



## **Effect of Planting Techniques and Nutrient Management Options on Crop Productivity and Soil Health of Wet Rice (*Oryza sativa* L) in *Typic Ustochrept* Soils**

**M. Sharath Chandra<sup>1\*</sup>, R. K. Naresh<sup>1</sup>, Vivek<sup>1</sup>, S. P. Singh<sup>2</sup>, Purushottam<sup>3</sup>,  
Vivak Kumar<sup>4</sup>, P. C. Jat<sup>5</sup> and Himanshu Tiwari<sup>1</sup>**

<sup>1</sup>Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, U.P., India.

<sup>2</sup>Department of Soil Science & Agricultural Chemistry, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, U.P., India.

<sup>3</sup>Department of Pathology & Microbiology, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, U.P., India .

<sup>4</sup>Department of Farm Machinery & Power, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, U.P., India.

<sup>5</sup>ICAR-Indian Institute of Farming System Research (IIFSR), Modipuram, Meerut-250110 U.P., India.

### **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

### **Article Information**

DOI: 10.9734/IJPSS/2021/v33i2230681

Editor(s):

(1) Dr. Hon H. Ho, State University of New York, USA.

Reviewers:

(1) Dwi Susanto, Mulawarman University, Indonesia.

(2) Athos Odin Severo Dorneles, Federal University of Santa Maria, Brazil.

Complete Peer review History: <https://www.sdiarticle4.com/review-history/76122>

**Original Research Article**

**Received 14 August 2021  
Accepted 27 October 2021  
Published 28 October 2021**

### **ABSTRACT**

A two years field experiment was carried out in sandy loam soil during rainy (*Kharif*) seasons in 2019-2020 at CRC farm of sardar vallabhbhai patel university of agricultural & technology, Meerut, Uttar Pradesh to evaluate the various Planting techniques and integrated nutrient management on yield and soil health of rice (*Oryza sativa* L.) under rice- wheat cropping system. The treatments comprised of two Planting techniques i.e., E<sub>1</sub>-Conventional puddled transplanted rice (CT- TPR),

E<sub>2</sub>- Wide bed Transplanted rice (W Bed-TPR) and Nine Nutrient management practices {N<sub>1</sub>- Control, N<sub>2</sub>- 100% RDF + ZnSO<sub>4</sub> 25 kg ha<sup>-1</sup>, N<sub>3</sub>- 125% RDN + ZnSO<sub>4</sub> 25 kg ha<sup>-1</sup>, N<sub>4</sub>- STCR based NPK application + ZnSO<sub>4</sub> 25 kg ha<sup>-1</sup>, N<sub>5</sub>- N<sub>2</sub>+ FYM (5 t ha<sup>-1</sup>), N<sub>6</sub>- N<sub>2</sub>+ FYM (5 t ha<sup>-1</sup>) + PSB (5 kg ha<sup>-1</sup>)+ Azotobactor 20 kg ha<sup>-1</sup>, N<sub>7</sub>- 75% RDN + FYM (5 t ha<sup>-1</sup>) + ZnSO<sub>4</sub> 25 kg ha<sup>-1</sup>, N<sub>8</sub>-75% RDN + FYM (5 t ha<sup>-1</sup>) + PSB (5 kg ha<sup>-1</sup>) + Azotobactor 20 kg ha<sup>-1</sup> + ZnSO<sub>4</sub> 25 kg ha<sup>-1</sup>, N<sub>9</sub>- Organics Practices @ FYM (30 t ha<sup>-1</sup>)+PSB (5 kg ha<sup>-1</sup>) + Azotobactor 20 kg ha<sup>-1</sup> + ZnSO<sub>4</sub> 25 kg ha<sup>-1</sup>} are laid down in Factorial Randomized block design and replicated thrice. The results indicated that among the different Planting techniques (PTs), conventional puddled transplanted rice (E<sub>1</sub>, CT-TPR) was recorded significantly higher grain yield (40.4 & 41.3 q ha<sup>-1</sup>), straw yield (62.7 & 63.8 q ha<sup>-1</sup>), NPK content and uptake and also improved soil health status *ie.*, available NPK, organic carbon and other physical properties *i.e.* Bulk density, EC, pH in soil than wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR) during both years of *kharif* 2019 & 2020 respectively. Among the nutrient management practices, the N<sub>6</sub> (100% RDF + ZnSO<sub>4</sub> 25 kg ha<sup>-1</sup> + FYM (5 t ha<sup>-1</sup>) + PSB (5 kg ha<sup>-1</sup>)+ Azotobactor 20 kg ha<sup>-1</sup>) treatment produced significantly higher grain yield (49.0 & 50.2 q ha<sup>-1</sup>), straw yield (81.2 & 82.8 q ha<sup>-1</sup>), NPK content and uptake, and available NPK organic carbon in soil than the other treatments, which were comparable to the N<sub>3</sub> (125% RDN + ZnSO<sub>4</sub> 25 kg ha<sup>-1</sup>) treatment and the lowest in the control treatment N<sub>1</sub>, respectively. Thus, the results suggest that inclusion of inorganic fertilizer along with organic manure (FYM) enhanced the rice yield Therefore, application of conventional puddled transplanted rice (E<sub>2</sub>, CT-TPR) along with N<sub>6</sub> (100% RDF + ZnSO<sub>4</sub> 25 kg ha<sup>-1</sup> + FYM (5 t ha<sup>-1</sup>) + PSB (5 kg ha<sup>-1</sup>)+ Azotobactor 20 kg ha<sup>-1</sup>) found beneficial to increase productivity and soil health of rice crop.

**Keywords:** Planting techniques; nutrient management practices; yield; soil health.

## 1. INTRODUCTION

Rice (*Oryza sativa* L.) is most important staple food of more than 60% of the world's population dominantly produced and consumed in the Asia with about two-thirds of the total rice production grown under irrigation utilizes two or three times more water than other cereal crops such as maize and wheat [1]. In India, rice occupies an area of 43.79 mha with production and productivity of 116.42 mt and 2.65 t/ha, respectively [2]. In the current scenario, changes in investigations on crop establishment techniques (CETs) and management practices in rice and wheat are getting more emphasis [3]. This is mainly because of variations in CETs with respect to their resource utilization, energy requirements, capacity to act as a mitigation strategy for climate change can have far reaching implications in terms of yield and income to the farmers, besides environmental health. Among them, mainly manual transplanting of seedlings into puddle soil is practiced in India which means a process of cultivating soil in standing water, consumes a large quantity of water and labor [4]. According to Chauhan et al. [5], the long-term viability of puddle transplanted rice (PTR) is threatened by increasing production costs (particularly labour) and increasing agricultural labour scarcity, which causes crop establishment to be delayed beyond the optimal time. Transplanting is a resource and

cost-intensive procedure since seedbed preparation, seedling raising, and transplanting are all labor-intensive operations [4]. Huge water inputs, labour costs and labour requirements for conventional transplanted puddle rice (CT-TPR) have reduced profit margins to the farmers [6]. To tackle this problem, the adoption of new CETs and nutrient management practices are becoming increasingly significant to address the issues related to degradation of natural resources and increasing cost of chemical and agronomic interventions or resources [3].

Fertilizer is one of the most important management factors to increase the productivity of crops. Farmers are using higher amount of fertilizer for every crop without considering crop requirement causing imbalance in the system. The imbalance usage of fertilizers is responsible for the low productivity and also the continuous use of inorganic fertilizers resulted in declining of soil fertility [7]. Continuous degradation of soil health is caused due to imbalance use of chemical fertilizer and non-recycling of organic matter [4]. The use of inorganic fertilizer in rice cultivation has been progressively increasing since its introduction. However, available reports indicate that the repeated use of chemical fertilizer alone fails to sustain desired yield, impairs soil physical condition and exhausts organic matter content leads to environmental degradation and soil health especially due to

their continuous use [8]. Hence, judicious application of inorganic fertilizer is paramount important for yield enhancement of rice [9].

