Effect of planting techniques and nitrogen scheduling on productivity and profitability of Basmati rice (*Oryza sativa* L.).

ABSTRACT

Aim: The study was carried out to see the effect of planting techniques and nitrogen scheduling on scented wet rice, water productivity and soil health in Inceptisol during *kharif* season of 2019 and 2020 at. Crop Research Center of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.), India,

Study design: Experiment was laid out in split plot design (SPD) with >> replication using crop planting techniques and nitrogen scheduling as main plots and as sub plots factor.

Place and duration of study: The present investigation was conducted during the *kharif* season of 2019 and 2020 at the Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.), India.

Methodology: The main factors consist of four planting techniques *viz.*(1) Furrow Irrigated Raised Bed System (FIRBs), (2) Reduced Tillage Transplanted Rice (RT-TPR)de, (3) Unpuddled Transplanted Rice (UTR) and (4) Conventional Transplanted Rice (CTR), the sub factors consist of six nitrogen scheduling variables *viz.,*(1) Control, (2) 100% RDN (50% B + 25% AT + 25% PI), (3) 100% RDN (40% B + 35% AT + 25% PI), (4) 120% RDN (50% B + 25% AT + 25% PI), (5) 120% RDN (40% B + 35% AT + 25% PI) and (6) Real Time N Management through LCC. Observations on crop yield and attributing parameters were recorded at the harvest of crop. Crop was harvested manually at full physiological maturity. The data on grain yield of each plot were recorded separately by threshing the harvested basmati rice plants on tarpaulin followed by proper drying and winnowing. The grain yield was measured in kilogram with help of weighing balance. The straw yield was obtained by subtract grain yield from the total biomass yield, recorded plot wise after sun drying and computed to q ha^{-1}.

Results: Highest yield recorded under conventional transplanting which was statistically at par with FIRBs and significantly higher than UTR and RT-TPR. Among the nitrogen scheduling practices the highest yield and NPK uptake was obtained with Real Time N Management through LCC which was statistically at par with 120% RDN (50% B + 25% AT + 25% PI) and 100% RDN (50% B + 25% AT + 25% PI), lowest yield and nutrient uptake was obtained in control treatment during both the years of study. Highest net return and B: C ratio was recorded under furrow irrigated raised beds transplanted rice.

Conclusion: Basmati rice gave the higher yield under CTR and net return was associated with FIRBs. Therefore, it may be concluded that transplanting of rice on FIRBs with real time nitrogen management through LCC might be a better option to get higher productivity and profitability of basmati rice.

Key words: *Basmati*, Planting techniques, Real time N management, Productivity, Profitability, significantly

1. INTRODUCTION

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Rice (*Oryza sativa*) is the second-most **important** cereal crop after maize in the **world**. It is a crop that ensures food security in many of the developing countries for East Asia and Southeast Asia regions. Therefore, **rice** being the most consumed cereal grain globally, the growth of the **rice** market is expected to increase. About 40% of the world population consumes rice as the major staple food (Dunna and Roy, 2013).

Rice is the major staple food crop of the world and the cultivation of rice is important for food security of Asia, where more than 90% of the global rice is produced and consumed. It is occupying by 162.97 m ha of area, producing 495.03 million tonnes of rice with an average productivity of 3.04 t/ha in the world. India is the second largest producer and consumer of rice in the world after china. In India, the area, production and productivity of rice is 43.79 m ha, 116.42 mt and 2.65 t/ha, respectively. However, Uttar Pradesh is the largest rice growing state after West Bengal but its productivity is low. Rice occupies an area of 5.75 m ha, produces 15.54 mt rice with an average productivity of 2.70 t/ha in UP, (Anonymous, 2019). Rice provides 32-59% of the dietary energy and 25-44% of the dietary protein in 39 countries. In India, it accounts more than 40% of food grain production, providing direct employment to 70% people in rural areas. Being the staple food for more than 65% of the people, our national food security hinges on the growth and stability of rice production.

