded maximum number of tillers hill⁻¹ (36.22 and 37.56) followed by 27.71 and 28.74 with F₂ (NPK 120: 60: 60 kg ha⁻¹). F₀ (NPK 0:0:0 kg ha⁻¹) recorded the minimum (19.88 and 20.63).

Interacting combination C₅ F₃ (SRI + NPK 150: 75: 75 kg ha⁻¹) recorded maximum number of tillers hill⁻¹ (40.06 and 41.55) followed by 37.72 and 39.11 with C₁ F₃ (ICM + NPK 120: 60: 60 kg ha⁻¹) while the minimum (18.11 and 18.77) remained with C₄ F₁ (drum seeder + no fertilizer). C₃ F₂ (farmers’ practice + NPK 120: 60: 60 kg ha⁻¹) and C₄ F₂ (drum seeder + NPK 120: 60: 60 kg ha⁻¹) were statistically at par during both the years.

C₅ (SRI) recorded maximum number of tillers hill⁻¹ (25.46 and 26.39 in 2007 and 2009, respectively) at 90 DAT/DAS followed by 23.17 and 24.04 with C₁ (ICM). C₄ (drum seeder) recorded the minimum (18.67 and 19.34).

NPK 150: 75: 75 kg ha⁻¹ (fertility level F₃) recorded maximum number of tillers hill⁻¹ (28.47 and 29.50) followed by 21.89 and 22.69 with F₃ (NPK 120: 60: 60 kg ha⁻¹). F₁ (no fertilizer) recorded the minimum (14.29 and 14.83).

C₅ F₃ (SRI + NPK 150: 75: 75 kg ha⁻¹) recorded maximum number of tillers hill⁻¹ (34.11 and 35.33) followed by 30.39 and 31.55 with C₁ F₃ (ICM + NPK 120: 60: 60 kg ha⁻¹). The minimum (11.07 and 11.47) remained with C₄ F₁ (drum seeder + no fertilizer). C₂ F₂ (line planting + NPK 120: 60: 60 kg ha⁻¹), C₃ F₂ (farmers’ practice + NPK 120: 60: 60 kg ha⁻¹); and C₃ F₃ (farmers’ practice + NPK 150: 75: 75 kg ha⁻¹),
C₄ F₃ (drum seeder + NPK 150: 75: 75 kg ha⁻¹) were statistically at par during both the years.

Maximum number of tillers hill⁻¹ was recorded with SRI technique of crop establishment at all the stages of growth. With increase in the dose of NPK from 0 to 120: 60: 60 kg ha⁻¹ and 150: 75 kg ha⁻¹, the number of tillers hill⁻¹ gradually increased at all the growth stages. Maximum number of tillers hill⁻¹ was recorded with SRI and NPK 150: 75 kg ha⁻¹. The interacting treatment combination comprising of SRI + 150: 75 kg ha⁻¹ also recorded maximum number of tillers hill⁻¹.

Higher number of tillers hill⁻¹ might have been possible due to more vigour and strength attained by the plants as a result of better photosynthetic activities with sufficient availability of light, spacing between the plants and supply of nutrients in balanced quantity to the plants at growing stages.

4.3  Dry weight (g plant\(^{-1}\))

The dry weight of plant as influenced by different techniques of crop establishment, fertility levels and their interaction, recorded at 30, 60 and 90 DAT/DAS are presented in Table 4.3.1, 4.3.2 and graphically represented in Fig. 4.3.

At 30 DAT/DAS, the difference in the dry weight of plant due to crop establishment technique and interaction between crop establishment techniques and fertility levels was non-significant, whereas, the effect of fertility levels was significant. At 60 and 90 DAT/DAS, dry weight of plant was significantly influenced by crop establishment techniques, fertility levels and their interaction.

Crop establishment technique C\(_5\) (SRI) recorded maximum dry weight of plant (7.56 and 7.85 g in 2007 and 2009, respectively) at 30 DAT/DAS followed by 6.70 and 6.95 g with C\(_1\) (ICM). C\(_4\) (drum seeder) recorded the minimum (4.41 and 4.57 g).

Fertility level F\(_3\) (NPK 150: 75: 75 kg ha\(^{-1}\)) recorded maximum dry weight of plant (9.04 and 9.39 g) followed by 4.88 and 5.06 g with F\(_2\) (NPK 120: 60: 60 kg ha\(^{-1}\)). F\(_1\) (no fertilizer) recorded the minimum dry weight (3.65 and 3.80 g). F\(_1\) (no fertilizer) and F\(_2\) (NPK 120: 60: 60 kg ha\(^{-1}\)) were statistically at par in both the years.

Combination of SRI + NPK 150: 75: 75 kg ha\(^{-1}\) (C\(_5\) F\(_3\)) recorded maximum dry weight of plant (12.90 and 13.37 g) followed by 11.17 and 11.58 g with C\(_1\) F\(_3\) (ICM + NPK 150: 75: 75 kg ha\(^{-1}\)), whereas, the minimum (2.83 and 2.93 g) remained with C\(_4\) F\(_1\) (drum seeder + no fertilizer).
At 60 DAT/DAS, C5 (SRI) recorded maximum dry weight of plant (39.30 and 40.77 g in 2007 and 2009, respectively) followed by 37.72 and 39.12 g with C1 (ICM), and C4 (drum seeder) recorded the minimum (31.94 and 33.13 g).

F3 (NPK 150: 75: 75 kg ha\(^{-1}\)) recorded maximum dry weight of plant (43.53 and 45.14 g) followed by 34.39 and 35.69 g with F2 (NPK 120: 60: 60 kg ha\(^{-1}\)). F1 (no fertilizer) recorded the minimum (25.28 and 29.29 g).

C5 F3 (SRI + NPK 150: 75: 75 kg ha\(^{-1}\)) recorded maximum dry weight of plant (49.87 and 51.70 g) followed by 45.59 and 47.27 g with C1 F3 (ICM + 150: 75: 75 kg ha\(^{-1}\)), while the minimum (24.45 and 25.36 g) remained with C4 F1 (drum seeder + no fertilizer). C1 F1 (ICM + no fertilizer), C3 F1 (SRI + no fertilizer); C1 F2 (ICM + NPK 120: 60: 60 kg ha\(^{-1}\)), C5 F2 (SRI + NPK 120: 60: 60 kg ha\(^{-1}\)); and C3 F2 (farmers’ practice + NPK 120: 60: 60 kg ha\(^{-1}\), and C4 F2 (drum seeder + NPK 120: 60: 60 kg ha\(^{-1}\)) were statistically at par during both the years.

Maximum dry weight of plant at 90 DAT/DAS (79.54 and 82.47 g in 2007 and 2009, respectively) was recorded with C5 (SRI) followed by 76.62 and 79.45 g with C1 (ICM), and the minimum (65.54 and 67.99 g) remained with C4 (drum seeder).

