Effect of planting techniques, fertilizer and manure on growth and yield of rice (*Oryza Sativa* L.) under rice-wheat cropping system in inceptisol

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Abstract

A field experiment was carried out at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.) during kharif season of 2017-18 to study the effect of planting techniques, fertilizer and manure on productivity, profitability and soil organic pools in rice (*Oryza sativa* L.) under rice-wheat cropping system in Inceptisol. The experiment was laid out in split plot design with three replications. The main factor consisted of three planting techniques viz. (T1 - reduced tillage-transplanted rice (RT-TPR), T2 - furrow irrigated raised beds (FIRRB), T3 - puddled - transplanted rice (CT-TPR)) and sub factor five nutrient management practices viz. (F1 – Control, F2 - RDF, F3 - 125% RDF, F4 -150% RDF and F5 - RDF+25 kg/ha ZnSO4) as subplot treatment. The soil of experimental site was low in organic carbon and nitrogen and medium in available phosphorus and available potassium in alkaline in reaction. The maximum values of growth characters and yield attributes (plant height, number of tillers, dry matter accumulation, number of panicles, panicle length, grain panicle weight) was recorded in F5 (CT- TPR) treatment which remained at par with F2 (FIRRB) treatment. Similarly, maximum grains & straw yield, among nutrient management treatments, the maximum values of growth characters, yield attributes, grain and straw yield was noticed with the application of fertilizer as 125% RDF.

Keywords: Rice, fertilizer manure, planting techniques.

Introduction

Traditionally rice is grown transplanted crop under puddled soil. Puddling is an essential operation for transplanted rice to minimize water percolation losses. Though rice-wheat cropping system is very productive but has fatigued natural resources with decline in ground water table, soil carbon stocks, plant nutrients and resulting in buildup of pests and diseases (Gupta et al., 2006). In India, rice is commonly grown by transplanting the seedlings into puddled soil (land preparation with wet tillage). Puddling benefits rice crop by reducing water percolation losses, facilitating easy seedling establishment and creating anaerobic conditions to enhance nutrient availability (Sanchez, 1973). But repeated puddling adversely affects soil physical properties by destroying soil aggregates, reducing permeability in subsurface layers and forming hard pan at shallow depths (Sharma and De Datta, 1985; Aggarwal et al., 1995; Jat et al., 2009; Naresh et al., 2014), all of which can negatively affect the following non-rice upland crop in rotation (Hobbs and Gupta, 2000; Tripathi et al., 2005). The significantly higher value of soil bulk density after rice harvest under zero tillage plots in the surface soil layer may be due to non-disturbance of the soil matrix, which resulted in less total porosity compared to tilled plots (Bhattacharyya et al., 2008) [1]. The disadvantages associated with puddled transplanted rice include the development of a hardpan at a depth of 15–30 cm, and the increased bulk density and soil compaction impair root growth of wheat due to the hardpan (Martinez et al., 2008). The higher bulk density under zero or reduced tillage might be due to more compactness of the soil, while the soil became more porous with the increased intensity of tillage in conventional practice (Ram et al., 2006). Moreover, puddling and transplanting require large amount of water and labor, both of which are becoming increasingly scarce and expensive thus making rice production less profitable. All these factors demand a major shift...
from puddled transplanted rice production to unpuddled transplanted rice in irrigated areas. To escape from drudgery in manual transplanting, mechanized rice transplanting is being practiced in many countries of the world, but in India mechanized transplanting has not popularized as yet due to high cost of transplan ters and land levelling problems. Raised beds are formed by moving soil from the furrows to the area of the bed, thus raising its surface level. The furrows serve as irrigation channels, drains and traffic lanes. Generally, two to six rows are planted on the top of each bed for rice crop (Naresh et al., 2011). Raised bed dimensions and configurations vary with soil type and available machinery. The ability of the soil to ‘sub’ (i.e. allow the lateral movement of irrigation water into the centre of the bed) is a key determinant of bed dimensions. For sandy loam soils that sub easily, growers use bed widths at 1.37 m for all crops like rice and wheat. Soils do not sub as well; narrower beds at 0.67 m centers are frequently used. Bed height may also vary with soil conditions and field slope. Higher beds are frequently used on soils that sub well and have flatter grades and longer run lengths, while beds of a lower height are used on steeper graded fields. The flat top of the bed varies from 0.37 to 1.07 m in width. Furrow irrigation used with raised beds requires growers to adopt a whole-farm planning approach to deal with drainage water and the integration of on farm drains and drainage water recycling systems, to increase both water use efficiency and drainage water quality control (Beecher et al., 2005).

