International Journal of Research in BioSciences
Vol. 2 Issue 3, pp. (53-59), July 2013
Available online at http://www.ijrbs.in
ISSN 2319-2844

*Research Paper*

# Effect of integrated nutrient management and spacing on growth parameters, nutrient content and productivity of rice under system of rice intensification

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(Received 7 January, 2013, Accepted 14 May, 2013)

## Abstract

**Field experiment was conducted to find out the effect of integrated nutrient management and spacing on productivity and economics of rice under system of rice intensification in Palampur, Himachal Pradesh during *Kharif* 2009-10. The treatments comprising of all possible combinations of three FYM levels (0, 10 and 20 t ha$^{-1}$) and three fertilizer levels (0, 50 and 100% of the recommended NPK) in main plots and two spacing (20 cm x 20 cm and 30 cm x 30 cm) in sub plots were tested in split plot design, replicated three times. Growth parameters and yield of rice increased consistently and significantly with increase in FYM and fertilizer levels. Significantly highest grain, straw and biological yield were recorded with FYM 20 t ha$^{-1}$ and application of chemical fertilizers at recommended dose gave significantly highest grain and straw yield. Growth parameters, nutrient content in grain and straw and yield were not influenced significantly by spacing.**

**Keywords:** FYM, fertilizer, spacing, growth, yield

## Introduction

"Rice is life" indicating that rice encompasses all the facets of life, the sources of livelihood and served as an essential element in the environment and biodiversity. In Himachal Pradesh also, rice is one of the important cereal crops next to wheat and maize on area basis. The crop is cultivated from foothill plains to an altitude of 2290 m above mean sea level covering an area of 69.21 thousand ha with a total production of 123.5 thousand tonnes, however, its productivity in the state is quite low (1.78 t ha$^{-1}$) compared to the national average [1]. Rice farmers in India and many countries are facing growing water constraints and higher costs of N fertilizer application. The System of Rice Intensification (SRI) is an emerging low-input method for production of rice (*Oryza sativa*) that has the potential to increase crop yields while reducing the consumption of water, seed and mineral fertilizer [2]. In various countries, use of SRI methods has been producing average yields 6–8 t ha$^{-1}$, double the present world average [3].

Since organic manures are difficult to find integrated nutrient management (INM), using both inorganic and organic manures, is currently recommended. Evaluating alternative combinations of organic and inorganic fertilization can thus help determine whether some optimization is possible. Such a study should not be done as a single-factor assessment because there can be strong interaction effects among practices, as seen for water management alternatives and plant spacing [4]. Optimum plant density per unit area is an important factor needed for realizing higher yields. Under SRI, transplanting in wider spacing in square geometry has generally been recommended; therefore, the optimum planting geometry under varied fertility regimes needs to be worked out to exploit the genetic potential of a genotype. Keeping in view the above facts, the integrated nutrient management with optimum plant population seems to be the viable option to realize higher crop yields *vis-à-vis* avoids deterioration in soil health. Hence, the present study was planned with the objective of effect of combined use of farm yard manure and fertilizer levels *vis- a-vis* spacing on growth, dry matter accumulation, soil properties, nutrient content and productivity of rice under system of rice intensification.