NPK 150: 75: 75 kg ha\(^{-1}\) (F3) recorded maximum dry weight of plant (89.29 and 92.59 g) followed by 72.32 and 75.00 g with F2 (NPK 120: 60: 60 kg ha\(^{-1}\)). F1 (no fertilizer) recorded the minimum (59.43 and 61.62 g). C1 F2 (ICM + NPK 120: 60: 60 kg ha\(^{-1}\) and C5 F2 (SRI + NPK 120: 60: 60 kg ha\(^{-1}\)) were statistically at par.

Dry matter production was recorded maximum with SRI technique of crop establishment followed by ICM. Dry weight of plant gradually increased at successive growth stages with increase in the fertility level from no fertilizer to NPK 120: 60: 60.
kg ha\(^{-1}\) and 150: 75: 75 kg ha\(^{-1}\). Combination of SRI and 150: 75: 75 kg ha\(^{-1}\) also recorded maximum plant dry weight. Dry matter production with treatment combination SRI + 150: 75: 75 kg ha\(^{-1}\) was nearly 95\% higher than the minimum with drum seeder + no fertilizer.

The plants attained more vigour with higher fertility level as compared to lower fertility level as well as no fertilizer, due to adequate supply and availability of nitrogen, phosphorus, potassium and FYM in balanced combination, resulting into increased dry weight of plant. Better photosynthetic activity due to greater exposure to light and increased availability of nutrients to plants with adequate spacing might have resulted into higher dry weight of plant.

Results reported by Singh and Jain (20), Murali and Setty (2001), Prasad \textit{et al.} (2001), Kundu and Kundu (2002), Jayakumar \textit{et al.} (2005), Gobi \textit{et al.} (2006) and Bhagat \textit{et al.} (2009) are more or less similar to these findings.
4.4 Crop growth rate (g m\(^{-2}\) day\(^{-1}\))

The crop growth rate (CGR) as influenced by different crop establishment techniques, fertility levels and their interaction, worked out during 0 – 30, 31 – 60 and 61 – 90 DAT/DAS, is presented in Table 4.4.1, 4.4.2 and graphically illustrated in Fig. 4.4.

During 0 – 30 DAT/DAS, the difference in CGR due to crop establishment technique and interaction between crop establishment techniques and fertility levels was non-significant. From 31 – 60 days, effect of crop establishment techniques and fertility levels was significant, but effect of interaction was non-significant during both the years. Effect of crop establishment techniques, fertility levels and their interaction was significant during 61 – 90 days.

During 0 – 30 DAT/DAS, maximum CGR (4.03 and 4.18 g m\(^{-2}\) day\(^{-1}\) in 2007 and 2009, respectively) was recorded with C\(_5\) (SRI) followed by 3.58 and 3.71 g m\(^{-2}\) day\(^{-1}\) with C\(_1\) (ICM); and C\(_4\) (drum seeder) recorded the minimum (2.35 and 2.44 g m\(^{-2}\) day\(^{-1}\)).

NPK 150: 75: 75 kg ha\(^{-1}\) (F\(_3\)) recorded maximum CGR (4.82 and 5.01 g m\(^{-2}\) day\(^{-1}\)) followed by 2.60 and 2.70 g m\(^{-2}\) day\(^{-1}\) with F\(_2\) (NPK 120: 60: 60 kg ha\(^{-1}\)). The minimum (1.95 and 2.02 g m\(^{-2}\) day\(^{-1}\)) was found with F\(_1\) (no fertilizer). F\(_1\) (no fertilizer) and F\(_2\) (NPK 120: 60: 60 kg ha\(^{-1}\) were statistically at par during both the years.

Treatment combination C\(_5\) F\(_3\) (SRI + NPK 150: 75: 75 kg ha\(^{-1}\)) recorded maximum CGR (6.88 and 7.13 g m\(^{-2}\) day\(^{-1}\)) followed by 5.96 and 6.18 g m\(^{-2}\) day\(^{-1}\).
with C1 F3 (ICM + NPK 150: 75: 75 kg ha⁻¹), whereas, the minimum (1.51 and 1.56 g m⁻² day⁻¹) was found with C4 F1 (drum seeder + no fertilizer).

C5 (SRI) recorded maximum CGR (16.93 and 17.56 g m⁻² day⁻¹ in 2007 and 2009, respectively) during 31 – 60 DAT/DAS followed by 16.54 and 17.16 g m⁻² day⁻¹ with C1 (ICM). C4 (drum seeder) recorded the minimum (14.68 and 15.21 g m⁻² day⁻¹). C1 (ICM), C2 (line planting); C1 (line planting), C5 (SRI); and C2 (line planting), C3 (farmers’ practice), C4 (drum seeder) were statistically at par during both the years.

NPK 150: 75: 75 kg ha⁻¹ (F3) recorded maximum CGR (18.39 and 19.07 g m⁻² day⁻¹) followed by 15.74 and 16.33 g m⁻² day⁻¹ with F2 (NPK 120: 60: 60 kg ha⁻¹). F1 (no fertilizer) recorded the minimum (13.12 and 13.60 g m⁻² day⁻¹).

C5 F3 (SRI + NPK 150: 75: 75 kg ha⁻¹) recorded maximum CGR (19.72 and 20.44 g m⁻² day⁻¹) followed by 18.36 and 19.03 g m⁻² day⁻¹ with C1 F3 (ICM + NPK 150: 75: 75 kg ha⁻¹), whereas, the minimum (11.48 and 11.90 g m⁻² day⁻¹) was recorded with C3 F1 (farmers’ practice + no fertilizer).

During 61 – 90 DAT/DAS, C5 (SRI) recorded maximum CGR (21.46 and 22.24 g m⁻² day⁻¹ in 2007 and 2009, respectively) followed by 21.35 and 22.13 g m⁻² day⁻¹ with C2 (line planting). C4 (drum seeder) recorded the minimum (17.92 and 18.60 g m⁻² day⁻¹). C1 (ICM), C3 (farmers’ practice) and C2 (line planting), C5 (SRI) were statistically at par during both the years.

NPK 150: 75: 75 kg ha⁻¹ (F3) recorded maximum CGR (24.41 and 25.31 g m⁻² day⁻¹) followed by 20.23 and 20.97 g m⁻² day⁻¹ with F2 (NPK 120: 60: 60 kg ha⁻¹). F1 (no fertilizer) recorded the minimum (16.63 and 17.24 g m⁻² day⁻¹).
Interacting treatment combination $C_5 F_3$ (SRI + NPK 150: 75: 75 kg ha$^{-1}$) recorded maximum CGR (25.49 and 26.44 g m$^{-2}$ day$^{-1}$) closely followed by 25.43 and 26.35 g m$^{-2}$ day$^{-1}$ with $C_2 F_3$ (line planting + NPK 150: 75: 75 kg ha$^{-1}$), whereas, the minimum (13.41 and 13.91 g m$^{-2}$ day$^{-1}$) was found with $C_4 F_1$ (drum seeder + no fertilizer). $C_2 F_1$ (line planting + no fertilizer), $C_5 F_1$ (SRI + no fertilizer); $C_1 F_2$ (ICM + NPK 120: 60: 60 kg ha$^{-1}$), $C_2 F_2$ (line planting + NPK 120: 60: 60 kg ha$^{-1}$); and $C_2 F_3$ (line planting + NPK 150: 75: 75 kg ha$^{-1}$), $C_3 F_3$ (SRI + NPK 150: 75: 75 kg ha$^{-1}$) were statistically at par in both the years of experimentation.