With the green revolution, the use of chemical fertilizers in agriculture increased several folds and insufficient use of these fertilizers has resulted in serious environmental consequences. The most adverse environmental impacts in the field crops is the depletion of stratospheric ozone due to NO and NO2 emission. Crop fertilization refers to fertilizer application according to the crop demands, while soil fertilization is targeted to replenish its fertility level. The strategy of efficient fertilizer management involves precise decision on the right rate, source, time and place of fertilizer application (Bruulsema et al., 2009). Keeping the above background information in view the present experiment was conducted.

Methods and materials
A field experiment was carried out at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.) during kharif season of 2017-18 to study the effect of planting techniques, fertilizer and manure on productivity, profitability and soil organic pools in rice (Oryza sativa L.) under rice-wheat cropping system in Inceptisol. The experiment was laid out in split plot design with three replications. The main factor consisted of three planting techniques viz. (T1 - reduced tillage- transplanted rice (RT-TPR), T2 - furrow irrigated raised beds (FIRB), T3 - puddled - transplanted rice (CT-TPR)) and sub factor five nutrient management practices viz. (F1 – Control, F2 - RDF, F3 - 125% RDF, F4 -150% RDF and F5 - RDF+25 kg/ha ZnSO4) as subplot treatment. Meerut is situated on the Delhi – Dehradun National Highway – 58. Geographically Meerut is located at latitude of 29° 40’ North and longitude of 77° 42’ East and at an altitude of 237 meter above mean sea level (MSL) and from 28.4° South and 28.0° North latitude and between 77.0° and 78.0° longitude of the District of Meerut. The climate of this region is semi-tropical characterized with hot summers and extremely cold winters. The mean maximum temperature was noticed in June, which is the hottest month of the year, ranges from 40°C to 45°C while very low temperature (4°C) accompanied by frost may be experienced in Dec. – Jan. The winters are cool, frost generally occurs towards the end of December and may continue till the end of January. The mean annual rainfall of the Meerut is about 840 mm, of which nearly 90 per cent is received in the monsoon period from June to September and the remaining in the period between October to May. The mean daily evaporation value reaches as high as 16.0 mm in the month of June and as low as 2.2 mm in the month of January. The mean annual pan evaporation reaches about 850 mm. The mean wind velocity varies from 3.5 km hrs. during season. The meteorological data have showed that average maximum weekly temperature ranged between 29.5°C to 37.1°C while average minimum weekly temperature ranged between 13.3°C to 25.2°C, respectively. The total amount of rainfall received during crop season was 416.5 mm whereas, mean relative humidity varied between 45.8 to 88.2 per cent.

Fig 1: Mean weekly meteorological observations during crop season
The rice variety ‘Pusa Basmati-1’ which is recommended for release and cultivation under Kharif irrigated conditions, was transplanted on July, 20th of 2018. The required quantities of N, P, K and Zn were applied in the different treatments by Urea, Diammonium Phosphate, Muriate of potash, Zinc sulphate Zinc oxide and chelated Zinc respectively. Half dose of nitrogen and full dose of all other nutrients (as per treatments) was applied as basal and remaining dose of nitrogen was applied in two equal splits at tillering and panicle initiation stages into the soil uniformly. A thin layer of water (approximately 3.0 cm) was maintained during the initial stage of crop growth for better establishment of seedlings and maximum 5.0 cm at tillering stage and later an intermittent irrigation at the time of panicle initiation, flowering and grain formation stage were applied. Water was drained out from the field one week before the harvesting of crop. Harvesting was done manually when the crop reached at full physiological maturity stage.

Results and discussion

Growth parameters of rice

Among the planting techniques, resulted in to maximum plant height with P2 (FIRB), while the lowest plant height was noticed in P1 (RT-TPR) at all the stages of crop growth. The better and early root development within P2 (FIRB) than other planting techniques might cause better crop. This could be attributed to the high cell turgidity and increased cell number.