Nutrient management through organics plays a major role in maintaining soil health due to build-up of soil organic matter, beneficial microbes and enzymes, besides improving soil physical and chemical properties. Application of organic manure with chemical fertilizer accelerates the microbial activity, increases nutrient use efficiency enhances the availability of the native nutrients to the plants resulting higher nutrient uptake. Integrated use of organic manures and chemical fertilizers has advantages over use of only organic manures or chemical fertilizers [10]. Biofertilizers are living microbes that enhance plant nutrition by either by mobilizing or increasing nutrient availability in soils. Despite their great potential to improve soil fertility, biofertilizers have yet to replace conventional chemical fertilizers in commercial agriculture [11]. Therefore, combined use of organic manure and inorganic fertilizers in an integrated manner will give better performance in cereals by sustaining higher yield and maintaining soil health [7,12].

The purpose of the current study was to investigate the response of rice (*Oryza sativa* L.) for their yield and soil health under different planting techniques and nutrient management practices in Western Uttar Pradesh.

## 2. MATERIALS AND METHODS

### 2.1 Location

The field experiment was conducted during 2019-2020 *kharif* seasons at the CRC Farm, College of Agriculture, of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut situated in Indo-Gangetic Plains of Western Uttar Pradesh, India. The farm is geographically situated at 29° 08' 12" N latitude, 77° 40' 52" E longitudes and at an elevation 232 meters above the sea level.

### 2.2 Treatments and Design

The experiment was laid out in a factorial randomized block design with eleven treatments consists of two Planting techniques and nine nutrient management practices as two factors and replicated thrice. The treatments combination include two Planting techniques i.e.,

E<sub>1</sub>-Conventional puddled transplanted rice (CT-TPR), E<sub>2</sub>- Wide bed Transplanted rice (W Bed-TPR) as one factor and Nine Nutrient management practices such as N<sub>1</sub>- Control, N<sub>2</sub>- 100% RDF + ZnSO<sub>4</sub> 25 kg ha<sup>-1</sup>, N<sub>3</sub>- 125% RDN + ZnSO<sub>4</sub> 25 kg ha<sup>-1</sup>, N<sub>4</sub>- STCR based NPK application + ZnSO<sub>4</sub> 25 kg ha<sup>-1</sup>, N<sub>5</sub>- N<sub>2</sub>+ FYM (5 t ha<sup>-1</sup>), N<sub>6</sub>- N<sub>2</sub>+ FYM (5 t ha<sup>-1</sup>) + PSB (5 kg ha<sup>-1</sup>) + Azotobacter 20 kg ha<sup>-1</sup>, N<sub>7</sub>- 75% RDN + FYM (5 t ha<sup>-1</sup>) + ZnSO<sub>4</sub> 25 kg ha<sup>-1</sup>, N<sub>8</sub>-75% RDN + FYM (5 t ha<sup>-1</sup>) + PSB (5 kg ha<sup>-1</sup>) + Azotobacter 20 kg ha<sup>-1</sup> + ZnSO<sub>4</sub> 25 kg ha<sup>-1</sup>, N<sub>9</sub>- Organics Practices @ FYM (30 t ha<sup>-1</sup>) + PSB (5 kg ha<sup>-1</sup>) + Azotobacter 20 kg ha<sup>-1</sup> + ZnSO<sub>4</sub> 25 kg ha<sup>-1</sup> as second factor respectively. The experimental plot size was 10 m × 3.0 m. The seedlings of rice variety PB-1509 at 21 days old were transplanted by adopting a spacing of 25 cm × 10 cm in conventional method and 20 cm × 10 cm in wide bed transplanted method. The experimental field was provided with proper irrigation channels and the individual plots were demarcated by bunds.

### 2.3 Soil properties and Fertilizer Application

The experimental soil was sandy loam in texture, moderately alkaline in reaction, non-saline, low in organic carbon content, low in available nitrogen (N- 235.8 & 242.5 kg ha<sup>-1</sup>), medium in available phosphorous (P<sub>2</sub>O<sub>5</sub>- 18.6 & 19.8 kg ha<sup>-1</sup>) and potassium (K<sub>2</sub>O- 210.5 & 215.6 kg ha<sup>-1</sup>) during *kharif* season (2019-2020). The recommended dose of fertilizer i.e., 150 kg N, 60 kg P<sub>2</sub>O<sub>5</sub> and 40 kg K<sub>2</sub>O ha<sup>-1</sup> was applied. The amount of N, P and K will be applied through urea, SSP and muriate of potash, respectively. Half of N and full dose of P and K was applied as basal before last plough of field. The remaining 50% N will be top dressed in splits at active tillering stage and at panicle initiation stage of rice. The amount of PSB @ 5 kg ha<sup>-1</sup>, Azotobacter will be applied @ 20 kg ha<sup>-1</sup> and FYM was 0.5% N, 0.2% P and 0.5% K will be applied in the soil at one week after transplanting of rice. The application of N, P and K of the basis STCR equation (developed by IARI) is followed  $6.97 \times T - 0.38 \times SN$ ,  $5.73 \times T - 4.81 \times SP$ ,  $3.92 \times T - 0.28 \times SK$  [13].

### 2.4 Calculations and Statistical Analysis

All data obtained from the experiment, conducted under factorial randomized block design were statistically analyzed using the F-test as per the procedure given by Gomez and Gomez [14].

Critical differences (CD) values at  $P = 0.05$  were used to determine the significance of difference between treatment means. Treatment differences that were non-significant were denoted by NS. The yield and yield attributes data were recorded, analyzed and tabulated after statistical test.

## 2.5 Methods of Measuring

### I. Yield, nutrient uptake, soil nutrient status and physical properties of soil analysis

- a) Grain yield ( $q\ ha^{-1}$ ):** The harvested plants from net plot area were threshed manually and each plot yield was separately sun dried, cleaned by winnowing and weighed. Grain yield was computed at 14 per cent moisture content and expressed in  $q\ ha^{-1}$ .
- b) Straw yield ( $q\ ha^{-1}$ ):** Dry weight of straw from each net plot was recorded after sun drying for couple of days and expressed in  $kg\ ha^{-1}$ .
- c) Biological yield ( $q\ ha^{-1}$ ):** The crop in each net plot will be harvested bundled, labelled and dried in the field for 4-5 days. Bundles will be weighed just before threshing to record biological yield (Grain yield + Straw yield  $q\ ha^{-1}$ ) per plot and expressed in  $q\ ha^{-1}$ .
- d) Harvest index (%):** Harvest index was calculated for each treatment using the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Grain Yield (q ha}^{-1}\text{)}}{\text{Grain Yield + Straw Yield (q ha}^{-1}\text{)}} \times 100$$

- e) Nutrients (NPK) Uptake by crop:** After estimating the nitrogen, phosphorus and potassium content in grain and straw, the uptake of these nutrients will be calculated as  $kg\ ha^{-1}$  by multiplying the contents with grain and straw yields in different treatments.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \text{Nutrient NPK(\%)} \text{ in grains/straw} \times \text{yield of grains/straw (q ha}^{-1}\text{)}.$$

- f) Soil pH:** Soil pH will be measured with the help of a glass electrode pH meter, buffer solution and  $CaCl_2$  solution and the

soil-water ratio being maintained at 1: 2.5 [15].

- g) Soil EC ( $ds\ m^{-1}$ ):** The EC will determine with the help of KCl solution and glass electrode of a EC meter in 1:2.5 soil: water suspension Method No.4, USDA Hand Book No.60 [16].
- h) Soil bulk density:** Soil samples were collected at initial and after harvest of crop at 0–5, 5-10 and 10-20 and 20-30 cm depth. An undisturbed soil cores were taken by hammering into the ground with the stainless steel cutter edge cylinders 5 cm high and 6 cm in diameter from three places in each plot, mixed and bulked for analysis. Samples were oven-dried for 48 h at  $105^{\circ}C$ ; weighed. Bulk density of soil was calculated from the formula according to Blake and Hartge [17].

$$BD\ (Mg\ M^3) = (X-Y)/V$$

Where,

X= Weight of core with oven dry soil,  
Y= Weight of core,  
V= Volume of core.