CGR was corresponding to the plant dry weight at all the growth stages during both the years. SRI recorded maximum CGR as in case of other growth parameters, followed by line planting and the minimum remained with drum seeder. It also registered increase with the higher fertility level, maximum was recorded with NPK 150: 75: 75 kg ha$^{-1}$ followed by NPK 120: 60: 60 kg ha$^{-1}$ while the minimum was observed with no fertilizer. Combination of SRI + NPK 150: 75: 75 ha$^{-1}$ also recorded maximum CGR.

Greater exposure to light and proper spacing between the plants leading to better photosynthetic activity and increased availability of nutrients to resulted into higher dry matter production which in turn registered better CGR.

These findings are in close conformity with the results reported by Singh and Jain (2000).
4.5 Relative growth rate (g g\(^{-1}\) day\(^{-1}\))

The relative growth rate (RGR) as influenced by different crop establishment techniques, fertility levels and their interaction, worked out during 0–30, 31–60 and 61–90 DAT/DAS, is presented in Table 4.5.1, 4.5.2 and graphically illustrated in Fig. 4.5.

During 0–30 and 31–60 DAT/DAS, the difference in RGR due to crop establishment technique and interaction between crop establishment techniques and fertility levels was non-significant, but effect of fertility levels was significant in both the years. Effect of crop establishment techniques, fertility levels and their interaction on RGR was significant during 61–90 days.

During 0–30 DAT/DAS, maximum RGR (0.608 and 0.621 g g\(^{-1}\) day\(^{-1}\) in 2007 and 2009, respectively) was recorded with C\(_5\) (SRI) followed by 0.0581 and 0.0593 g g\(^{-1}\) day\(^{-1}\) with C\(_1\) (ICM). C\(_4\) (drum seeder) recorded the minimum (2.35 and 2.44 g g\(^{-1}\) day\(^{-1}\)).

NPK 150: 75: 75 kg ha\(^{-1}\) (F\(_3\)) recorded maximum RGR (0.0698 and 0.0710 g g\(^{-1}\) day\(^{-1}\)) followed by 0.0512 and 0.0524 g g\(^{-1}\) day\(^{-1}\) with F\(_2\) (NPK 120: 60: 60 kg ha\(^{-1}\)). The minimum (0.0414 and 0.0427 g g\(^{-1}\) day\(^{-1}\)) was found with F\(_1\) (no fertilizer). F\(_1\) (no fertilizer) and F\(_2\) (NPK 120: 60: 60 kg ha\(^{-1}\)) were statistically at par during both the years.

Combination C\(_5\) F\(_3\) (SRI + NPK 150: 75: 75 kg ha\(^{-1}\)) recorded maximum RGR (0.0811 and 0.0823 g g\(^{-1}\) day\(^{-1}\)) followed by 0.0780 and 0.0793 g g\(^{-1}\) day\(^{-1}\) with C\(_1\) F\(_3\)
(ICM + NPK 150: 75: 75 kg ha\(^{-1}\)), whereas, the minimum (0.0331 and 0.0342 g g\(^{-1}\) day\(^{-1}\)) was found with C\(_4\) F\(_1\) (drum seeder + no fertilizer).

C\(_4\) (drum seeder) recorded maximum RGR during 31 – 60 DAT/DAS (0.0689 and 0.0690 g g\(^{-1}\) day\(^{-1}\) in 2007 and 2009, respectively) followed by 0.0656 and 0.0654 g g\(^{-1}\) day\(^{-1}\) with C\(_3\) (farmers’ practice). C\(_5\) (SRI) recorded the minimum (0.0610 and 0.0609 g g\(^{-1}\) day\(^{-1}\)). C\(_1\) (ICM) and C\(_2\) (line planting) were statistically at par during both the years.

Fertility level F\(_1\) (no fertilizer) recorded maximum RGR (0.0697 and 0.0696 g g\(^{-1}\) day\(^{-1}\)) followed by 0.0667 and 0.0667 g g\(^{-1}\) day\(^{-1}\) with F\(_2\) (NPK 120: 60: 60 kg ha\(^{-1}\)). F\(_3\) (NPK 150: 75: 75 kg ha\(^{-1}\)) recorded the minimum (0.0559 and 0.0558 g g\(^{-1}\) day\(^{-1}\)). F\(_1\) (no fertilizer) and F\(_2\) (NPK 120: 60: 60 kg ha\(^{-1}\)) were statistically at par during both the years.

C\(_4\) F\(_1\) (drum seeder + no fertilizer) recorded maximum RGR (0.0735 and 0.0735 g g\(^{-1}\) day\(^{-1}\)) followed by 0.0716 and 0.0715 g g\(^{-1}\) day\(^{-1}\) with C\(_1\) F\(_1\) (ICM + no fertilizer), whereas, the minimum (0.0492 and 0.0492 g g\(^{-1}\) day\(^{-1}\)) was recorded with C\(_5\) F\(_3\) (SRI + NPK 150: 75: 75 kg ha\(^{-1}\)).

During 61 – 90 DAT/DAS, C\(_3\) (farmers’ practice) recorded maximum RGR (0.0260 and 0.0260 g g\(^{-1}\) day\(^{-1}\) in 2007 and 2009, respectively) followed 0.0255 and 0.0255 g g\(^{-1}\) day\(^{-1}\) with C\(_2\) (line planting). C\(_1\) (ICM) and C\(_5\) (SRI) recorded the minimum (0.0236 and 0.0236 g g\(^{-1}\) day\(^{-1}\)). C\(_1\) (ICM) and C\(_5\) (SRI) were at par during both the years.

Fertility level F\(_1\) (no fertilizer) and F\(_2\) (NPK 120: 60: 60 kg ha\(^{-1}\)) recorded the maximum RGR (0.0248 and 0.0248 g g\(^{-1}\) day\(^{-1}\)). NPK 150: 75: 75 kg ha\(^{-1}\) (F\(_3\))
recorded the minimum (0.0240 and 0.0240 g g\(^{-1}\) day\(^{-1}\)). \(F_1\) (no fertilizer) and \(F_2\) (NPK 120: 60: 60 kg ha\(^{-1}\)) were at par during both the years.