Traditionally rice is grown as transplanted crop under puddled soil. Puddling is an essential operation for transplanted rice, to minimize water percolation losses and weed management . Conservation agriculture has come up as a new paradigm to achieve goal of sustained agricultural production. It is major step toward transition to sustainable agriculture. At present, growth in agricultural area is slowing and is not expected to play a major role in future production growth in South Asia. Productivity increases will thus comprise the main source of additional grain to meet rising demand, barring large increases in food imports. But some long-term experiments show stagnation and even decline in yield of the rice in South Asia (Naresh *et al.,* 2010). Total factor productivity is declining and farmers have to apply more fertilizer to obtain the same yields. Soil organic matter is declining but new weeds, pest and diseases are creating more problems and irrigation water is less available.

Natural resource conservation is a step towards successful crop production. Hence, adoption of resource conserving technologies is essentially needed to revert the damage made to the natural resources. Resource conservation technologies include *i.e.,* reduced tillage, FIRB, soil water management practices that are cost effective and environment friendly. Resource conservation technologies improve input use efficiency at low cost and preserve ecological integrity of crop production system (Abrol and Sangar, 2006).

Rice plant require sufficient nitrogen at early and mid-tillering stage to achieve an adequate yield attributes viz. number of panicles, number of grains per panicle. There is need to measure nitrogen requirement of crop at different critical stages of growth. Real time corrective nitrogen management is based on periodic assessment of plant nitrogen status and the appearance of nitrogen deficiency symptoms especially on leaves. Thus, the key ingredient for real time nitrogen management is a method of rapid assessment of leaf nitrogen content that is closely related to the photosynthetic rate and biomass production and is a sensitive indicator of changes in crop nitrogen demand within a growing season. Recently, it has become possible to quickly and non-destructively quantify spectral characteristics of leaves, which can be used to diagnose

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plant nitrogen deficiency and in-directly, to correct nitrogen fertilization and improve nitrogen-use efficiency in rice crop. Thus, Leaf colour chart (LCC) has been found an effective, inexpensive and easy to use tool for monitoring the greenness of plant and providing a quick estimate of leaf nitrogen status and highly useful to synchronize fertilizer N application with crop demand (Nainwal *et al*., 2013). Keeping in view an experiment was conducted to study the effect of planting techniques and nitrogen scheduling on productivity and profitability of rice.

2. METHODS AND MATERIALS

The field experiment was conducted at Crop Research Center of Sardar Vallabhbhai Patel University of Agriculture &Technology, Meerut (U.P.), to study the effect of planting techniques and nitrogen scheduling on productivity of Basmati rice (*Oryza sativa* L.) during the *kharif* season of 2019 and 2020. The climate of this region is characterized as semi-arid and sub-tropical. The summer is very hot and dry while winters are too cold. Moderate rainfall and wide temperature variation is the characteristic features of the semi-arid and sub-tropical climate. Generally, South-West monsoon sets in IIIrd or IVth week of June, reaches its peaks in July to August, and continues up to September, cyclonic weather leads to few winter rains. The area receives mean annual rainfall of 845 mm, of which 80-90 per cent is received from June to September. Winter season extends from November to February, whereas frost occurs generally in the end of December and may continue up to the end of January. The mean minimum temperature reaches as low as 3°C in winters, while during summer the mean maximum temperature varies from 43-45°C in the month of May.

The soil of the experimental field was sandy loam in texture and slightly alkaline in reaction. The soil was medium in available phosphorus and potassium but low in organic carbon and available nitrogen. The experiment was laid out in split plot design with four main factors *viz.*(1) Furrow Irrigated Raised Bed System (FIRBs) (2) Reduced Tillage Transplanted Rice (RT-TPR) (3) Unpuddled Transplanted Rice (UTR) and (4) Conventional Transplanted Rice (CTR)and six sub factors *viz.,*(1) Control (2) 100% RDN (50% B + 25% AT + 25% PI), (3) 100% RDN (40% B + 35% AT + 25% PI), (4) 120% RDN (50% B + 25% AT + 25% PI), (5) 120% RDN (40% B + 35% AT + 25% PI) and (6) Real Time N Management through LCC. The experiment was replicated thrice with three replications. Harvesting of crop was done manually when the crop reached at full physiological maturity. First of all, the border rows were harvested and separated. Later, the crop from net plot area was harvested and sun dried. The harvested material from each plot was carefully bundled, tagged and brought to threshing floor. Threshing was done plot wise and grains were, dried, cleaned and weighed separately for each net plot and computed to q ha^{-1} at 14% moisture level. The straw yield was obtained by subtract the grain yield from total biomass yield, also recorded plot wise after sun drying and computed to q ha^{-1}.The data collected from the experiment was subjected to statistical analysis with the procedure of Split Plot Design as suggested by Cochran and Cox [6]. The standard error of mean was calculated and critical difference (C.D. at 5%) was worked out for comparing the treatment means, wherever "f" test was found significant.