- i) Organic carbon (%):** Organic carbon content in soil will be determined volumetrically by wet oxidation method, as outlined by [18]. The reagent such as  $K_2Cr_2O_7$  solution, conc.  $H_2SO_4$ , 0.2 N Ferrous Ammonium Sulphate and diphenylamine indicator will be used. The organic matter will be calculated by multiplying the per cent organic carbon by 1.73 (Van Bemmelen factor).
- j) Available nitrogen:** Available nitrogen estimated by alkaline  $KMnO_4$  method where the organic matter in soil would be oxidized with hot alkaline  $KMnO_4$  solution. The ammonia evolved during oxidation will be distilled and trapped in boric acid mixed indicator solution. The amount of  $NH_3$  trapped will be estimated by titrating with standard acid [15].
- k) Available phosphorus:** Available phosphorus extracted with sodium bicarbonate (0.5 M) at pH 8.5 (Olsen's reagent) and the amount of P in the extract will be estimated by using ascorbic acid as reducing agent and blue colour intensity

will be measured by using spectrophotometer at wave length of 660 nm [19].

**I) Available potassium:** Available K will be extracted with neutral normal ammonium acetate and determined using flame photometer [15].

### 3. RESULTS AND DISCUSSION

Grain yield, straw yield and harvest index of rice was significantly influenced by different Planting techniques and nutrient management practices (Fig. 1a & 1b). However, there was no significant effect of interaction between different Planting techniques and nutrient management practices.

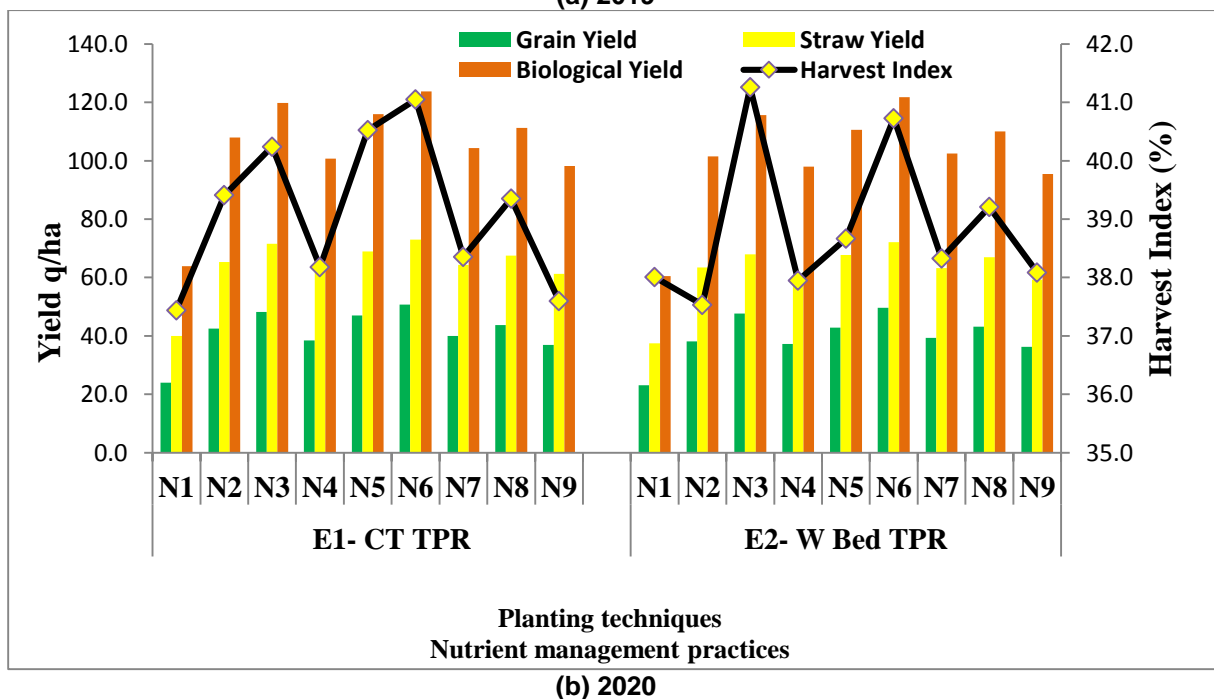
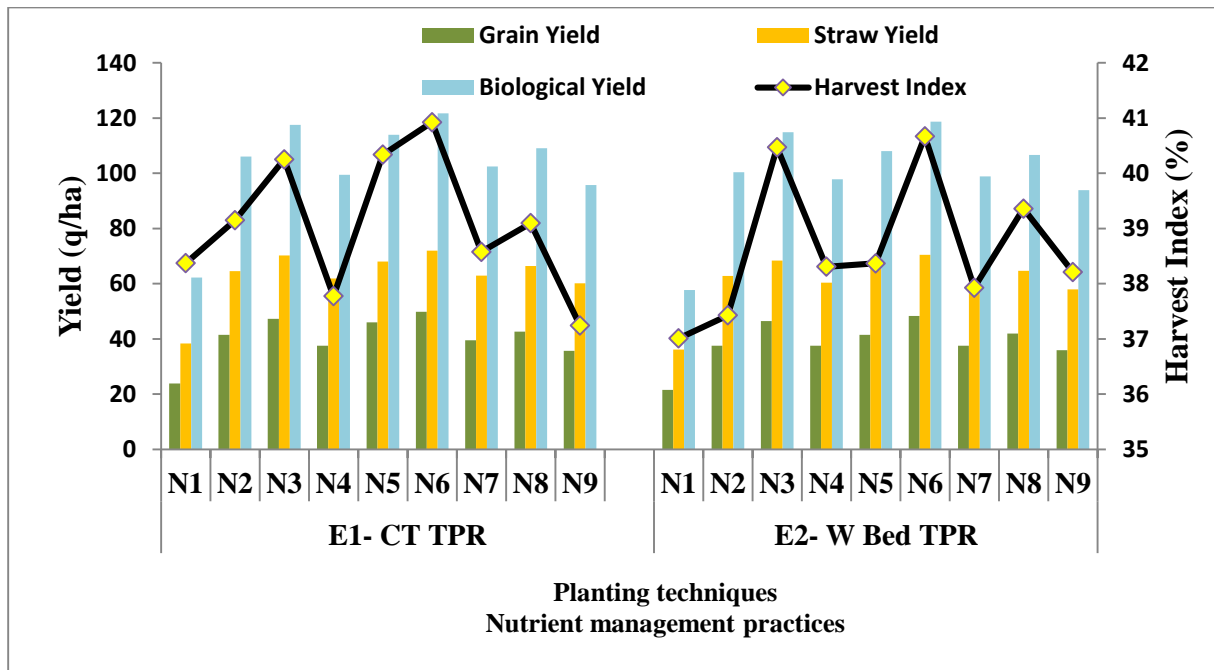


Fig. 1. Effect of different Planting techniques and nutrient sources on yield (q ha<sup>-1</sup>) and harvest index (%) of rice during Kharif 2019-2020

### 3.1 Yield

#### 3.1.1 Grain Yield (q ha<sup>-1</sup>):

Grain yield of rice was significantly influenced by different Planting techniques and nutrient management practices (Fig. 1a & 1b). Among the different Planting techniques, conventional puddled transplanted rice (E<sub>1</sub>, CT-TPR) was recorded significantly higher grain yield (40.4 & 41.3 q ha<sup>-1</sup>) than wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR) during both years of *kharif* 2019 & 2020. Significantly lower grain yield (38.7 & 39.7 q ha<sup>-1</sup>) was recorded with wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR) during the both year of study.

Among the nutrient management practices, significantly higher grain yield was recorded with N<sub>6</sub> (49.0 & 50.2 q ha<sup>-1</sup>) treatment over rest of the other treatment and which was *at par* with N<sub>3</sub> (46.9 & 47.9 q ha<sup>-1</sup>) treatment respectively. However, the treatments N<sub>3</sub>, N<sub>5</sub>, N<sub>8</sub> and N<sub>2</sub> were recorded higher grain yield and which were statistically superior than remaining other nutrient management treatments during both the year of experimentation. Moreover, the treatments N<sub>7</sub>, N<sub>4</sub>, N<sub>9</sub> was observed similar pace of grain yield and were *at par* to each other respectively. The significantly lower grain yield was observed with control treatment N<sub>1</sub> (22.7 & 23.5 q ha<sup>-1</sup>) over rest of the other treatment during both the year of study.