Interacting treatment combination \(C_3\) \(F_1\) (farmers’ practice + no fertilizer) recorded maximum RGR (0.0274 and 0.0274 g g\(^{-1}\) day\(^{-1}\)) followed by 0.0263 and 0.0262 g g\(^{-1}\) day\(^{-1}\) with \(C_2\) \(F_1\) (line planting + no fertilizer), whereas, the minimum (0.0224 and 0.0224 g g\(^{-1}\) day\(^{-1}\)) was found with \(C_5\) \(F_3\) (SRI + NPK 150: 75: 75 kg ha\(^{-1}\)). \(C_1\) \(F_2\) (ICM + NPK 120: 60: 60 kg ha\(^{-1}\)), \(C_5\) \(F_2\) (SRI + NPK 120: 60: 60 kg ha\(^{-1}\)); and \(C_2\) \(F_3\) (line planting + NPK 150: 75: 75 kg ha\(^{-1}\)), \(C_3\) \(F_3\) (farmers’ practice + NPK 150: 75: 75 kg ha\(^{-1}\)) were statistically at par in 2007. In 2009, \(C_1\) \(F_2\) (ICM + NPK 120: 60: 60 kg ha\(^{-1}\)), \(C_4\) \(F_2\) (drum seeder + NPK 120: 60: 60 kg ha\(^{-1}\)); \(C_1\) \(F_2\) (ICM + NPK 120: 60: 60 kg ha\(^{-1}\)), \(C_5\) \(F_2\) (SRI + NPK 120: 60: 60 kg ha\(^{-1}\)); \(C_1\) \(F_2\) (ICM + NPK 120: 60: 60 kg ha\(^{-1}\)), \(C_5\) \(F_2\) (SRI + NPK 120: 60: 60 kg ha\(^{-1}\)); \(C_2\) \(F_2\) (line planting + NPK 120: 60: 60 kg ha\(^{-1}\)), \(C_3\) \(F_2\) (farmers’ practice + NPK 120: 60: 60 kg ha\(^{-1}\)); \(C_1\) \(F_3\) (ICM + NPK 150: 75: 75 kg ha\(^{-1}\)), \(C_4\) \(F_3\) (drum seeder + NPK 150: 75: 75 kg ha\(^{-1}\)); and \(C_2\) \(F_3\) (line planting + NPK 150: 75: 75 kg ha\(^{-1}\)), \(C_3\) \(F_3\) (farmers’ practice + NPK 150: 75: 75 kg ha\(^{-1}\)) were statistically at par.

RGR was corresponding to the plant dry weight at all the growth stages during both the years. At 0 – 30 DAT/DAS, SRI recorded maximum RGR followed by ICM and the minimum remained with drum seeder. NPK 150: 75: 75 kg ha\(^{-1}\) recorded maximum RGR followed by NPK 120: 60: 60 kg ha\(^{-1}\) while the minimum was observed with no fertilizer. Combination of SRI + NPK 150: 75: 75 kg ha\(^{-1}\) also recorded maximum RGR. It also registered increase with increase of fertility level. At 31 – 60 DAT/DAS, drum seeder, no fertilizer and their combination (drum seeder + no fertilizer) recorded maximum RGR. However, during 61 – 90 DAT/DAS farmers’
practice, no fertilizer and NPK 120: 60: 60 kg ha\(^{-1}\), and the combination (farmers’ practice + no fertilizer recorded maximum RGR.

Results reported by Singh and Jain (2000) are more or less similar to these findings.

Out of the five techniques of crop establishment and three fertility levels tried in this experiment, system of rice intensification (SRI) (C\(_5\)) and fertility level NPK 150: 75: 75 kg ha\(^{-1}\) (F\(_3\)) was found to be the appropriate crop establishment technique and fertility level, respectively. The interacting treatment combination of SRI technique + NPK 150: 75: 75 kg ha\(^{-1}\) (C\(_5\) F\(_3\)) maintained its superiority over all other treatment combinations in relation to growth of rice. Gobi et al. (2006) and Hussain et al. (2009) reported more or less similar results in their experiments.
B. Yield and yield attributes

4.6 Number of effective tillers hill$^{-1}$

The number of effective tillers hill$^{-1}$ is presented in Table 4.6.1, 4.6.2 and graphically illustrated in Fig. 4.6. The data shows that there was a significant effect of different crop establishment techniques, fertility levels and their interaction on the number of effective tillers hill$^{-1}$ during both the years of experimentation, i.e. 2007 and 2009.

C$_5$ (SRI technique) recorded maximum number of effective tillers hill$^{-1}$ (22.02 and 23.00 in 2007 and 2009, respectively) followed by 20.45 and 21.33 with C$_1$ (integrated crop management). C$_4$ (drum seeder) recorded the minimum (17.00 and 17.75).

Fertility level F$_3$ (NPK 150: 75: 75 kg ha$^{-1}$) recorded maximum number of effective tillers hill$^{-1}$ (25.35 and 26.45) followed by 18.46 and 19.27 with F$_2$ (NPK 120: 60: 60 kg ha$^{-1}$). The minimum (14.28 and 14.92) remained with F$_1$ (no fertilizer).

Treatment combination C$_5$ F$_3$ (SRI + NPK 150: 75: 75 kg ha$^{-1}$) recorded maximum number of effective tillers hill$^{-1}$ (29.78 and 31.07) followed by 27.21 and 28.37 with C$_1$ F$_3$ (ICM + NPK 150: 75: 75 kg ha$^{-1}$), whereas, C$_4$ F$_1$ (drum seeder + no fertilizer) recorded the minimum (12.18 and 12.74). C$_5$ F$_1$ (SRI + no fertilizer), C$_4$ F$_2$ (drum seeder + NPK 120: 60: 60 kg ha$^{-1}$); C$_1$ F$_2$ (ICM + NPK 120: 60: 60 kg ha$^{-1}$), C$_2$ F$_2$ (line planting + NPK 120: 60: 60 kg ha$^{-1}$); and C$_3$ F$_2$ (farmers’ practice + NPK 120: 60: 60 kg ha$^{-1}$) were statistically at par during both the years.
Highest number of effective tillers hill\(^{-1}\) was observed with SRI technique of crop establishment, fertility level of NPK 150: 75: 75 kg ha\(^{-1}\), which was found to be the appropriate crop establishment technique and fertility level, respectively. Their combination also recorded maximum number of effective tillers hill\(^{-1}\). Increase in NPK from 120: 60: 60 kg ha\(^{-1}\) to 150: 75: 75 kg ha\(^{-1}\) registered significant increase in number of effective tillers hill\(^{-1}\).

Greater exposure to light leading to better photosynthetic activity and increased availability of nutrients to plants due to proper spacing between plants might have resulted into higher number of effective tillers hill\(^{-1}\).

These findings are in close conformity with the results reported by Kundu and Kundu (2002), Gupta et al. (2006), Bhagat et al. (2009) and Shekhar et al. (2009).

### 4.7 Number of effective tillers m\(^{-2}\)

The number of effective tillers m\(^{-2}\) is presented in Table 4.7.1, 4.7.2 and graphically illustrated in Fig. 4.7. The data shows that there was a significant effect of different crop establishment techniques, fertility levels and their interaction on the number of effective tillers m\(^{-2}\) during both the years of experimentation, i.e. 2007 and 2009.

C\(_5\) (SRI) recorded maximum number of effective tillers m\(^{-2}\) (306.87 and 312.62 in 2007 and 2009, respectively) followed by 292.00 and 298.45 with C\(_1\) (ICM). C\(_4\) (drum seeder) recorded the minimum (246.33 and 251.50).
F$_3$ (NPK 150: 75: 75 kg ha$^{-1}$) recorded maximum number of effective tillers m$^{-2}$ (365.80 and 372.89) followed by 264.53 and 269.22 with F$_2$ (NPK 120: 60: 60 kg ha$^{-1}$). The minimum (197.80 and 202.40) remained with F$_1$ (no fertilizer).