3. RESULT AND DISCUSSION

3.1Yield of rice

Grain yield (q ha^{-1})

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The yield was the ultimate result of final assessment of treatment in any agronomic investigation. Grain yield was significantly influenced by planting techniques. The effect of different planting techniques on grain yield was significant. The highest grain yield (44.52 and 45.95 q ha^{-1}) was obtained recorded under conventional transplanted rice (P_4) which was significantly higher than the reduced tillage transplanted rice (P_2) (37.80 and 39.32 q ha^{-1}) and at par with furrow irrigated raised bed method (P_1) (42.43 and 43.13 q ha^{-1}) in the year 2019 and 2020, respectively. Grain yield was also significantly influenced by nitrogen scheduling. The highest grain yield (48.02 and 50.14 q ha^{-1}) was obtained with N_6 (Real Time N Management through LCC) which was statistically at par with N_4 (120% RDN (50% B + 25% AT + 25% PI) followed by N_5 **(**120% RDN (40% B + 35% AT + 25% PI) and N_3 (100% RDN (40% B + 35% AT + 25% PI) in the year 2019 and 2020, respectively.

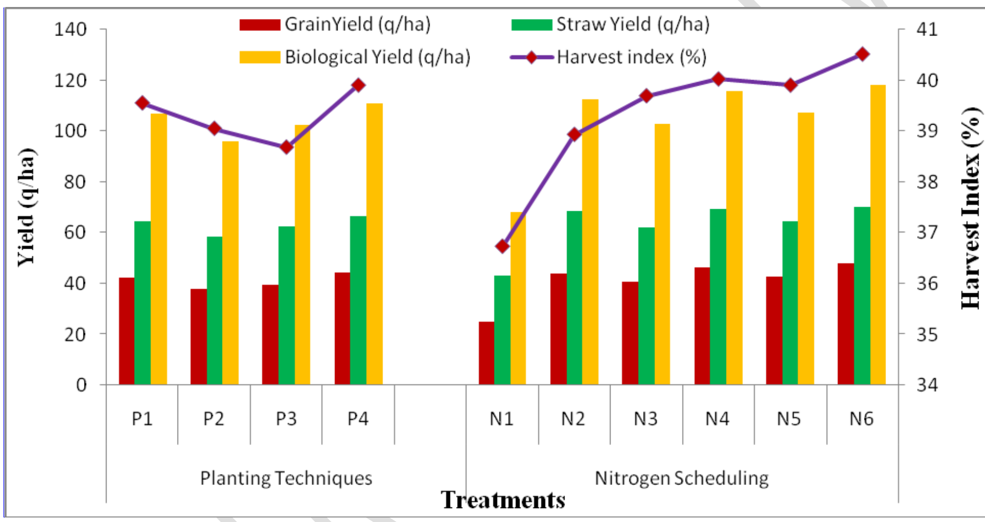

Fig. 1a: Effect planting techniques and nitrogen scheduling on yield and harvest index of Basmati rice (2019)

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Comment [a67]: Please planting techniques and nitrogen scheduling using statistics split plot technique. After pooling data of both years