#### 3.1.2 Straw Yield (q ha<sup>-1</sup>):

Mean straw yield of 62.7 & 63.8 q ha<sup>-1</sup> registered under conventional puddled transplanted rice (E<sub>1</sub>, CT-TPR) was significantly higher than the wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR) during both years of *kharif* 2019 & 2020 respectively. Among the different Planting techniques, significantly lower straw yield (61.0 & 62.1 q ha<sup>-1</sup>) was recorded with wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR) during the both year of experimental study.

Among the nutrient management practices, significantly maximum straw yield was registered with N<sub>6</sub> (71.2 & 72.5 q ha<sup>-1</sup>) treatment over rest of the other treatment except N<sub>3</sub> (69.3 & 69.8 q ha<sup>-1</sup>) treatment respectively. However, the treatments N<sub>3</sub>, N<sub>5</sub>, N<sub>8</sub> and N<sub>2</sub> were recorded higher straw yield and which were statistically superior than remaining other nutrient management treatments during both the year of experimentation. Moreover, the treatments N<sub>7</sub>, N<sub>4</sub>, N<sub>9</sub> was observed similar pace of grain yield and

were *at par* to each other respectively. The significantly minimum straw yield was recorded with control treatment N<sub>1</sub> (37.2 & 38.7 q ha<sup>-1</sup>) over rest of the other treatment during both the year of study.

#### 3.1.3 Biological Yield (q ha<sup>-1</sup>):

The biological yield (sum of grain and straw yield) of wheat is an important index indicating the photosynthetic efficiency of crop and photosynthetic left behind after respiration which ultimately influenced the crop yield. Among the different Planting techniques, conventional puddled transplanted rice (E<sub>1</sub>, CT-TPR) was recorded significantly higher biological yield (103.1 & 105.1 q ha<sup>-1</sup>) than wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR) during both years of *kharif* 2019 & 2020 respectively. Significantly lower biological yield (99.7 & 101.8 q ha<sup>-1</sup>) was recorded with wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR) during the both years of experimentation.

Among the nutrient management practices, significantly higher biological yield was recorded with N<sub>6</sub> (120.2 & 122.7 q ha<sup>-1</sup>) treatment over rest of the other treatment and which was *at par* with N<sub>3</sub> (116.2 & 117.7 q ha<sup>-1</sup>) treatment respectively. However, the treatments N<sub>3</sub>, N<sub>5</sub>, N<sub>8</sub> and N<sub>2</sub> were recorded higher biological yield and which were statistically superior than rest of the other nutrient management treatments during both *kharif* 2019 & 2020 respectively. The treatments N<sub>7</sub>, N<sub>4</sub>, N<sub>9</sub> was observed similar pace of biological yield and were *at par* to each other respectively. The significantly lower biological yield was observed with control treatment N<sub>1</sub> (59.9 & 62.2 q ha<sup>-1</sup>) over rest of the other treatment during both the years of experimental study.

#### 3.1.4 Harvest index

The harvest index of rice ranged from 37.69 to 37.72 and 40.80 to 40.89 per cent among different nutrient sources. There is no significant variation was not observed in test weight among different Planting techniques. Among different nutrient management practices, significantly highest harvest index was recorded with N<sub>6</sub> (40.80 to 40.89 %) treatment over rest of the other treatment except N<sub>3</sub> (40.36 & 40.75 %) and N<sub>5</sub> (39.35 & 39.59 %) treatment during *kharif* 2019 & 2020 respectively. However, the treatments N<sub>3</sub> and N<sub>8</sub> were recorded highest harvest index and which were statistically superior than remaining other nutrient management treatments during both the year of

experimentation. Moreover, the treatments N<sub>7</sub>, N<sub>2</sub>, N<sub>4</sub>, N<sub>9</sub> was observed similar tune of harvest index and were *at par* to each other respectively. The lowest harvest index was noticed in control treatment N<sub>1</sub> (37.69 to 37.72 q ha<sup>-1</sup>) than rest of the other treatment during both the years of study.

Yield is the resultant of growth characters and yield attributes. Grain and straw yield were significantly influenced by Planting techniques and nutrient management practices. Higher grain & straw yield noticed in E<sub>2</sub> (CT-TPR) and lowest grain and straw yield observed in E<sub>1</sub> (RT-TPR). Higher grain & straw yield significantly shown with application of N<sub>6</sub> (100% RDF + ZnSO<sub>4</sub> 25 kg ha<sup>-1</sup> + FYM (5 t ha<sup>-1</sup>) + PSB (5 kg ha<sup>-1</sup>) + Azotobactor 20 kg ha<sup>-1</sup>) treatment. The increase in yield was further attributed to better translocation of photosynthates from source to sink due to higher uptake of NPK which are responsible for quick and easy translocation of photosynthetic products. The better vegetative growth coupled with high yield attributes resulted in higher grain and straw yield of rice. Higher level of fertilizers FYM and Biofertilizer significantly influenced the growth development yield attributes and yield of rice reported by Gautam et al., [20]; Singh and Walia [21]; Kumar et al. [22].

### 3.2 Nutrient (NPK) Uptake

#### 3.2.1 Nitrogen uptake (kg ha<sup>-1</sup>)

The nitrogen content and uptake in grain and straw as influenced by various treatments (Table 1). Among the Planting techniques there was a significant variation was found in various treatment. Among them, conventional puddled transplanted rice (E<sub>1</sub>, CT-TPR) registered significantly higher nitrogen uptake in grain (51.63 & 53.39 kg ha<sup>-1</sup>) and straw (28.36 & 32.01 kg ha<sup>-1</sup>) over wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR) during both years of *kharif* 2019 & 2020 respectively. Significantly lower nitrogen uptake in grain (48.37 & 50.00 kg ha<sup>-1</sup>) and in straw (25.83 & 29.41 kg ha<sup>-1</sup>) was observed with wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR) during the both year of experimental study.

Nutrient management practices exhibited significant effect on nitrogen uptake of grain and straw in rice. Perusal of data presented in Table \_\_\_ & depicted in Figure \_\_\_ revealed that all the nutrient management practices increased nitrogen uptake in grain and straw over control conditions. Nitrogen uptake in rice grain ranged

from 26.23 to 66.55 and 27.43 to 68.65 kg/ha while in straw from 12.44 to 38.93 & 14.47 to 43.99 kg/ha respectively, during both the years among different treatments. Significantly maximum nitrogen uptake in grain (66.55 & 68.65 kg/ha) and straw (38.93 & 43.99 kg/ha) was recorded with N<sub>6</sub> treatment over rest of the other treatment during both years of *kharif* 2019 & 2020 respectively. However, the treatments N<sub>3</sub>, N<sub>5</sub>, N<sub>8</sub> and N<sub>2</sub> were recorded greater nitrogen uptake in grain and straw of rice which were statistically superior than remaining other nutrient management treatments during both the year of experimentation. Moreover, the treatments N<sub>7</sub>, N<sub>4</sub>, N<sub>9</sub> was observed similar trend of nutrient uptake in grain and straw and were *at par* to each other respectively. Significantly minimum nitrogen uptake in grain (26.33 & 27.43 kg/ha) and straw (12.44 & 14.47 kg/ha) of rice was recorded under control conditions among rest of the other treatment during both the year of study.

#### 3.2.2 Phosphorous uptake (kg ha<sup>-1</sup>)

The phosphorous uptake in grain and straw revealed that there was a significant variation was found in various treatments under different Planting techniques and all the nutrient management practices (Table 1).

There was a substantial difference in the various treatments among the Planting techniques. During the *kharif* of 2019 and 2020, conventional puddled transplanted rice (E<sub>1</sub>, CT-TPR) had considerably higher phosphorus uptake in grain (14.33 & 15.47 kg ha<sup>-1</sup>) and straw (11.97 & 12.74 kg ha<sup>-1</sup>) than wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR). During both years of the experimental study, wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR) had significantly reduced phosphorus uptake in grain (12.68 & 13.87 kg ha<sup>-1</sup>) and straw (10.42 & 10.94 kg ha<sup>-1</sup>) respectively.