C$_5$ F$_3$ (SRI + NPK 150: 75: 75 kg ha$^{-1}$) recorded maximum number of effective tillers m$^{-2}$ (404.00 and 411.46) followed by 386.00 and 395.67 with C$_1$ F$_3$ (ICM + NPK 150: 75: 75 kg ha$^{-1}$), whereas, C$_4$ F$_1$ (drum seeder + no fertilizer) recorded the minimum (186.00 and 190.174). C$_2$ F$_1$ (line planting + no fertilizer) and C$_3$ F$_1$ (farmers’ practice + no fertilizer) were statistically at par during both the years.

With the increase in NPK from 120: 60: 60 kg ha$^{-1}$ to 150: 75: 75 kg ha$^{-1}$ there was significant increase in number of effective tillers m$^{-2}$. Highest number of effective tillers m$^{-2}$ was observed with SRI technique of crop establishment, fertility level of NPK 150: 75: 75 kg ha$^{-1}$, which was found to be the appropriate crop establishment technique and fertility level, respectively; and their combination also recorded maximum number of effective tillers m$^{-2}$.

Greater exposure to light leading to better photosynthetic activity and increased availability of nutrients to plants due to proper spacing between plants might have resulted into higher number of effective tillers m$^{-2}$.

Results reported by Kundu and Kundu (2002), Gupta et al. (2006), Bhagat et al. (2009), Shekhar et al. (2009) and Tzudir et al. (2009) are in close conformity with these findings.
4.8 Number of panicles hill$^{-1}$

The number of panicles hill$^{-1}$ is presented in Table 4.8.1, 4.8.2 and graphically illustrated in Fig. 4.8. The data shows that there was a significant effect of different crop establishment techniques, fertility levels and their interaction on the number of panicles hill$^{-1}$ during both the years of experimentation, i.e. 2007 and 2009.

Maximum number of panicles hill$^{-1}$ (14.73 and 15.35 in 2007 and 2009, respectively) was recorded with C$_5$ (SRI) followed by 14.10 and 14.71 with C$_1$ (ICM). C$_4$ (drum seeder) recorded the minimum (12.57 and 13.11).

F$_3$ (NPK 150: 75: 75 kg ha$^{-1}$) recorded maximum number of panicles hill$^{-1}$ (16.41 and 17.08) followed by 13.55 and 14.17 with F$_2$ (NPK 120: 60: 60 kg ha$^{-1}$). The minimum (10.76 and 11.20) was recorded with F$_1$ (no fertilizer).

C$_5$ F$_3$ (SRI + NPK 150: 75: 75 kg ha$^{-1}$) recorded maximum number of panicles hill$^{-1}$ (17.60 and 18.33) followed by 16.67 and 17.33 with C$_1$ F$_3$ (ICM + NPK 150: 75: 75 kg ha$^{-1}$), whereas, C$_4$ F$_1$ (drum seeder + no fertilizer) recorded the minimum (9.84 and 10.25).

Increase in NPK from 120: 60: 60 kg ha$^{-1}$ to 150: 75 kg ha$^{-1}$ registered significant increase in number of panicles hill$^{-1}$. Maximum number of panicles hill$^{-1}$ was observed with SRI technique of crop establishment, fertility level of NPK 150: 75: 75 kg ha$^{-1}$, which was found to be the appropriate crop establishment technique and fertility level, respectively. Their combination also recorded maximum number of panicles hill$^{-1}$. 

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*Results and Discussion*
Better photosynthetic activity due to greater exposure to light and increased availability of nutrients to plants with proper spacing between plants might have resulted into greater number of panicles hill$^{-1}$.

These findings are in close conformity with the results reported by Dwivedi and Thakur (2000), Prasad et al. (2001), Subbalakshmi and Pandian (2002), Quyen et al. (2002), Mondal et al. (2003), Anupama and Ajay (2004), Murthy and Goud (2007) and Patil et al. (2008).

4.9 Length of panicle (cm)

The length of panicle recorded under different treatments and their combinations is presented in Table 4.9.1, 4.9.2 and graphically represented in Fig. 4.9. The data reveals that the length of panicle was significantly influenced by crop establishment techniques, fertility levels and their interaction during both the years.

C$_5$ (SRI technique) recorded maximum length of panicle (28.27 and 29.48 cm in 2007 and 2009, respectively) followed by 27.96 and 29.15 cm with C$_1$ (integrated crop management). C$_4$ (drum seeder) recorded the minimum (27.29 and 28.46 cm).

F$_3$ (NPK 150: 75: 75 kg ha$^{-1}$) recorded maximum length of panicle (28.68 and 29.89 cm) followed by 27.77 and 28.96 cm with F$_2$ (NPK 120: 60: 60 kg ha$^{-1}$). F$_1$ (no fertilizer) recorded the minimum (26.77 and 27.91 cm).

Longest panicles (29.44 and 30.67 cm) were obtained with interacting treatment combination C$_5$ F$_3$ (SRI + NPK 150: 75: 75 kg ha$^{-1}$) followed by 28.88 and 30.11 cm with C$_1$ F$_3$ (ICM + NPK 150: 75: 75 kg ha$^{-1}$), whereas, the minimum (26.21 cm) was found with C$_4$ F$_1$ (drum seeder + no fertilizer). C$_5$ F$_1$ (SRI + no fertilizer),
C₄ F₂ (drum seeder + NPK 120: 60: 60 kg ha⁻¹); C₁ F₂ (ICM + NPK 120: 60: 60 kg ha⁻¹), C₂ F₂ (line planting + NPK 120: 60: 60 kg ha⁻¹); C₂ F₂ (line planting + NPK 120: 60: 60 kg ha⁻¹), C₃ F₂ (farmers’ practice + NPK 120: 60: 60 kg ha⁻¹); C₃ F₂ (farmers’ practice + NPK 120: 60: 60 kg ha⁻¹), C₄ F₂ (drum seeder + NPK 120: 60: 60 kg ha⁻¹); C₅ F₂ (SRI + NPK 120: 60: 60 kg ha⁻¹), C₄ F₃ (drum seeder + NPK 150: 75: 75 kg ha⁻¹); C₂ F₃ (line planting + NPK 150: 75: 75 kg ha⁻¹), C₃ F₃ (farmers’ practice + NPK 150: 75: 75 kg ha⁻¹); C₂ F₃ (line planting + NPK 150: 75: 75 kg ha⁻¹), C₃ F₃ (farmers’ practice + NPK 150: 75: 75 kg ha⁻¹), C₄ F₃ (drum seeder + NPK 150: 75: 75 kg ha⁻¹) were statistically at par during both the years.

SRI (C₅) and NPK 150: 75: 75 kg ha⁻¹ (F₃) were found to be the appropriate crop establishment technique and fertility level, respectively; and their combination C₅ F₃ (SRI + NPK 150: 75: 75 kg ha⁻¹) was found best for as it recorded maximum length of panicle of 17.33 cm.