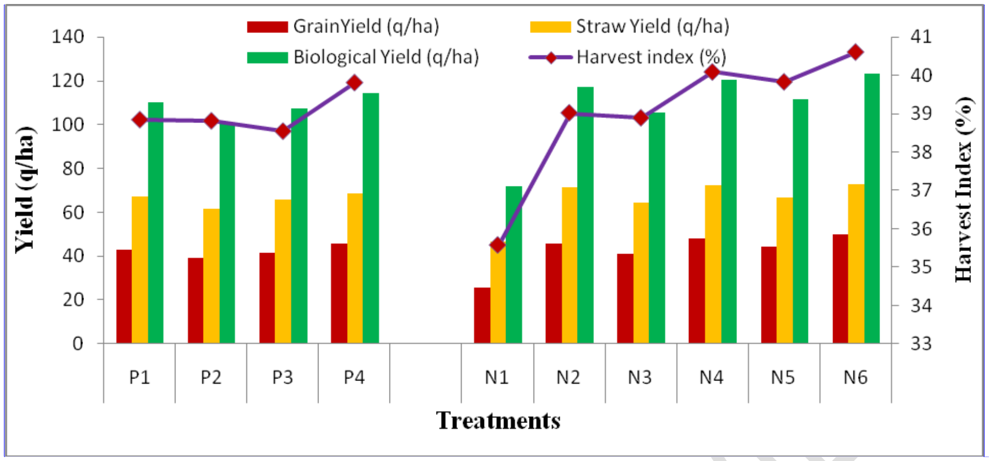

Fig. 1b: Effect planting techniques and nitrogen scheduling on yield and harvest index of Basmati rice (2020)

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Straw yield (q ha^{-1})

Straw yield was significantly influenced by planting techniques. The effect of different planting techniques on straw yield was significant. The highest straw yield (66.43 and 68.47 q ha^{-1}) recorded under conventional transplanted rice (P$_4$) which was significantly higher than the reduced tillage transplanted rice (P$_2$) (58.36 and 61.46 q ha^{-1}) and at par with furrow irrigated raised bed method (P$_1$) (64.59 and 67.21 q ha^{-1}) in the year 2019 and 2020, respectively. Straw yield was also significantly influenced by nitrogen scheduling. The highest straw yield (70.27 and 73.01 q ha^{-1}) was obtained withN$_6$(Real Time N Management through LCC) which was statistically at par withN$_4$ (120% RDN (50% B + 25% AT + 25% PI) (69.46 and 72.18q ha^{-1}) followed by N$_5$ **(**120% RDN (40% B + 35% AT + 25% PI) and N$_3$(100% RDN (40% B + 35% AT + 25% PI) in the year 2019 and 2020, respectively.

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Biological Yield (q ha^{-1})

Biological yield was significantly influenced by planting techniques. The effect of different planting techniques on biological yield was significant. The highest biological yield (110.96 and 114.42 q ha^{-1}) recorded under conventional transplanted rice (P$_4$) which was significantly higher than the reduced tillage transplanted rice (96.16 and 100.78 q ha^{-1}) and at par with furrow irrigated raised bed method (P$_1$) (107.02 and 110.34 q ha^{-1}) in the year 2019 and 2020, respectively. Biological yield was also significantly influenced by nitrogen scheduling treatments. The highest biological yield (118.29 and 123.15 q ha^{-1}) was obtained with N$_6$ (Real Time N Management through LCC) which was statistically at par with N$_4$ (120% RDN (50% B + 25% AT + 25% PI) (115.78 and 121.04q ha^{-1}) followed by N$_5$ **(**120% RDN (40% B + 35% AT + 25% PI) and N$_3$ (100% RDN (40% B + 35% AT + 25% PI) in the year 2019 and 2020, respectively.

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Harvest index (%) (HI) (R**atio of harvested grain to total shoot dry matter**, and this can be used as a measure of reproductive efficiency.)