Significant variation was found in phosphorus uptake in grain and straw under different nutrient management strategies. Among nutrient management sources, significantly maximum phosphorus uptake in grain (17.98 & 19.21 kg/ha) and straw (14.42 & 15.25 kg/ha) was recorded with N<sub>6</sub> treatment over rest of the other treatment except N<sub>3</sub> treatment during both years of *kharif* 2019 & 2020 respectively. However, the treatments N<sub>5</sub>, N<sub>8</sub> and N<sub>2</sub> were recorded higher phosphorus uptake in grain and straw of rice which were statistically superior than remaining other nutrient management treatments during both the year of experimentation. Moreover, the

treatments N<sub>7</sub>, N<sub>4</sub>, N<sub>9</sub> was observed similar trend of phosphorus uptake in grain and N<sub>4</sub>, N<sub>9</sub> in straw were *at par* to each other respectively. Significantly minimum phosphorus uptake in grain (6.08 & 6.48 kg/ha) and straw (4.04 & 4.18 kg/ha) of rice was recorded under control conditions among rest of the other treatment during both the year of study.

### 3.2.3 Potassium uptake (kg ha<sup>-1</sup>)

The potassium uptake in grain and straw (%) of rice revealed that there was a significant variation was found in various treatments under different Planting techniques and nutrient management practices (Table 1).

The potassium uptake in rice grain and straw differed significantly based on the Planting techniques. Conventional puddled transplanted rice (E<sub>1</sub>, CT-TPR) was recorded higher potassium uptake in grain (17.79 & 19.09 kg ha<sup>-1</sup>) and straw (100.82 & 105.60 kg ha<sup>-1</sup>) than wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR). During both years of the experimental study, wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR) had significantly lower potassium uptake in grain (15.79 & 17.19 kg ha<sup>-1</sup>) and straw (95.01 & 99.18 kg ha<sup>-1</sup>) respectively.

Nutrient management practices exhibited significant effect on potassium uptake of grain and straw in rice. Significantly higher maximum potassium uptake in grain (22.71 & 24.68 kg/ha) and straw (120.94 & 124.14 kg/ha) was recorded with N<sub>6</sub> treatment over rest of the other treatment in 2019 except N<sub>3</sub> in *kharif* 20202 respectively. However, the treatments N<sub>5</sub>, N<sub>8</sub> and N<sub>2</sub> were recorded greater nitrogen uptake in grain and straw of rice which were statistically superior than remaining other nutrient management treatments during both the year of experimentation. Moreover, the treatments N<sub>7</sub>, N<sub>4</sub>, N<sub>9</sub> was observed similar trend of potassium uptake in grain and straw and were *at par* to each other respectively. Significantly lower nitrogen uptake in grain (7.71 & 8.59 kg/ha) and straw (51.97 & 56.14 kg/ha) of rice was recorded under control conditions (N<sub>1</sub>) among rest of the other treatment during both the year of study.

The uptake of nutrients like nitrogen, phosphorus and potassium by rice grain and straw were determined separately using their content in respective part and their production on hectare basis. Total uptake of NPK was worked out by summation of uptake NPK by grain and straw. Among crop management methods, higher

content of NPK in grain and straw and higher total uptake of NPK noticed under E<sub>2</sub> (CT-TPR) and the lowest total nitrogen, phosphorus and potassium uptake was noticed with E<sub>2</sub> (Wide bed-TPR). Nutrient management practices also significantly influenced on total uptake NPK. Higher content of NPK in grain and straw and higher total uptake of NPK recorded with application of N<sub>6</sub> (100% RDF + ZnSO<sub>4</sub> 25 kg ha<sup>-1</sup> + FYM (5 t ha<sup>-1</sup>) + PSB (5 kg ha<sup>-1</sup>) + Azotobactor 20 kg ha<sup>-1</sup>) respectively. This is attributed to the higher tillers number and dry matter production by younger seedlings ultimately resulting in higher straw and grain yield and nutrient removal. This result is in line with the findings of Tomar et al. [23] and Puli et al. [24].

## 3.3 Soil Nutrient Status

The data pertaining to soil nutrient status as influence by different Planting techniques and Nutrient management practices (Table 2).

### 3.3.1 Available nitrogen (kg ha<sup>-1</sup>)

The effect of Planting techniques on available nitrogen was found to be significant. Among them, conventional puddled transplanted rice (E<sub>1</sub>, CT-TPR) registered significantly higher nitrogen availability in soil (225.91 & 228.80 kg ha<sup>-1</sup>) compared to wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR) during both years of *kharif* 2019 & 2020 respectively. Significantly lower nitrogen availability in soil (219.18 & 221.86 kg ha<sup>-1</sup>) was observed with wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR) during the both year of experimental study.

Available nitrogen in soil was also significantly influence by nutrient management practices. Among the nutrient management practices, significantly higher available nitrogen in soil was recorded with N<sub>6</sub> (241.89 & 244.91 kg ha<sup>-1</sup>) treatment over rest of the other treatment and which was *at par* with N<sub>3</sub> treatment respectively. However, the treatments N<sub>5</sub>, N<sub>8</sub> and N<sub>2</sub> were recorded higher available nitrogen in soil and which were statistically superior than remaining other nutrient management treatments during both the year of experimentation. Moreover, the treatments N<sub>7</sub>, N<sub>4</sub>, N<sub>9</sub> was observed similar pace of available nitrogen in soil and were *at par* to each other respectively. The significantly lower available nitrogen in soil was observed with control treatment N<sub>1</sub> (195.56 & 197.90 kg ha<sup>-1</sup>) over rest of the other treatment during both the years of study.



**Table 1. Effect of different Planting techniques and nutrient sources on NPK uptake (kg ha<sup>-1</sup>) in grain and straw of rice**

Treatment	Nitrogen (N) uptake (kg ha <sup>-1</sup> )				Phosphorous (P) uptake (kg ha <sup>-1</sup> )				Potassium (K) uptake (kg ha <sup>-1</sup> )			
	Grain		Straw		Grain		Straw		Grain		Straw	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
<b>Planting techniques</b>												
E <sub>1</sub> : Conventional puddled transplanted rice (CT- TPR)	51.63	53.39	28.36	32.01	14.33	15.47	11.97	12.74	17.79	19.09	100.82	105.60
E <sub>2</sub> : Wide bed Transplanted rice (W Bed-TPR)	48.37	50.00	25.83	29.41	12.68	13.87	10.42	10.94	15.79	17.19	95.01	99.18
SEm±	<b>0.57</b>	<b>0.67</b>	<b>0.43</b>	<b>0.57</b>	<b>0.22</b>	<b>0.25</b>	<b>0.16</b>	<b>0.19</b>	<b>0.26</b>	<b>0.33</b>	<b>1.20</b>	<b>1.59</b>
CD (p=0.05)	<b>1.65</b>	<b>1.93</b>	<b>1.23</b>	<b>1.64</b>	<b>0.63</b>	<b>0.71</b>	<b>0.45</b>	<b>0.55</b>	<b>0.73</b>	<b>0.94</b>	<b>3.46</b>	<b>4.57</b>
<b>Nutrient sources</b>												
N <sub>1</sub> : Control (No N,P,K)	26.00	27.43	12.44	14.47	6.08	6.48	4.04	4.18	7.71	8.59	51.97	56.14
N <sub>2</sub> : 100% RDF + ZnSO <sub>4</sub> 25 kg ha <sup>-1</sup>	49.44	50.89	27.52	31.56	13.55	14.74	11.81	12.41	17.06	18.26	101.27	104.34
N <sub>3</sub> : 125% RDN + ZnSO <sub>4</sub> 25 kg ha <sup>-1</sup>	61.55	63.30	34.44	38.40	17.10	18.19	13.67	14.22	20.62	23.00	113.89	117.66
N <sub>4</sub> : STCR based NPK application + ZnSO <sub>4</sub> 25 kg ha <sup>-1</sup>	46.19	47.05	23.04	26.17	12.44	13.36	10.42	10.90	15.26	15.83	94.10	98.28
N <sub>5</sub> : N <sub>2</sub> + FYM (5 t ha <sup>-1</sup> )	56.38	58.36	32.51	35.29	15.29	16.96	12.89	13.85	19.23	21.31	109.55	113.96
N <sub>6</sub> : N <sub>2</sub> + FYM (5 t ha <sup>-1</sup> ) + PSB (5 kg ha <sup>-1</sup> ) + Azotobactor 20 kg ha <sup>-1</sup>	66.55	68.65	38.93	43.99	17.98	19.21	14.42	15.25	22.71	24.68	120.94	124.14
N <sub>7</sub> : 75% RDN + FYM (5 t ha <sup>-1</sup> ) + ZnSO <sub>4</sub> 25 kg ha <sup>-1</sup>	47.93	49.62	24.45	28.23	13.03	14.36	11.48	12.03	16.31	16.80	97.33	102.57