Abundant availability of nutrients (nitrogen, phosphorus, potassium and FYM) and their absorption by the plants, coupled with better photosynthetic activity due to adequate light and spacing between the plants increased the vigour index and plant growth thereby resulting in higher length of panicle.

Results reported by Chaunabasappa et al. (1998), Quyen et al. (2002), Gobi et al. (2006), Hugar et al. (2009) and Tzudir et al. (2009) are in close conformity with these findings.
4.10 Number of spikelets panicle\(^{-1}\)

The number of spikelets panicle\(^{-1}\) is presented in Table 4.10.1, 4.10.2 and graphically illustrated in Fig. 4.10. The data shows that there was a significant effect of different crop establishment techniques, fertility levels and their interaction on the number of spikelets panicle\(^{-1}\) during both the years of experimentation, i.e. 2007 and 2009.

\(C_5\) (SRI) recorded maximum number of spikelets panicle\(^{-1}\) (204.78 and 213.29 in 2007 and 2009, respectively) followed by 200.74 and 209.07 with \(C_1\) (ICM). \(C_4\) (drum seeder) recorded the minimum (195.58 and 203.73).

\(F_3\) (NPK 150: 75: 75 kg ha\(^{-1}\)) recorded maximum number of spikelets panicle\(^{-1}\) (208.98 and 217.66) followed by 200.78 and 209.13 with \(F_2\) (NPK 120: 60: 60 kg ha\(^{-1}\)). The minimum (188.90 and 196.74) remained with \(F_1\) (no fertilizer).

Interacting treatment combination \(C_5\ F_3\) (SRI + NPK 150: 75: 75 kg ha\(^{-1}\)) recorded maximum number of spikelets panicle\(^{-1}\) (213.59 and 222.44) followed by 211.33 and 220.11 with \(C_1\ F_3\) (ICM + NPK 150: 75: 75 kg ha\(^{-1}\)), whereas, \(C_4\ F_1\) (drum seeder + no fertilizer) recorded the minimum (183.76 and 191.44). \(C_1\ F_1\) (ICM + no fertilizer), \(C_2\ F_1\) (line planting + no fertilizer); \(C_3\ F_1\) (farmers’ practice + no fertilizer), \(C_4\ F_1\) (drum seeder + no fertilizer); \(C_5\ F_1\) (SRI + no fertilizer), \(C_3\ F_2\) (farmers’ practice + NPK 120: 60: 60 kg ha\(^{-1}\)), \(C_4\ F_2\) (drum seeder + NPK 120: 60: 60 kg ha\(^{-1}\)); \(C_1\ F_2\) (ICM + NPK 120: 60: 60 kg ha\(^{-1}\)), \(C_2\ F_2\) (line planting + NPK 120: 60: 60 kg ha\(^{-1}\)), \(C_3\ F_2\) (farmers’ practice + NPK 120: 60: 60 kg ha\(^{-1}\)), \(C_4\ F_2\) (drum seeder + NPK 120: 60: 60 kg ha\(^{-1}\)), \(C_5\ F_2\) (SRI + NPK 120: 60: 60 kg ha\(^{-1}\)); \(C_1\ F_3\) (ICM + NPK 150: 75: 75 kg ha\(^{-1}\)), \(C_2\ F_3\) (line planting + NPK 150: 75: 75 kg ha\(^{-1}\)); and \(C_1\ F_3\) (ICM...
+ NPK 150: 75: 75 kg ha$^{-1}$), C$_3$ F$_3$ (SRI + NPK 150: 75: 75 kg ha$^{-1}$) were statistically at par during both the years.

Highest number of spikelets panicle$^{-1}$ was observed with SRI technique of crop establishment, fertility level of NPK 150: 75: 75 kg ha$^{-1}$, which was found to be the appropriate crop establishment technique and fertility level, respectively. Their combination also recorded maximum number of spikelets panicle$^{-1}$. Increase in NPK from 120: 60: 60 kg ha$^{-1}$ to 150: 75: 75 kg ha$^{-1}$ registered significant increase in number of spikelets panicle$^{-1}$.

Sufficient availability of nutrients (nitrogen, phosphorus, potassium and FYM) and their absorption by the plants, together with better photosynthetic activity due to proper light and spacing between the plants increased the vigour and plant growth thereby resulting in greater number of spikelets panicle$^{-1}$.

These findings are in close conformity with the results reported by Prasad et al. (2001), Subbalakshmi and Pandian (2002), Mondal et al. (2003), Gobi et al. (2006), Gupta et al. (2006), and Hugar et al. (2009).

4.11 Test weight (g)

The test weight recorded in different treatment combinations is presented in Table 4.11.1, 4.11.2 and graphically illustrated Fig. 4.11. The data shows significant effect of crop establishment techniques, fertility levels and their interaction on test weight.

Maximum test weight (21.68 and 22.66 g in 2007 and 2009, respectively) was recorded with C$_5$ (SRI) followed by 21.23 and 22.14 g with C$_1$ (ICM), whereas, the minimum (19.49 and 20.33 g) remained with C$_4$ (drum seeder).
Results and Discussion
F3 (NPK 150: 75: 75 kg ha\(^{-1}\)) recorded maximum test weight (23.62 and 24.69 g) followed by 19.70 and 20.56 g with F2 (NPK 120: 60: 60 kg ha\(^{-1}\)). The minimum (18.70 and 19.52 g) remained with F1 (no fertilizer).

C5 F3 (SRI + NPK 150: 75: 75 kg ha\(^{-1}\)) recorded maximum test weight (25.79 and 26.95 g) followed by 24.59 and 25.66 g with C1 F3 (ICM + NPK 150: 75: 75 kg ha\(^{-1}\)), whereas, the minimum (18.14 and 18.93 g) was recorded with C4 F1 (drum seeder + no fertilizer). C1 F1 (ICM + no fertilizer), C2 F1 (line planting + no fertilizer); C5 F1 (SRI + no fertilizer), C4 F2 (drum seeder + NPK 120: 60: 60 kg ha\(^{-1}\)); C1 F2 (ICM + NPK 120: 60: 60 kg ha\(^{-1}\), C5 F2 (SRI + NPK 120: 60: 60 kg ha\(^{-1}\)); and C3 F2 (farmers’ practice + NPK 120: 60: 60 kg ha\(^{-1}\), C4 F2 (drum seeder + NPK 120: 60: 60 kg ha\(^{-1}\)) were statistically at par during both the years.

Increase in fertility level from no fertilizer to NPK 120: 60: 60 kg ha\(^{-1}\) and NPK 150: 75: 75 kg ha\(^{-1}\) resulted into higher test weight. SRI (C5) and NPK 150: 75: 75 kg ha\(^{-1}\) (F3) were found to be the appropriate crop establishment technique and fertility level; and their combination C5 F3 (SRI + NPK 150: 75: 75 kg ha\(^{-1}\)) was found best for test weight, as it recorded maximum as compared to all other treatment combinations.