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Harvest index was non significantly influenced by planting techniques. The highest harvest index (39.90 and 39.82 %) recorded under conventional transplanted rice (P_4) which was significantly higher than the unpuddled transplanted rice (P_3) (38.68 and 38.55 %) and at par with furrow irrigated raised bed method (P_1) (39.55 and 38.85 %) in the year 2019 and 2020, respectively. Harvest index was also significantly influenced by nitrogen scheduling treatments. The highest harvest index (40.51 and 40.62 %) was obtained with N_6 (Real Time N Management through LCC) which was statistically at par with N_4 (120% RDN (50% B + 25% AT + 25% PI) (40.02 and 40.10 %) followed by N_2 (100% RDN (50% B + 25% AT + 25% PI), N_5 **(**120% RDN (40% B + 35% AT + 25% PI) and N_3 (100% RDN (40% B + 35% AT + 25% PI) in the year 2019 and 2020, respectively.

The significantly higher grain (48.02 and 49.10 %), straw (38.67 and 36.39 %) and biological yield (42.49 and 41.56 %) in treatment N_6 (Real Time N Management through LCC) over control (N_1) was because of more efficient use of nutrients for their growth and development of better yield attributes and yield. The poor nutrition in control affected the grain yield more than biological yield which ultimately resulted in significant reduction in harvest index. Similar trend has been observed by Gautam *et al.* (2008); Singh and Walia (2010); Naresh *et al*. 2014 and Kumar *et al*. 2015.

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3.2 Nutrient uptake by rice

Nitrogen uptake (kg ha^{-1})

The Data revealed that, in general the nitrogen uptake was higher by rice grains than straw. The nitrogen uptake by rice grain and straw was significantly influenced with planting techniques during both the years of experimentation. The highest uptake of nitrogen (57.04 and 60.30 kg ha^{-1}) by rice grain, (29.83 and 31.27 kg ha^{-1}) by rice straw and total uptake was recorded under conventional transplanted rice (P_4) followed by rest of the treatments. However, the lowest nitrogen uptake by grain and straw (47.22, 50.84 and 24.67, 26.55 kg ha^{-1}) was found under P_2(reduced tillage transplanted rice) during 2019 and 2020, respectively.

The nitrogen scheduling treatments had significant effect on nitrogen uptake (by grains, straw and total) during both the years. The highest nitrogen uptake (65.25 and 68.87 kg ha^{-1}) by grain, (34.31 and 36.18 kg ha^{-1}) by straw and total uptake was recorded with N_6 (Real Time N Management through LCC) followed by N_4, N_2, N_5 and N_3. However, the lowest nitrogen uptake (28.97, 30.62 and 15.74, 17.65 kg ha^{-1}) in grain and straw was found under N_1 (control) during 2019 and 2020, respectively.

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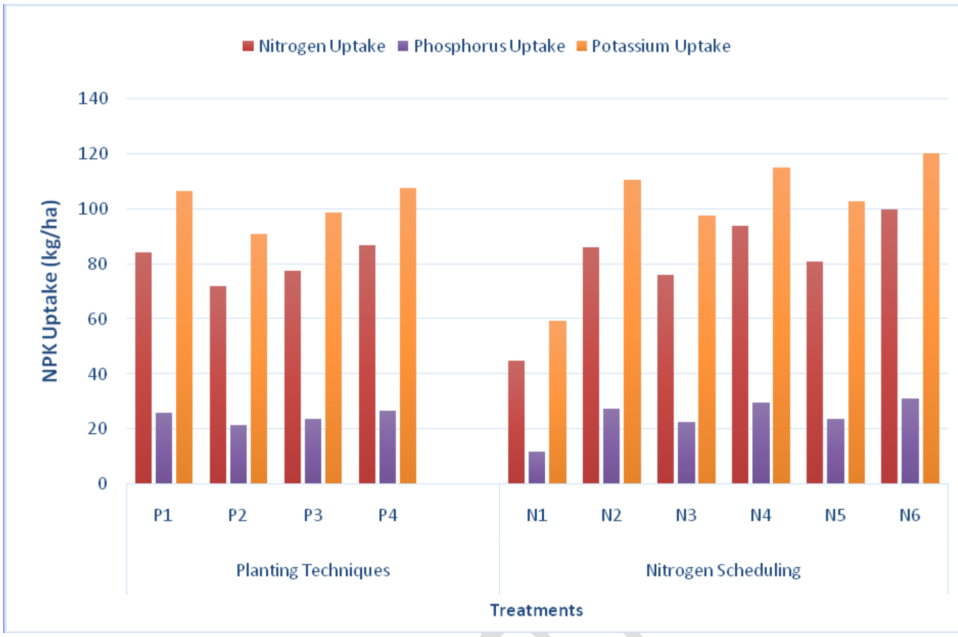