Treatment	Nitrogen (N) uptake (kg ha <sup>-1</sup> )				Phosphorous (P) uptake (kg ha <sup>-1</sup> )				Potassium (K) uptake (kg ha <sup>-1</sup> )			
	Grain		Straw		Grain		Straw		Grain		Straw	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
<b>N<sub>8</sub></b> : 75% RDN + FYM (5 t ha <sup>-1</sup> ) + PSB (5 kg ha <sup>-1</sup> ) + Azotobactor 20 kg ha <sup>-1</sup> + ZnSO <sub>4</sub> 25 kg ha <sup>-1</sup>	52.74	54.95	28.95	33.09	14.46	15.94	12.26	13.06	18.26	19.84	105.40	110.03
<b>N<sub>9</sub></b> : Organics Practices @ FYM (30 t ha <sup>-1</sup> )+PSB (5 kg ha <sup>-1</sup> ) + Azotobactor 20 kg ha <sup>-1</sup> + ZnSO <sub>4</sub> 25 kg ha <sup>-1</sup>	43.21	45.04	21.59	25.17	11.61	12.79	9.73	10.66	13.94	14.95	86.79	94.38
SEm±	<b>1.22</b>	<b>1.42</b>	<b>0.91</b>	<b>1.21</b>	<b>0.47</b>	<b>0.53</b>	<b>0.33</b>	<b>0.41</b>	<b>0.54</b>	<b>0.69</b>	<b>2.55</b>	<b>3.38</b>
CD (p =0.05)	<b>3.50</b>	<b>4.09</b>	<b>2.62</b>	<b>3.49</b>	<b>1.34</b>	<b>1.51</b>	<b>0.95</b>	<b>1.17</b>	<b>1.55</b>	<b>1.99</b>	<b>7.34</b>	<b>9.70</b>

\*RDF –recommended dose of fertilizer (150:60:40:: N:P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O kg ha<sup>-1</sup>); \*STCR- Soil test crop response; \*FYM –Farm yard manure; \*PSB– Phosphate solubilising bacteria.

**Table 2. Effect of different Planting techniques and nutrient management practices on soil health of rice**

Treatment	Available nutrients (kg ha <sup>-1</sup> )							
	Nitrogen (N)		Phosphorus (P <sub>2</sub> O <sub>5</sub> )		Potassium (K <sub>2</sub> O)		Organic carbon (%)	
	2019	2020	2019	2020	2019	2020	2019	2020
<b>Planting techniques</b>								
<b>E<sub>1</sub></b> : Conventional puddled transplanted rice (CT- TPR)	225.91	228.80	16.52	18.41	205.07	206.55	0.47	0.48
<b>E<sub>2</sub></b> : Wide bed Transplanted rice (W Bed-TPR)	219.18	221.86	15.06	16.31	200.66	202.97	0.46	0.47
SEm±	1.63	1.84	0.32	0.36	0.89	1.17	0.002	0.004
CD (p=0.05)	4.70	5.29	0.93	1.03	2.55	3.36	0.006	0.010
<b>Nutrient sources</b>								
<b>N<sub>1</sub></b> : Control (No N,P,K)	195.56	197.90	10.54	12.38	184.43	186.01	0.40	0.41
<b>N<sub>2</sub></b> : 100% RDF + ZnSO <sub>4</sub> 25 kg ha <sup>-1</sup>	225.19	227.79	16.76	18.30	203.67	204.98	0.48	0.48
<b>N<sub>3</sub></b> : 125% RDN + ZnSO <sub>4</sub> 25 kg ha <sup>-1</sup>	239.71	242.48	18.26	19.87	211.65	215.94	0.50	0.51
<b>N<sub>4</sub></b> : STCR based NPK application + ZnSO <sub>4</sub> 25 kg ha <sup>-1</sup>	214.75	217.48	14.39	15.97	199.08	200.95	0.44	0.45
<b>N<sub>5</sub></b> : N <sub>2</sub> + FYM (5 t ha <sup>-1</sup> )	225.58	233.25	17.21	19.10	207.38	206.88	0.49	0.50
<b>N<sub>6</sub></b> : N <sub>2</sub> + FYM (5 t ha <sup>-1</sup> ) + PSB (5 kg ha <sup>-1</sup> )+ Azotobactor 20 kg ha <sup>-1</sup>	241.89	244.91	18.73	20.32	216.42	219.42	0.51	0.52
<b>N<sub>7</sub></b> : 75% RDN + FYM (5 t ha <sup>-1</sup> ) + ZnSO <sub>4</sub> 25 kg ha <sup>-1</sup>	219.33	222.10	15.68	16.91	200.68	204.21	0.45	0.46
<b>N<sub>8</sub></b> : 75% RDN + FYM (5 t ha <sup>-1</sup> ) + PSB (5 kg ha <sup>-1</sup> ) + Azotobactor 20 kg ha <sup>-1</sup> + ZnSO <sub>4</sub> 25 kg ha <sup>-1</sup>	229.44	227.87	16.98	18.35	205.75	206.06	0.49	0.50
<b>N<sub>9</sub></b> : Organics Practices @ FYM (30 t ha <sup>-1</sup> )+PSB (5 kg ha <sup>-1</sup> ) + Azotobactor 20 kg ha <sup>-1</sup> + ZnSO <sub>4</sub> 25 kg ha <sup>-1</sup>	211.47	214.20	13.61	15.07	196.73	198.45	0.44	0.43
SEm±	3.47	3.90	0.69	0.76	1.88	2.48	0.005	0.007
CD (p =0.05)	9.97	11.22	1.98	2.18	5.40	7.12	0.014	0.022

\*RDF–recommended dose of fertilizer (150:60:40:: N:P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O kg ha<sup>-1</sup>); \*STCR- Soil test crop response; \*FYM –Farm yard manure; \*PSB– Phosphate solubilising bacteria.

### 3.3.2 Available phosphorous (kg ha<sup>-1</sup>)

The influence of Planting techniques on phosphorus availability in soil was revealed to be significant. Conventional puddled transplanted rice (E<sub>1</sub>, CT-TPR) had substantially higher phosphorus availability in soil (16.52 & 18.41 kg ha<sup>-1</sup>) than wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR). During both years of the experimental study, wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR) had significantly lower phosphorus availability in soil (15.6 & 16.31 kg ha<sup>-1</sup>) respectively.

Available phosphorus in soil was also significantly influence by nutrient management practices. Among the nutrient management practices, significantly higher available phosphorus in soil was recorded with N<sub>6</sub> (18.73 & 20.32 kg ha<sup>-1</sup>) treatment over rest of the other treatment and which was *at par* with N<sub>3</sub> and N<sub>5</sub> treatment respectively. However, the treatments N<sub>8</sub> and N<sub>2</sub> were recorded higher available phosphorus in soil and which were statistically superior than remaining other nutrient management treatments during both the year of experimentation. Moreover, the treatments N<sub>7</sub>, N<sub>4</sub>, N<sub>9</sub> was observed similar pace of available

phosphorus in soil and were *at par* to each other respectively. The significantly lower available phosphorus in soil was observed with control treatment N<sub>1</sub> (10.54 & 12.38 kg ha<sup>-1</sup>) over rest of the other treatment during both the years of study.

### 3.3.3 Available potassium (kg ha<sup>-1</sup>)

The available potassium in soil was found to be significant under different Planting techniques. Conventional puddled transplanted rice (E<sub>1</sub>, CT-TPR) had substantially higher potassium availability in soil (205.07 & 206.355 kg ha<sup>-1</sup>) than wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR). Wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR) had significantly lower potassium availability in soil (200.66 & 202.97 kg ha<sup>-1</sup>) during both years of study.