## Materials and Methods

A field experiment was conducted during 2009-10 at the Research Farm of CSK HPKV, Palampur, Himachal Pradesh. The experiment was laid out in split plot design with all possible combinations of three FYM levels (0, 10 and 20 t $ha^{-1}$) and three fertilizer levels (0, 50 and 100 %) of the recommended NPK i.e. 90:40:40 kg of N, $P_2O_5$ and $K_2O$ per ha) in main plots and two spacing (20 cm x 20 cm and 30 cm x 30 cm) in sub plots. Whole of the P and K along with ½ N were applied as basal, and the remaining N was split applied at tillering and panicle initiation stages. FYM @ 10 t $ha^{-1}$ and 20 t $ha^{-1}$ on dry weight basis was incorporated in puddled plots as per treatment and mixed well with the help of spades. Arize- 6129 (HRI-152 hybrid) was the test variety used during the investigation. Modified rice mat nursery was raised for producing robust, healthy rice seedlings in 12 days time suitable for transplanting under SRI method of cultivation. The already treated incubated and pre-sprouted rice seeds were used @ 6 kg $ha^{-1}$. Seedlings were then transplanted manually with seed and soil attached by using index finger and thumb at 20 cm x 20 cm and 30 cm x 30 cm spacing. Plant height and number of tillers of ten randomly selected plants in the net plot area was measured. For dry matter, destructive sampling from sampling zone was done. The crop from the net plot area was harvested with the help of sickles and was left in the respective plots for sun drying. When most of the straw in a handful bundle broke up on folding, then total produce was weighed and recorded as biological yield. The produce was then threshed manually; winnowed and clean grains were separated out. The grains thus collected were weighed and converted into t/ha. The grain yield was adjusted at 14% moisture after determining the moisture content in grains. Straw yield was obtained by subtracting the grain weight from the corresponding weight of biological produce and was converted into t/ha. Bulk density of 0-15 cm soil layer was determined with the help of core sampler. Composite soil samples from 0-15 cm from each net plot area were collected and analyzed for available N, P, K, organic carbon content and pH. Representative samples of grain and straw from each net plot were taken and analyzed for N, P and K contents. N was determined by Modified Kjeldahl's method [5], P by Vanado molybdate and K by Flame Photometric method. The data recorded on various parameters were subjected to statistical analysis, following analysis of variance technique as described by [6] and were tested at 5% level of significance to interpret the significant differences.

## Results and Discussion

The application of FYM had significant effect on dry matter accumulation and number of tillers per hill (Table 1 and 2). The dry matter accumulation was highest with the application of FYM @ 20 t/ha and was followed by FYM application @ 10 t/ha and lowest dry matter accumulation was observed when no FYM was applied. It may be due to the FYM provides better growing condition to plants by continuous supply of nutrients and improvement of soil properties. Consequent upon the increased radiation interception as well as better nutrition of crop plants due to FYM application might have increased the photosynthesis rate which was reflected in significant increase in the dry matter accumulation and number of tillers per hill at all the dates of observation [7]. The dry matter accumulation increased significantly and consistently with the increase in fertilizer levels (Table 1) from 0 to 100% RDF. Unlike number of tillers per hill, dry

matter accumulation showed a linear increase upto maturity at 50 % and 100 % RDF over no fertilization with the advancement of crop growth during entire crop life.

Singh et al. 2000 [8] and Meena et al. 2003 [9] also reported significant improvement in dry matter accumulation of rice with increasing nutrition on account of better growth and development of the plant. The dry matter accumulation (Table 1) was not significantly influenced by plant spacing. Both crop geometries produced significantly similar biomass at all the dates of observation. Although, dry matter accumulation was not influenced significantly by spacing but numerically dry matter accumulation was higher under wider spacing.

The interaction effects (Table 3) of fertilizer levels and FYM on dry matter accumulation ($g/m^2$) were found significant. [10] also reported that significant improvement in the dry weight accumulation of rice plant due to conjunctive use of inorganic and organic sources of nutrition.

**Table 1: Effect of FYM levels, fertilizer levels and spacing on number of tillers/hill of rice under SRI**

| Treatments | 15 DAT | 30 DAT | 45 DAT | 60 DAT | 75 DAT | 90 DAT | 105 DAT | 120 DAT |
|---|---|---|---|---|---|---|---|---|
| **FYM levels (t/ha)** | | | | | | | | |
| 0 | 5.3 | 15.4 | 21.7 | 25.2 | 23.2 | 21.3 | 19.5 | 18.5 |
| 10 | 6.4 | 17.1 | 24.0 | 29.0 | 29.0 | 24.0 | 23.4 | 22.3 |
| 20 | 7.5 | 18.1 | 24.7 | 30.6 | 30.9 | 25.6 | 24.2 | 23.5 |
| SEm± | 0.11 | 0.30 | 0.29 | 0.44 | 0.20 | 0.38 | 0.36 | 0.13 |
| LSD (P=0.05) | 0.33 | 0.90 | 0.89 | 1.32 | 0.60 | 1.14 | 1.09 | 0.39 |
| **Fertilizer levels** | | | | | | | | |
| 0 | 5.5 | 14.9 | 21.2 | 25.2 | 23.6 | 21.4 | 20.1 | 19.0 |
| 50% RDF | 6.5 | 16.8 | 23.5 | 28.2 | 27.4 | 23.4 | 22.3 | 21.1 |
| 100% RDF | 7.2 | 18.9 | 25.7 | 31.4 | 32.2 | 26.0 | 25.3 | 24.2 |
| SEm± | 0.11 | 0.30 | 0.29 | 0.44 | 0.20 | 0.38 | 0.36 | 0.13 |
| LSD (P=0.05) | 0.33 | 0.91 | 0.89 | 1.32 | 0.60 | 1.14 | 1.09 | 0.39 |
| **Spacing** | | | | | | | | |
| 20 x 20 cm | 5.4 | 14.1 | 17.7 | 21.6 | 21.0 | 17.8 | 17.3 | 16.6 |
| 30 x 30 cm | 7.4 | 19.6 | 29.3 | 35.0 | 34.4 | 29.4 | 27.8 | 26.3 |
| SEm± | 0.13 | 0.46 | 0.32 | 0.47 | 0.57 | 0.57 | 0.55 | 0.64 |
| LSD (P=0.05) | 0.39 | 1.37 | 0.96 | 1.41 | 1.71 | 1.71 | 1.66 | 1.72 |