Table 1: Effect of different planting techniques and fertility levels on growth parameters of basmati rice

| Treatment   | Crop growth parameters | Plant height (cm) | Number of tillers (m⁻²) | Dry matter (g m⁻²) |
|-------------|------------------------|-------------------|-------------------------|--------------------|
|             | Planting techniques    |                   |                         |                    |
| P1 (RT-TPR) |                        | 110.1             | 317.5                   | 897.0              |
| P2 (FIRB)   |                        | 120.1             | 335.6                   | 935.6              |
| P3 (CT-TPR) |                        | 116.8             | 344.1                   | 958.0              |
| SEm±        |                        | 0.9               | 3.01                    | 8.8                |
| CDi(p=0.05) |                        | 3.6               | 11.5                    | 34.3               |
|             | Fertility levels       |                   |                         |                    |
| F1 (Control)|                        | 111.4             | 320.6                   | 913.8              |
| F2 (RDF)   |                        | 114.5             | 328.1                   | 918.1              |
| F3 (125% RDF) |                    | 117.1             | 342.9                   | 941.7              |
| F4 (150% RDF) |                    | 119.7             | 336.5                   | 949.3              |
| F5 (RDF + 25 kg ZnSO₄) | | 115.5             | 333.9                   | 928.2              |
| SEm±        |                        | 0.6               | 1.9                     | 7.7                |
| CDi(p=0.05) |                        | 1.7               | 5.7                     | 22.5               |

Yield attributes and yield of rice

Yield attributes of rice

Number of effective tillers/m²: Planting techniques and fertility levels caused significant variation in number of effective tillers/m² in rice. Highest number of effective tillers (169) were recorded under the treatment P3 (CT-TPR) which was statistically at par with P2 (FIRB). The significantly minimum number of effective tillers (149) were noted under the treatment P1 (RT-TPR). Fertility levels also caused variation in number of effective tillers. The highest number of effective tillers were recorded with the application of RDF+25 kg ZnSO₄. The significantly lowest number of effective tillers were observed under control treatment.

Grains/Panicle: Planting techniques and fertility levels caused significant variation in grains/panicle in rice. The significantly highest average number of grains/panicle (127.6) was observed under the treatment P3 (CT-TPR) and the minimum number of grains (121.1) was recorded under the treatment P1 (RT-TPR). Variation in grains per panicle was also observed due to fertility levels. The significantly highest grains per panicle (127.6) were recorded with the application of 125% RDF (F5) and the lowest value of grains per panicle was recorded and control treatment.

Test Weight (g): The 1000 grain weight did not significantly influenced by various planting techniques, however, the maximum and minimum (23.7 & 22.3 g) 1000 grain weight was noticed in P1 (RT-TPR) and P3 (CT-TPR) treatments, respectively. The 1000 grain weight was significantly influenced by various fertility levels. The maximum 1000 grain weight (24.6 g) was recorded with application of 125% RDF. However, the minimum 1000 grains weight (21.7 g) was recorded in F1 (control) treatment.

Yield of rice

Biological Yield (q ha⁻¹): The highest biological yield (94.2 q ha⁻¹) was recorded under the treatment P3 (CT-TPR) which was statistically at par with P2 (FIRB). The significantly lowest biological yield was observed in P1 (RT-TPR)
Grain yield (q ha⁻¹): Planting techniques and fertility levels caused significant variation in grain yield (q ha⁻¹) of rice. The maximum grain yield of 41.2 q ha⁻¹ was recorded under the treatment P₁ (CT-TPR) which was statistically at par with treatment P₂ (FIRB). However, the lowest grain yield (37.9 q ha⁻¹) was recorded under P₁ (RT-TPR). The highest grain yield was recorded with application of 125% RDF (F₁) which was statistically at par with Treatment F₁(150% RDF) and the significantly lowest grain yield was associated with the control treatment.

Straw yield (q ha⁻¹): Planting techniques and fertility levels caused significant variation in straw yield (q ha⁻¹) of rice. The maximum straw yield of 52.9 q ha⁻¹ was recorded under the treatment P₁ (CT-TPR). However, the lowest straw yield (45.8 q ha⁻¹) was recorded under P₁ (RT-TPR). The highest straw yield was recorded with application of RDF + 25 kg ZnSO₄ (F₁) which was statistically at par with Treatment F₁ (125% RDF) and F₂ (150% RDF). However, the significantly lower straw yield was associated with the control treatment.