Available potassium in soil was also significantly influence by nutrient management practices. Among the nutrient management practices, significantly higher available potassium in soil was recorded with N<sub>6</sub> (216.42 & 219.42 kg ha<sup>-1</sup>) treatment over rest of the other treatment except N<sub>3</sub> treatment respectively. However, the treatments N<sub>5</sub>, N<sub>8</sub> and N<sub>2</sub> were recorded higher available potassium in soil and which were statistically superior than remaining other nutrient management treatments during both the year of experimentation. Moreover, the treatments N<sub>7</sub>, N<sub>4</sub>, N<sub>9</sub> was observed similar tune of available potassium in soil and were *at par* to each other respectively. The significantly lower available potassium in soil was observed with control treatment N<sub>1</sub> (184.43 & 186.01 kg ha<sup>-1</sup>) over rest of the other treatment during both the years of experimental study.

### 3.3.4 Organic carbon (%)

Effect of Planting techniques on organic carbon in soil was found significant. The highest organic carbon recorded in conventional puddled transplanted rice (E<sub>1</sub>, CT-TPR) (0.47 & 0.46 %) than wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR). The lowest organic carbon (0.48 & 0.47 %) was observed in wide bed transplanted rice (E<sub>2</sub>, W Bed-TPR) during both years of study.

The organic carbon in soil was also significantly influence by nutrient management practices. Among the nutrient management practices, significantly highest available potassium in soil was recorded with N<sub>6</sub> (0.51 & 0.52 %) treatment over rest of the other treatment except N<sub>3</sub> and N<sub>5</sub>

treatment respectively. However, the treatments N<sub>8</sub> and N<sub>2</sub> were recorded higher available organic carbon in soil and which were statistically superior than remaining other nutrient management treatments during both the year of experimentation. Moreover, the treatments N<sub>7</sub>, N<sub>4</sub>, N<sub>9</sub> was observed similar trend of available organic carbon in soil and were *at par* to each other respectively. The significantly lowest available organic carbon in soil was observed with control treatment N<sub>1</sub> (0.40 & 0.41 %) over rest of the other treatment during both the years of experimental study.

The maximum available soil nutrients (NPK) recorded in E<sub>1</sub> (CT-TPR) at harvest which was significantly higher than the minimum available nutrients (NPK) were recorded in E<sub>2</sub> (Wide bed-TPR) plot at harvest when applied organic and inorganic sources of nutrients continuously. Integration of organic sources with inorganic fertilizer were found more effective as compared to single application in building up fertility and improving physical status of soil. The higher availability of nutrient NPK in soil after harvest were recorded under all the INM modules as compared to inorganic fertilizer application. Organic carbon status in soil after harvest of crop was significantly influenced by different treatment however; maximum values observed in E<sub>1</sub> (CT-TPR) treatment. This might be due to use of conventional method is ascribed to greater and healthy root growth, increased availability and efficient absorption from the soil and transport of nutrient from roots to shoots and grains, which ultimately improved growth and yield. Among the nutrient management practices with application of N<sub>6</sub> (100% RDF + ZnSO<sub>4</sub> 25 kg ha<sup>-1</sup> + FYM (5 t ha<sup>-1</sup>) + PSB (5 kg ha<sup>-1</sup>) + Azotobactor 20 kg ha<sup>-1</sup>) treatment was resulted into more organic carbon status in soil due to FYM and biofertilizers adds organic carbon to soil. The buildup of neutral soil pH and EC were recorded under INM modules as compared to sole inorganic fertilizer treatment (N<sub>2</sub>) whereas, maximum reduction in pH was also observed with the application of N<sub>6</sub> (100% RDF + ZnSO<sub>4</sub> 25 kg ha<sup>-1</sup> + FYM (5 t ha<sup>-1</sup>) + PSB (5 kg ha<sup>-1</sup>) + Azotobactor 20 kg ha<sup>-1</sup>) respectively. Similar results were also reported by Bharose et al., [25] and Dubey et al. [26].

## 3.4 Soil Physical Properties

### 3.4.1 Bulk density (Mg m<sup>-3</sup>)

The effect of different treatments on bulk density (Mg m<sup>-3</sup>) are found to be significant (Table 3).

Table 3. Effect of different Planting techniques on physical properties of soil

Treatments	Bulk density ( $\text{Mg m}^{-3}$ )								EC ( $\text{dSm}^{-1}$ )		pH	
	2019				2020				2019	2020	2019	2020
	0-5 cm	5-10 cm	10-15cm	15-20 cm	0-5 cm	5-10 cm	10-15 cm	15-20 cm				
<b>E1: CT-TPR</b>	1.61	1.64	1.71	1.82	1.58	1.61	1.64	1.76	0.26	0.25	7.9	7.8
<b>E2: WB-TPR</b>	1.45	1.50	1.54	1.65	1.48	1.52	1.54	1.70	0.22	0.21	7.4	7.3
<b>SEm±</b>	0.02	0.02	0.01	0.02	0.02	0.02	0.03	0.02	0.004	0.003	0.029	0.021
<b>CD (P=0.05)</b>	0.07	0.05	0.03	0.06	0.05	0.06	0.08	0.06	0.010	0.008	0.084	0.061

In general, the upper 15 cm (0-5, 5-10 and 10-15 cm) layer contributed about 7.2, 7.6 and 8.8 per cent of total bulk density and the second 15-20 cm about 6.9 per cent  $E_1$  over  $E_2$  in the both year of experimentation, thus the maximum bulk density recorded from top 0-15 cm depth, whereas the contribution of bulk density to 15-20 cm soil layer was about 36.8 per cent. It was observed that  $E_1$  treatment recorded higher bulk density and more contribution was from top layer 0-15 cm and less from deeper layer 15-20 cm. Among tillage planting techniques, plots under conventional till puddled plot  $E_1$  had about 10.4 and 5.60 % higher soil bulk density ( $M\text{ gm}^{-3}$ ) than  $E_2$  plots (Table 3). Unlike land configuration, tillage had greater impacts on soil bulk density. The bulk density did varied significantly due to planting techniques and it was significantly reduced under raised wide beds planting techniques ( $E_2$ ) compared to conventional tillage puddled transplanting ( $E_1$ ). Treatment ( $E_2$ ) transplanted rice on wide raised beds recorded lower bulk density under different soil layers as compared to  $E_1$  conventional till transplanted rice treatment during the years of experimental study.

### 3.4.2 Soil electric conductivity (EC)

After wheat harvest the data in respect to electric conductivity is given in (Table 3). Effect of planting techniques on electric conductivity ( $\text{dSm}^{-1}$ ) was found significant among treatments. The electric conductivity was recorded maximum 0.26 and 0.25  $\text{dSm}^{-1}$  under conventional till puddled transplanting technique (T1) treatment and minimum values 0.22 and 0.21  $\text{dSm}^{-1}$  also obtained under wide beds transplanting technique (T2) during 2019 and 2020, respectively.

### 3.4.3 Soil pH

Effect of planting techniques on soil pH was found significant. The results revealed that pH was registered lowest values (7.4 and 7.3) under transplanted rice on wide beds (T2) land configuration treatments and highest (7.9 and 7.8) under conventional till puddled transplanting technique (T1) treatment during both the years of experimental study.

Increases in the bulk density usually result in large decreases in water flow through the soil and conservation tillage practices i.e. furrow irrigated raised bed (FIRB) and conventional transplanted rice would reduce evapotranspiration and increase infiltration rate. The

adoption of wide bed transplanted rice resulted in the greatest increase in neutral soil pH and EC when compared to conventional till puddled transplanting technique. Similar result have been reported by Gangwar and Singh [27] and Naresh et al. [28].