**Table 2: Effect of FYM levels, fertilizer levels and spacing on dry matter accumulation ($g/m^2$) of rice under SRI**

| Treatments | 15 DAT | 30 DAT | 45 DAT | 60 DAT | 75 DAT | 90 DAT | 105 DAT | 120 DAT |
|---|---|---|---|---|---|---|---|---|
| **FYM levels (t/ha)** | | | | | | | | |
| 0 | 17.6 | 32.3 | 101.2 | 209.3 | 425.7 | 590.2 | 729.9 | 784.4 |
| 10 | 25.7 | 40.1 | 134.2 | 261.3 | 536.9 | 742.0 | 906.2 | 937.3 |
| 20 | 32.0 | 53.1 | 158.3 | 359.3 | 595.3 | 794.2 | 998.6 | 1109.0 |
| SEm± | 0.48 | 0.84 | 2.05 | 3.75 | 9.11 | 10.24 | 10.39 | 11.27 |
| LSD (P=0.05) | 1.44 | 2.53 | 6.16 | 11.26 | 27.31 | 30.72 | 31.16 | 33.80 |
| **Fertilizer levels** | | | | | | | | |
| 0 | 18.1 | 32.1 | 96.3 | 218.7 | 424.3 | 605.7 | 736.5 | 775.6 |
| 50% RDF | 26.2 | 42.3 | 129.3 | 280.8 | 528.3 | 718.3 | 880.3 | 956.8 |
| 100% RDF | 32.0 | 51.0 | 168.1 | 330.3 | 605.3 | 802.4 | 1017.9 | 1098.3 |
| SEm± | 0.48 | 0.84 | 2.05 | 3.75 | 9.11 | 10.24 | 10.39 | 11.27 |
| LSD (P=0.05) | 1.44 | 2.53 | 6.16 | 11.26 | 27.31 | 30.72 | 31.16 | 33.80 |
| **Spacing** | | | | | | | | |
| 20 x 20 cm | 25.2 | 41.0 | 129.5 | 273.1 | 513.7 | 704.2 | 880.7 | 937.3 |
| 30 x 30 cm | 25.7 | 42.6 | 133.0 | 280.1 | 524.9 | 713.3 | 875.8 | 949.9 |
| SEm± | 0.53 | 0.77 | 3.78 | 6.33 | 8.57 | 9.21 | 15.18 | 10.91 |
| LSD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS |

**Table 3: Interaction effect of fertilizer levels and FYM on dry matter accumulation (g/m$^2$) of rice**

| FYM levels(t/ha) | Fertilizer levels | | | |
|---|---|---|---|---|
| | 0 | 50% RDF | 100% RDF | **Mean** |
| | | **15 DAT** | | |
| 0 | 12.4 | 16.3 | 24.2 | 17.6 |
| 10 | 16.3 | 27.7 | 33.0 | 25.7 |
| 20 | 25.7 | 34.4 | 38.8 | 33.0 |
| **Mean** | 18.1 | 26.2 | 32.0 | |
| SEm± | | 0.83 | | |
| LSD (P=0.05) | | 2.49 | | |
| | | **30 DAT** | | |
| 0 | 25.8 | 31.6 | 39.4 | 32.3 |
| 10 | 27.9 | 42.6 | 49.6 | 40.1 |
| 20 | 42.7 | 52.7 | 64.0 | 53.1 |
| **Mean** | 32.1 | 42.3 | 51.0 | |
| SEm± | | 1.46 | | |
| LSD (P=0.05) | | 4.38 | | |
| | | **45 DAT** | | |
| 0 | 74.0 | 87.8 | 141.9 | 101.2 |
| 10 | 92.6 | 142.8 | 167.2 | 134.2 |
| 20 | 122.3 | 157.2 | 195.3 | 158.3 |
| **Mean** | 96.3 | 129.3 | 168.1 | |
| SEm± | | 3.55 | | |
| LSD (P=0.05) | | 10.67 | | |
| | | **60 DAT** | | |
| 0 | 167.3 | 195.5 | 265.0 | 209.3 |
| 10 | 194.3 | 268.9 | 320.6 | 261.3 |
| 20 | 294.5 | 377.9 | 405.5 | 359.3 |
| **Mean** | 218.7 | 280.8 | 330.3 | |
| SEm± | | 6.50 | | |
| LSD (P=0.05) | | 19.50 | | |
| | | **75 DAT** | | |
| 0 | 354.4 | 401.0 | 521.8 | 425.7 |
| 10 | 439.5 | 553.7 | 617.4 | 536.9 |
| 20 | 479.0 | 630.2 | 676.7 | 595.3 |
| **Mean** | 424.3 | 528.3 | 605.3 | |
| SEm± | | 15.78 | | |
| LSD (P=0.05) | | 47.32 | | |
| | | **120 DAT** | | |
| 0 | 674.1 | 733.2 | 945.9 | 784.4 |
| 10 | 784.3 | 958.5 | 1,069.1 | 937.3 |
| 20 | 868.6 | 1,178.7 | 1,279.8 | 1,109.0 |
| **Mean** | 775.6 | 956.8 | 1,098.3 | |
| SEm± | | 19.53 | | |
| LSD (P=0.05) | | 58.56 | | |

The effect of FYM treatments on N, P, K content in grain and straw (Table 4) of rice indicated that N content in grain and K content in straw was influenced significantly with increasing level of FYM from no FYM to 20 t/ha FYM, whereas P and K content in grain and N and P content in straw remained unaffected with the application of FYM. It is evident from the (Table 4) that N content in grain and K content in straw was significantly higher with the application of 10 t/ha FYM over no FYM, further application of 20 t/ha FYM proved its superiority over 10 t/ha FYM. Highest level of FYM *i.e.*20 t FYM/ha produced highest content of N in grain and K in straw. The respective improvement in nutrient contents in different treatments of FYM might be due to the reason that nutrients (especially P) are released slowly in FYM and the amount of nutrients it contains were not available during one season, therefore, the effect of FYM to all the treatments was not significant except N content in grain and K content in straw.

**Table 4: Effect of FYM levels, fertilizer levels and spacing on N, P and K content in rice grain and straw under SRI**

| Treatments | Grain | | | Straw | | |
|---|---|---|---|---|---|---|
| | N | P | K | N | P | K |
| **FYM levels(t/ha)** | | | | | | |
| 0 | 1.34 | 0.18 | 0.24 | 0.63 | 0.06 | 1.02 |
| 10 | 1.38 | 0.22 | 0.25 | 0.70 | 0.07 | 1.07 |
| 20 | 1.43 | 0.25 | 0.26 | 0.76 | 0.07 | 1.09 |
| SEm± | 0.35 | 0.24 | 0.30 | 0.43 | 0.025 | 0.34 |
| LSD (P=0.05) | 1.07 | NS | NS | NS | NS | 1.02 |
| **Fertilizer levels** | | | | | | |
| 0 | 1.33 | 0.18 | 0.23 | 0.63 | 0.061 | 1.02 |
| 50% RDF | 1.37 | 0.22 | 0.25 | 0.70 | 0.071 | 1.06 |
| 100% RDF | 1.45 | 0.26 | 0.27 | 0.76 | 0.080 | 1.10 |
| SEm± | 0.35 | 0.24 | 0.30 | 0.43 | 0.025 | 0.34 |
| LSD (P=0.05) | 1.07 | NS | NS | NS | NS | 1.02 |
| **Spacing** | | | | | | |
| 20 x 20 cm | 1.38 | 0.21 | 0.25 | 0.69 | 0.069 | 1.05 |
| 30 x 30 cm | 1.38 | 0.22 | 0.25 | 0.70 | 0.071 | 1.06 |
| SEm± | 0.28 | 0.25 | 0.28 | 0.41 | 0.02 | 0.26 |
| LSD (P=0.05) | NS | NS | NS | NS | NS | NS |