Harvest index (%): Harvest index which is a ratio of grain yield to biological yield did not significantly influence due to planting techniques however the highest value (44.7%) was recorded under P₂ (FIRB) and lowest harvest index (43.4%) was observed under the treatment P₁ (CT-TPR). Fertility levels caused significant difference in harvest index of rice. The highest value of harvest index (47.1%) was recorded with the application of 125% RDF (F₁) and it was found statistically at par with the treatment F₁ (150% RDF). However, the lowest harvest index value was associated with control treatment.

Among the planting techniques P₁ (CT-TPR) resulted in to maximum yield attributes viz. effective tillers, grains per panicle and 1000- weight while the lowest values of yield attributes were noticed in P₁ (RT-TPR). The higher values of yield attributes may probably due to more dry matter accumulation which increased synthesis and translocation of metabolites for the panicle development and grains formation. Besides, thousand grains weight was also increased due to high mobilization of photosynthates from source to sink which is essential for protein synthesis and carbon assimilation. The CT-TPR resulted in to maximum grain and straw yield while the lowest grain and straw yield was noticed in P₁ (RT-TPR). The higher values of yield attributes with P₁ (CT-TPR) might be due to providing more nutrition and favorable conditions for growth and development. The higher vegetative growth and significantly higher dry matter production led to higher photosynthetic efficiency which have favorable effect on yield contributing characters and their effects are consequently higher grain yield of basmati rice. The beneficial effect of planting techniques on growth and dry matter accumulation was ultimately exhibited on straw and biological yield of rice. Similar findings were also reported by Bajpai and Tripathi (2000), Prasad et al. (2001) and Choudhary et al. (2004). Effective tillers, grains panicle⁻¹ and 1000- grains weight were significantly influenced due to various fertility levels. Treatment F₁ (125% RDF) was found superior as compared to other fertility levels treatments followed by F₂ (150% RDF) and F₃ (RDF + 25 kg ZnSO₄). Due to reduced crop-weed competition and better sink capacity performed more effective tillers, grains panicle⁻¹ and 1000- grains weight. The yield attributes are decided by genetic makeup of the crop and variety, but the agronomic manipulation also affects them to a great extent. The reproductive and growth depends on vegetative growth of plant. More vegetative growth increases the photosynthetic area and supply of photosynthotic toward sink which decided the yield attributes and ultimately the yield. The higher values of yield attributes were due to increased synthesis and translocation of metabolites for the panicle development and grain formation. Besides, thousand grain weights were also maintained because of high mobilization of photo-synthesis from source to sink. Similar results were also noticed by Chopra and Chopra (2004) [2]. The final yield of the crop was the cumulative effect of yield attributes and the factor which directly affect and or indirectly influenced them. A crop can perform best only when the display of foliage on the ground surface was in such a manner that utilizes maximum natural resources. In our study, grain yield ha⁻¹ was significantly influenced by the different fertility levels. Treatment F₁ (125% RDF) was superior in relation to grain yield per hectare followed by F₂ (150% RDF) and F₃ (RDF + 25 kg ZnSO₄). Fertility levels the F₁ (125% RDF) was superior in grain yield ha⁻¹ and 71.58% higher grain yield over control plot. This was might be due to the higher crop growth of rice in terms of foliage, large amount of photosynthesis, which act as source and helped in developing yield attributes due to low crop weed competition and finally the higher grain yield Application of F₁ (125% RDF) resulted in the highest grain yield Saharawat et al., (2009) [3]. The minimum grain yield was obtained from control treatment due to no control measure was adopted in this plot. Findings of the present investigation are in agreement with the finding of Singh and Kumar (2005) [5]. Higher straw yield was due to more accumulation of dry matter m⁻² along with highest plant height and number of tillers plant⁻¹. Treatment F₁ (RDF + 25 kg ZnSO₄) produced higher straw yield over F₃ (150% RDF) due to better vegetative growth and more dry matter accumulation. However, lowest straw yield was obtained in control plots. Similar pattern was observed in biological yield. The finding confirms the results of Youseftabar et al. (2012).