## 4. CONCLUSION

It can be concluded that among the different Planting techniques, conventional puddled transplanted rice ( $E_1$ , CT-TPR) was recorded significantly higher yield, NPK content and uptake and also improved soil health status i.e., available NPK, organic carbon and other physical properties i.e, Bulk density, EC, pH in soil than wide bed transplanted rice ( $E_2$ , W Bed-TPR) during both years of *kharif* 2019 & 2020 respectively. Among the nutrient management practices, significantly higher yield, NPK content and uptake and also improved soil health status i.e., available NPK, organic carbon in soil was recorded with  $N_6$  (100% RDF +  $\text{ZnSO}_4$  25  $\text{kg ha}^{-1}$  + FYM (5 t  $\text{ha}^{-1}$ ) + PSB (5  $\text{kg ha}^{-1}$ ) + Azotobactor 20  $\text{kg ha}^{-1}$ ) treatment over rest of the other treatment and which was at par with  $N_3$  treatment and lowest was observed in control treatment respectively. Thus, the results suggest that inclusion of inorganic fertilizer along with organic manure (FYM) enhance the productivity of rice. Therefore, application of conventional puddled transplanted rice ( $E_2$ , CT-TPR) along with  $N_6$  (100% RDF +  $\text{ZnSO}_4$  25  $\text{kg ha}^{-1}$  + FYM (5 t  $\text{ha}^{-1}$ ) + PSB (5  $\text{kg ha}^{-1}$ ) + Azotobactor 20  $\text{kg ha}^{-1}$ ) found beneficial to increase yield, NPK content and uptake and also improved soil health of rice crop compared to other establishment methods and nutrient management practices.

## ACKNOWLEDGEMENT

I am grateful to the department of agronomy and authorities of the Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, U.P., India for all support in execution of this experiment. I respect and thank Dr. RK. Naresh sir, for providing me immensely support and guidance. I also acknowledge the technical support and facilities provided from staff. Moreover, I would like to express our great respect for the editors and anonymous reviewers to improve the manuscript quality.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

- Chandra MS, Kumar KA. Impact of Water Management on Rice Varieties (*Oryza sativa* L.), Yield and Water Use Efficiency under Alternate Wetting and Drying Method in Puddled Soil. *Chemical Science Review and Letters*. 2020;9(33): 192-199.
- Anonymous. Agriculture statistics at a glance. Directorate of Economics and Statistics Department of Agriculture and cooperation Ministry of agriculture Govt. of India New Delhi; 2019.
- Shahane AA, Shivay YS, Prasanna R, Kumar D. Nutrient removal by rice–wheat cropping system as influenced by crop establishment techniques and fertilization options in conjunction with microbial inoculation. *Scientific Reports, Nature Research*. 2020;10:21944.
- Nahar L, Sarker ABS, Mahbub MM, Akter R. Effect of crop establishment method and nutrient management on yield and yield attributes of short duration T. Aman rice. *Bangladesh Agron. J*. 2017;21(1): 117-123.
- Chauhan BS, Mahajan G, Sardana V, Timsina J, Jat ML. Productivity and sustainability of the rice-wheat cropping system in the Indo-Gangetic Plains of the Indian subcontinent: problems opportunities, and strategies. *Adv. Agron*. 2012;117:315–369.
- Naresh RK, Prem Singh, Purushottam, Shahi UP, Singh SP, Gupta Raj K. Management of crop residues in rice–wheat cropping system on crop productivity and soil properties through conservation effective tillage in north western India. *Journal of Farming Systems Research Develop*. 2015;21(1):27-38.
- Mahmud AK, Shamsuddoha ATM, Haque MN. Effect of Organic and Inorganic Fertilizer on the Growth and Yield of Rice (*Oryza sativa* L.) *Nature and Science*. 2016;14(2).
- Mohammad SI. Effect of integrated nutrient management on yield and nutrient use efficiency of rice-rice based cropping system. Ph.D. Thesis. Bangabandhu Sheikh Muzibur Agricultural University, Salna, Gazipur; 2010.
- Anamul Haque MD, Moynul Haque M. Growth, yield and nitrogen use Efficiency of new rice variety under variable nitrogen rates. *American Journal of Plant Sciences*. 2016;7(3):612–22.
- Kumar RM, Surekha K, Padmavathi C, Subbarao LV, Latha PC, Prasad MS, Ravindrababu V, Ramprasad AS, Rupela OP, Goud V, Muthuraman P, Somashekhar N, Ravichandran SM, Singh SP and Viraktamath BC. Research experiences on system of rice intensification and future directions. *Journal of Rice Research*. 2009;2(2):61-71.
- Mitter EK, Tosi M, Obregón D, Dunfield KE, Germida JJ. Rethinking Crop Nutrition in Times of Modern Microbiology: Innovative Biofertilizer Technologies. *Front. Sustain. Food Syst*. 2021;5:606815. DOI: 10.3389/fsufs.2021.606815
- Sharma A, Singh SV, Patel A, Yadav RA. Growth and yield of scented rice (*Oryza sativa* L.) as influenced by integrated nutrient management practices. *Res.on Crops*. 2017;18(3):409-414.
- Argal MS. Effect of organic and inorganic sources of plant nutrients on wheat production and soil health in Chambal Ravine. Ph.D. Thesis submitted to the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Collage of Agriculture, Gwalior (M.P.); 2017.
- Gomez KA, Gomez AA. Statistical procedure for agriculture research 2<sup>nd</sup> edition Jon Wielly and Sons, New York; 1984.
- Jackson ML. Soil chemical analysis. Prentice Hall India Pvt. Ltd. New Delhi. 1973;232-235.
- Richards LA. Diagnosis and improvement of saline and alkali soil. United States Department of Agronomy, Hand Book No. 60 Oxford and IBH Publishing Company, New York; 1968.
- Blake GR, Hartge KH. Bulk density. In A. Klute (ed.) *Methods of soil analysis*. Part 1. (2nd ed.). Agron. Monogr. 9. ASA and SSSA, Madison, WI. 1986;363-375.
- Walkley A, Black CA. An examination of digestion method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*. 1934;37:29-38.
- Olsen SR, Cole CV, Watanable FS, Dean LA. Estimation of available phosphorus in soil by extraction with sodium bicarbonate, USDA, Circ. 1954;939.
- Gautam O, Sharma GD, Rana R, Lal B. Performance of hybrid rice INM in SRI

- under mid-hill condition of HP. Journal. Agriculture Sci. Cambridg. 2012;32(2):52-53.
21. Singh G, Walia SS. Influence of FYM, brown manuring and levels of nitrogen on yield and soil properties of direct seeded and transplanted rice. Geobios. 2010;37: 210-16.
  22. Kumar V, Naresh RK, Tomar VK, Kumar R, Vivek, Kumar R, Yadav RB, Mahajan NC, Singh A, Singh SP, Chandra S, Yadav OS. Growth, Yield and Water Productivity of Scented Rice (*Oryza sativa* L.) as Influenced by Planting Techniques and Integrated Nutrient Management Practice. International Journal of Current Microbiology and Applied Sciences. 2019; 8(06):2319-7706.
  23. Tomar R, Singh NB, Singh V, Kumar D. Effect of planting methods and integrated nutrient management on growth parameters, yield and economics of rice, Journal of Pharmacognosy and Phytochemistry. 2018;7(2):520-527.
  24. Puli MR, Prasad PRK, Jayalakshmi M, Rao BS. Effect of Organic and Inorganic Sources of Nutrients on NPK Uptake by Rice Crop at Various Growth Periods. Research Journal of Agricultural Sciences. 2017;8(1):64-69.
  25. Bharose M, Gohain T, Apon R, Banik M, Kumar D. Effect of integrated Nutrient Management on rice (*Oryza sativa* L.) Productivity and sustainability. Journal of Pharmacognosy and Phytochemistry. 2017;1:278-280.
  26. Dubey R, Sharma RS, Dubey DP. Effect of organic, inorganic and integrated nutrient management on crop productivity, water productivity and soil properties under various rice-based cropping systems in Madhya Pradesh, India. Int. J. Curr. Microbiol. App. Sci. 2014;3(2):381-389.
  27. Gangwar KS, Singh HR. Effect of rice crop establishment technique on succeeding crops. Indian Journal of Agricultural Science. 2010;80(1):24-28.
  28. Naresh RK, Tomar SS, Samsher P, Singh SP, Kumar D, Dwivedi A, Kumar V. Experiences with rice grown on permanent raised beds: effect of water regime and planting techniques on rice yield, water use, soil properties and water productivity. Rice Science. 2014;21(3): 170–180.

© 2021 Chandra et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*

*The peer review history for this paper can be accessed here:*  
<https://www.sdiarticle4.com/review-history/76122>