Higher vigour and growth attained by the plants due to sufficient absorption of nutrients (FYM and NPK) as well as light and proper spacing might have resulted into higher test weight.

Results reported by Prasad et al. (2001), Anupama and Ajay (2004), Gobi et al. (2006) and Hugar et al. (2009) more or less similar to these findings.
4.12 Grain yield (t ha\(^{-1}\))

The grain yield per hectare worked out for different crop establishment techniques, fertility levels and their interaction is presented in Table 4.12.1, 4.12.2 and graphically illustrated in Fig. 4.12. The data reveals that the grain yield was significantly influenced by different crop establishment techniques, fertility levels and their interaction.

Maximum grain yield (6.14 and 6.37 t ha\(^{-1}\) in 2007 and 2009, respectively) was recorded with C\(_5\) (SRI) followed by 5.91 and 6.12 t ha\(^{-1}\) with C\(_1\) (ICM), whereas, the minimum (5.33 and 5.52 t ha\(^{-1}\)) was recorded with C\(_4\) (drum seeder).

F\(_3\) (NPK 150: 75: 75 kg ha\(^{-1}\)) recorded maximum grain yield (6.75 and 6.99 t ha\(^{-1}\)) followed by 5.56 and 5.75 t ha\(^{-1}\) with F\(_2\) (NPK 120: 60: 60 kg ha\(^{-1}\)). The minimum (4.86 and 5.04 t ha\(^{-1}\)) remained with F\(_1\) (no fertilizer).

Interacting treatment combination C\(_5\) F\(_3\) (SRI + NPK 150: 75: 75 kg ha\(^{-1}\)) recorded maximum grain yield (7.35 and 7.61 t ha\(^{-1}\)) followed by 7.00 and 7.25 t ha\(^{-1}\) with C\(_1\) F\(_3\) (ICM + NPK 150: 75: 75 kg ha\(^{-1}\)). The minimum (4.52 and 4.69 t ha\(^{-1}\)) remained with C\(_4\) F\(_1\) (drum seeder + no fertilizer). C\(_3\) F\(_2\) (farmers’ practice + NPK 120: 60: 60 kg ha\(^{-1}\)) and C\(_4\) F\(_2\) (drum seeder + NPK 120: 60: 60 kg ha\(^{-1}\)) were statistically at par during both the years.

Grain yield per hectare was commensurate with yield attributes like effective tillers, number of length of panicles, number of spikelets per panicle. C\(_5\) (SRI) and F\(_3\) (NPK 150: 75: 75 kg ha\(^{-1}\)) were most appropriate and suitable crop establishment technique and fertility level for grain yield per hectare and their combination C\(_5\) F\(_3\).
(SRI + NPK 150: 75: 75 kg ha\(^{-1}\)) also recorded maximum grain yield (7.35 and 7.61 t ha\(^{-1}\) in 2007 and 2009, respectively).

The behaviour of NPK could be explained by the fact that it is builder of protein and form the main constituents of protoplasm with induced cell division and initiated meristematic activity. The synthesis of amino acid in plant seemed to have accelerated, which is exhibited by enhanced grain yield. It is, therefore, logical to correlate the increased grain yield with the increased level of nitrogen, phosphorus and potassium.

Lattimore et al. (1994), Chaunabasappa et al. (1998), Pandiarajan et al. (1999), Santhi et al. (1999), Gangaiah and Rao (2000), Prasad et al. (2001), Srivastava et al. (2001), Nagappa et al. (2002), Subbaiah et al. (2002), Subbalakshmi and Pandian (2002), Quyen et al. (2002), Mondal et al. (2003), Anupama and Ajay(2004), Francis and Lokanandhan (2005), Singh et al. (2005), Gobi et al. (2006), Gupta et al. (2006), Mankotia et al. (2006), Sanjay et al. (2006), Murthy and Goud (2007), Gangwar et al. (2008), Patil et al. (2008), Bhagar et al. (2009), Hugar et al. (2009), and Tzudir et al. (2009) reported almost similar results in their experiments.

4.13 Straw yield (t ha\(^{-1}\))

The straw yield per hectare worked out for different crop establishment techniques, fertility levels and their interaction is presented in Table 4.13.1, 4.13.2 and graphically illustrated in Fig. 4.13. The data contained in the table shows that the straw yield was significantly influenced by different crop establishment techniques, fertility levels and their interaction.
C₅ (SRI) recorded maximum straw yield (8.30 and 8.69 t ha⁻¹ in 2007 and 2009, respectively) followed by 8.09 and 8.69 t ha⁻¹ with C₁ (ICM). The minimum (7.44 and 7.97 t ha⁻¹) was recorded with C₄ (drum seeder).

F₃ (NPK 150: 75: 75 kg ha⁻¹) recorded maximum straw yield (8.90 and 9.56 t ha⁻¹) followed by 7.85 and 8.42 t ha⁻¹ with F₂ (NPK 120: 60: 60 kg ha⁻¹). The minimum (6.78 and 7.28 t ha⁻¹) remained with F₁ (no fertilizer).

Treatment combination C₅ F₃ (SRI + NPK 150: 75: 75 kg ha⁻¹) recorded maximum straw yield (9.48 and 10.18 t ha⁻¹) followed by 9.18 and 9.86 t ha⁻¹ with C₁ F₃ (ICM + NPK 150: 75: 75 kg ha⁻¹). The minimum (6.46 and 6.93 t ha⁻¹) remained with C₄ F₁ (drum seeder + no fertilizer) and C₄ F₁ (drum seeder + no fertilizer) were statistically at par during both the years.

Straw yield per hectare was commensurate with grain yield. C₅ (SRI) and F₃ (NPK 150: 75: 75 kg ha⁻¹) were most appropriate and suitable crop establishment technique and fertility level for straw yield per hectare and their combination C₅ F₃ (SRI + NPK 150: 75: 75 kg ha⁻¹) also recorded maximum straw yield (9.48 and 10.18 t ha⁻¹ in 2007 and 2009, respectively).

Results reported by Chaunabasappa et al. (1998), Nagappa et al. (2002), Subbaiah et al. (2002), Sharma et al. (2003), Francis and Lokanandhan (2005), Gobi et al. (2006), Gupta et al. (2006), Sanjay et al. (2006), Singh et al. (2006), Halder and Patra (2007), Hugar et al. (2009), Hussain et al. (2009) and Shekhar et al. (2009) are more or less similar to these findings.
4.14 Harvest index (%)

The harvest index worked out for different crop establishment techniques, fertility levels and their combinations is presented in Table 4.14.1, 4.14.2 and graphically illustrated Fig. 4.14. The data shows significant effect of crop establishment techniques, fertility levels and their interaction on harvest index.

Maximum harvest index (42.43 and 41.56% in 2007 and 2009, respectively) was recorded with C5 (SRI) followed by 42.18 and 41.31% with C2 (line planting), whereas, the minimum (41.70 and 40.85%) remained with C4 (drum seeder).