Kumar et al. [11] reported that application of 10 t/ha FYM in rice-wheat system significantly increased N, P and K content by 4.0, 7.8 and 7.6 percent as compared with no FYM. In rice straw N and P content remained unaffected with increase in fertilizer levels but K content was increased significantly with increased fertilizer dose from 0 to 100 % RDF. Highest level of fertilizer (100 % RDF) produced highest K content in straw and was followed by 50 % RDF. Significantly minimum K content in Straw was observed with no fertilization. Increase in nutrient contents and uptake with higher fertilizer levels in rice has also been reported by Kumar 2000 [12]. Thorat 2007 [13] also concluded that different spacing had no significant influence on N and P content in grain and straw of rice.

Effect of FYM application on grain, straw and biological yields of rice was significant (Table 4). With the increasing levels of FYM grain and straw yield increased significantly and consistently. Application of FYM @ 10 t/ha produced higher grain as well as straw yields over no FYM and produced 22.6 percent and 23.4 percent more yield of grain and straw respectively. Application of FYM @ 20 t/ha proved its significant superiority with respect to grain as well as straw yield by producing 14.9 percent and 14.7 percent and 34.1 percent and 34.8 percent more grain and straw yield over 10 t/ha FYM and no FYM respectively.

The incremental improvement in yield was more from 0 to 10 t/ha FYM than 10 t/ha to 20 t/ha FYM. The situation also satisfy the conditions of Baule unit concept., The nutrient contents of FYM was 0.62, 0.2 and 0.8 percent N, P and K, respectively, hence 20 t/ha and 10 t/ha FYM supplied 124:40:160 and 62:20:80 kg N:P:K per ha respectively. If only 60% was available during the first season even then FYM application gave better nutrition to crop along with residual effect which ultimately improved soil health and thereby yield. Bhattacharya et al. 2003 [14] and Shekhar 2009 [15] have also reported beneficial effects of FYM on yield of rice due to better nutrition of crop.

Data on grain and straw yield of rice presented in table 5 revealed that there was a consistent and significant increase in grain and straw yields with the increase in fertilizer levels from 0 to 100% RDF. Grain yield, the ultimate result of various interacting growth factors, interdependence of growth, development and yield contributing characters, increased consistently and significantly with increasing levels of fertilization in the crop. These results could be very well attributed to better growth and development of rice plants. The effect of spacing on grain and straw yields of rice was not significant. But numerically average yield was slightly higher in wider spacing as compared to closer spacing.

**Table 5: Effect of FYM levels, fertilizer levels and spacing on grain, straw and biological yield (q/ha) of rice under SRI**

| Treatments | Grain Yield | Straw Yield | Biological yield |
|---|---|---|---|
| **FYM levels(t/ha)** | | | |
| 0 | 32.85 | 48.73 | 81.58 |
| 10 | 42.44 | 63.65 | 106.09 |
| 20 | 49.88 | 74.69 | 124.57 |
| SEm± | 0.64 | 0.75 | 1.39 |
| LSD (P=0.05) | 1.94 | 2.26 | 4.20 |
| **Fertilizer levels** | | | |
| 0 | 33.35 | 50.05 | 83.4 |
| 50% RDF | 43.21 | 64.14 | 107.35 |
| 100% RDF | 48.61 | 72.87 | 121.48 |
| SEm± | 0.64 | 0.75 | 1.39 |
| LSD (P=0.05) | 1.94 | 2.26 | 4.20 |
| **Spacing** | | | |
| 20 x 20 cm | 41.02 | 61.46 | 102.48 |
| 30 x 30 cm | 42.42 | 63.25 | 105.67 |
| SEm± | 0.69 | 0.86 | 1.55 |
| LSD (P=0.05) | NS | NS | NS |

## Conclusion

From the present study conducted at Palampur during *Kharif* 2009-10, it can be concluded that higher level of fertilizer and FYM significantly influenced the growth characters, nutrient content and yield of rice, whereas, spacing did not affect these parameters except number of effective tillers per hill and B: C ratio. Application of 20 t FYM/ha along with 100% RDF at 20 cm x 20 cm spacing produced highest yield followed by 20 t FYM/ha + 50% RDF at 20 cm x 20 cm spacing.

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