Table 2: Effect of different planting techniques and fertility levels on yield contributing characteristics of basmati rice

| Treatment        | Effective tillers (m⁻²) | Grain panicle⁻¹ | 1000- grains weight (g) |
|------------------|------------------------|-----------------|------------------------|
| **Planting techniques** |                        |                 |                        |
| P₁ (RT- TPR)     | 149                    | 127.6           | 23.7                   |
| P₂ (FIRB)        | 162                    | 124.9           | 23.4                   |
| P₁ (CT- TPR)     | 169                    | 121.2           | 22.3                   |
| SEm              | 1.9                    | 0.4             | 0.1                    |
| CD₁(α=0.05)      | 7.6                    | 1.7             | NS                     |
| **Fertility levels** |                        |                 |                        |
| F₁ (Control)     | 137                    | 120.9           | 21.7                   |
Table 3: Effect of different planting techniques and fertility levels on yield (q ha\(^{-1}\)) of basmati rice

| Treatment | Yield (q ha\(^{-1}\)) | Harvest index (%) |
|-----------|------------------------|-------------------|
|           | Grain | Straw | Biological | Grain | Straw | Biological |
| Planting techniques |       |       |             |       |       |             |
| P\(_1\) (RT- TPR)  | 37.9  | 45.8  | 83.8       | 44.5  |       |             |
| P\(_2\) (FIRB)     | 40.7  | 49.5  | 90.3       | 44.7  |       |             |
| P\(_3\) (CT- TPR)  | 41.2  | 52.9  | 94.2       | 43.4  |       |             |
| SEm±             | 0.4   | 0.7   | 1.0        | 0.4   |       |             |
| CD\(_{P=0.05}\)   | 1.7   | 2.6   | 3.9        | NS    |       |             |
| Fertility levels   |       |       |             |       |       |             |
| F\(_1\) (Control) | 27.1  | 38.5  | 65.6       | 41.2  |       |             |
| F\(_2\) (RDF)     | 39.8  | 50.1  | 89.9       | 43.8  |       |             |
| F\(_3\) (125% RDF) | 46.5  | 51.8  | 98.2       | 47.1  |       |             |
| F\(_4\) (150% RDF) | 44.6  | 52.1  | 96.7       | 45.9  |       |             |
| F\(_5\) (RDF + 25 kg ZnSO\(_4\)) | 41.8 | 54.7 | 96.6 | 43.0 |       |             |
| SEm±             | 1.0   | 1.1   | 1.8        | 0.7   |       |             |
| CD\(_{P=0.05}\)   | 3.0   | 3.1   | 5.1        | 1.9   |       |             |

Fig 2: Effect of different planting techniques and fertility levels on yield contributing characteristics of basmati rice

Fig 3: Effect of different planting techniques and fertility levels on yield (q ha\(^{-1}\)) of basmati rice
**Economics of rice**

Among the planting techniques highest B: C ratio was recorded with P₂ (FIRB) treatment. The highest B: C ratio was in P₃ (FIRB) treatment might be due to effective utilization of available nutrients which resulted in more yield as compare to P₁ (RT-TPR). The lowest B: C ratio was recorded in P₃ (CT-TPR). In fertility levels the highest cost of cultivation (Rs 40,523 ha⁻¹) was recorded under F₂ (150% RDF) while lowest cost of cultivation (Rs 26,209 ha⁻¹) was observed in control treatment. The highest B:C ratio was noticed in F₃ (125% RDF) treatment might be due to maximum net return and less cost of cultivation in F₃ (125% RDF) than F₄ (150% RDF) and F₃ (RDF+25kg ZnSO₄). The similar findings were also noticed by Hossain (2014) and Mehala et al. (2016).

**Conclusion**

On the basis of experimental findings, it may be concluded that the application of P₃ (CT-TPR) resulted into the maximum crop yield, gross return and net return, which was statistically at par to the application of P₂ (FIRB) treatment. However, the maximum B: C ratio (2.82) was noticed in P₂ (FIRB). Among the fertility levels, the highest crop yield net return and B:C ratio was recorded in F₃ (125% RDF). Therefore, it may be concluded that use of P₂ (FIRB) along with F₂ fertility (125% RDF) is beneficial than other combinations of planting techniques and fertility levels.

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