F3 (NPK 150: 75: 75 kg ha\(^{-1}\)) recorded maximum harvest index (43.09 and 42.22%) followed by 41.76 and 40.90% with F1 (no fertilizer). The minimum (41.45 and 40.60%) remained with F2 (NPK 120: 60: 60 kg ha\(^{-1}\)).

C5 F3 (SRI + NPK 150: 75: 75 kg ha\(^{-1}\)) recorded maximum harvest index (43.67 and 42.80%) followed by 43.26 and 42.39% with C1 F3 (ICM + NPK 150: 75: 75 kg ha\(^{-1}\)). The minimum (41.20 and 40.34%) was recorded with C4 F1 (drum seeder + no fertilizer), C1 F1 (ICM + no fertilizer), C1 F2 (ICM + NPK 120: 60: 60 kg ha\(^{-1}\)), C4 F2 (drum seeder + NPK 120: 60: 60 kg ha\(^{-1}\)); C2 F1 (line planting + no fertilizer), C4 F3 (drum seeder + NPK 150: 75: 75 kg ha\(^{-1}\)); C3 F1 (farmers’ practice + no fertilizer), C5 F1 (SRI + no fertilizer); C4 F1 (drum seeder + no fertilizer), C2 F2 (line planting + NPK 120: 60: 60 kg ha\(^{-1}\)), C3 F2 (farmers’ practice + NPK 120: 60: 60 kg ha\(^{-1}\)); C4 F2 (drum seeder + NPK 120: 60: 60 kg ha\(^{-1}\)); C5 F2 (SRI + NPK 120: 60: 60 kg ha\(^{-1}\)); and C1 F3 (ICM + NPK 150: 75: 75 kg ha\(^{-1}\)), C2 F3 (line planting + NPK 150: 75: 75 kg ha\(^{-1}\)), C3 F3 (farmers’ practice + NPK 150: 75: 75 kg ha\(^{-1}\)) were statistically at par during both the years.
Increase in fertility level from NPK 120: 60: 60 kg ha\(^{-1}\) to NPK 150: 75: 75 kg ha\(^{-1}\) resulted into higher harvest index. SRI (C\(_5\)), NPK 150: 75: 75 kg ha\(^{-1}\) (F\(_3\)) and their combination C\(_5\) F\(_3\) (SRI + NPK 150: 75: 75 kg ha\(^{-1}\)) recorded maximum harvest index as compared to all other treatment combinations.

Harvest index was commensurate with the grain yield and straw yield.

C. Economics of different treatment combinations

The economics of different treatments viz., grain and straw yield (t ha\(^{-1}\)), cost of cultivation, gross return, net return and benefit cost ratio have been worked out and presented in Table 4.15.1, 4.15.2, 4.15.3 and 4.15.4.

Maximum grain yield (7.35 and 7.61 t ha\(^{-1}\) in 2007 and 2009, respectively) was recorded with treatment combination C\(_5\) F\(_3\) (SRI + NPK 150: 75: 75 kg ha\(^{-1}\)) followed by 7.00 and 7.25 t ha\(^{-1}\) with C\(_1\) F\(_3\) (ICM + NPK 150: 75: 75 kg ha\(^{-1}\)), and the minimum (4.52 and 4.69 t ha\(^{-1}\)) was recorded with C\(_4\) F\(_1\) (drum seeder + no fertilizer).

Straw yield was recorded maximum (9.48 and 10.18 t ha\(^{-1}\)) with treatment combination C\(_5\) F\(_3\) (SRI + NPK 150: 75: 75 kg ha\(^{-1}\)) followed by 9.18 and 9.86 t ha\(^{-1}\) with C\(_1\) F\(_3\) (ICM + NPK 150: 75: 75 kg ha\(^{-1}\)), and the minimum (6.46 and 6.93 t ha\(^{-1}\)) remained with C\(_4\) F\(_1\) (drum seeder + no fertilizer).

Treatment combination C\(_5\) F\(_3\) (SRI + NPK 150: 75: 75 kg ha\(^{-1}\)) recorded maximum gross return (Rs. 1,19,683 and 1,24,387 ha\(^{-1}\)) followed by Rs. 1,14,134 and 1,18,620 ha\(^{-1}\) with treatment combination C\(_1\) F\(_3\) (ICM + NPK 150: 75: 75 kg ha\(^{-1}\)),

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while the minimum gross return (Rs. 74,317 and Rs. 77,253 ha$^{-1}$) was recorded with C$_4$ F$_1$ (drum seeder + no fertilizer).

Maximum net return (Rs. 78,895 and 83,599 ha$^{-1}$) was recorded with treatment combination C$_5$ F$_3$ (SRI + NPK 150: 75: 75 kg ha$^{-1}$) followed by Rs. 73,346 and 77,832 ha$^{-1}$ with treatment combination C$_1$ F$_3$ (ICM + NPK 150: 75: 75 kg ha$^{-1}$) while the minimum net return (Rs. 42,077 and 45,013 ha$^{-1}$) was recorded with C$_4$ F$_1$ (drum seeder + no fertilizer).

Highest benefit cost ratio (2.93 and 3.05) was recorded with treatment combination C$_5$ F$_3$ (SRI + NPK 150: 75: 75 kg ha$^{-1}$) followed by 2.80 and 2.91 with combination C$_1$ F$_3$ (ICM + NPK 150: 75: 75 kg ha$^{-1}$) while the minimum (2.23 and 2.31) was recorded with C$_4$ F$_2$ (drum seeder + NPK 120: 60: 60 kg ha$^{-1}$). The minimum BCR was recorded with C$_4$ F$_2$ (drum seeder + NPK 120: 60: 60 kg ha$^{-1}$) instead of C$_4$ F$_1$ (drum seeder + no fertilizer) was due to higher cost of cultivation in case of the former.

Maximum grain yield (7.35 and 7.61 t ha$^{-1}$), straw yield (9.48 and 10.18 t ha$^{-1}$), gross return (Rs. 1,19,683 and 1,24,387 ha$^{-1}$), net return (Rs. 78,895 and 83,599 ha$^{-1}$) and cost: benefit ratio (2.93 and 3.05) was recorded with treatment combination C$_5$ F$_3$ (SRI + NPK 150: 75: 75 kg ha$^{-1}$).

These results are more or less in conformity with the findings reported by Pandiarajan et al. (1999), Nagappa et al. (2002), Subbaiah et al. (2002), Sharma et al. (2003), Francis and Lokanandhan (2005), Gobi et al. (2006), Gupta et al. (2006), Sanjay et al. (2006), Singh et al. (2006), Halder and Patra (2007), Hugar et al. (2009), Hussain et al. (2009), Rajinder et al. (2009) and Shekhar et al. (2009).
Above results clearly show that out of the 15 interacting combinations of crop establishment techniques and fertility levels, treatment combination C5 F3 (SRI + NPK 150: 75: 75 kg ha⁻¹) emerged as significantly superior over all other treatment combinations in relation to growth, yield and yield attributes, and economic returns for cultivation of Rice under the agro-climatic conditions of Allahabad. These findings are almost similar to the results reported by Balasubramanian and Palaniappan (1991), Gobi et al. (2006), Hussain et al. (2009) and Shekhar et al. (2009).