Fig. 2a: Effect of planting techniques and nitrogen scheduling on NPK uptake (kg ha^{-1}) of Basmati rice (2019)

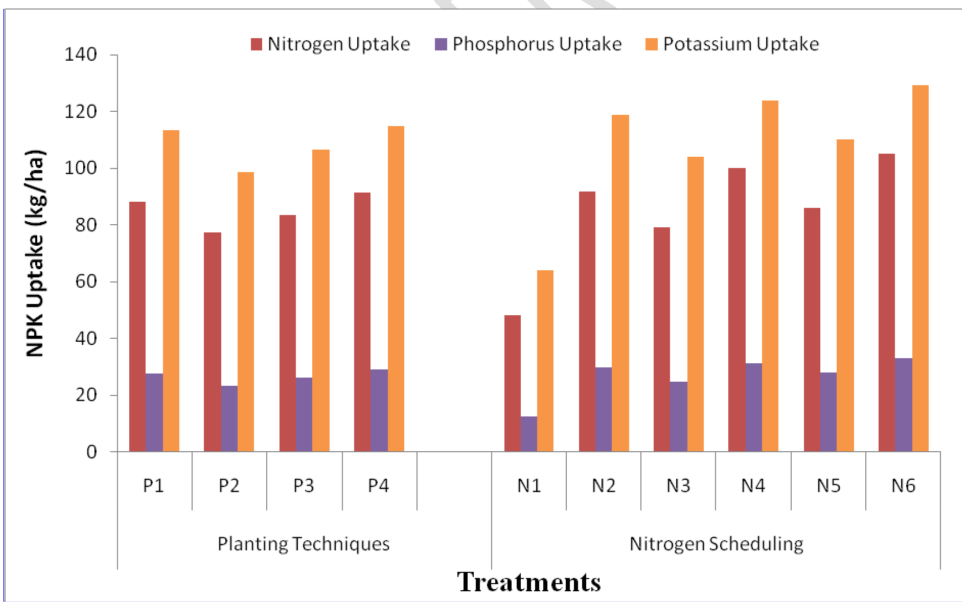

Fig. 2b: Effect of planting techniques and nitrogen scheduling on NPK uptake (kg ha^{-1}) of Basmati rice (2020)

Phosphorus uptake (kg ha^{-1})

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Comment [a84]: pooled the data of both years (2019 and 2020) and make analysis with split plot technique (ANOVA) conclude best combination

The phosphorus uptake in rice grain, straw and total was significantly influenced by different planting techniques during both the year of experimentation. The maximum uptake of phosphorus (15.32 and 16.61 kg ha^{-1}) in rice grain, (11.25 and 12.41 kg ha^{-1}) in rice straw and total uptake (26.57 and 29.02 kg ha^{-1}) was recorded under conventional transplanted rice (P_4). However, the lowest phosphorus uptake in grain and straw (12.30, 13.41 and 9.22, 10.02 kg ha^{-1}) was found under P_2(reduced tillage transplanted rice) during 2019 and 2020, respectively.

The nitrogen scheduling treatments also had significant effect on phosphorus uptake (in grains, straw and total) during both the years. The maximum phosphorus uptake (17.20 and 18.93 kg ha^{-1}) in grain, (13.95 and 14.07 kg ha^{-1}) in straw and total uptake were recorded with N_6 (Real Time N Management through LCC) followed by N_4, N_2, N_5 and N_3. However, the lowest phosphorus uptake (6.98, 7.44 and 4.73, 5.24 kg ha^{-1}) was found under N_1 (control) treatment during 2019 and 2020, respectively.

Potassium uptake (kg ha^{-1})

The Data revealed that, the potassium uptake in rice grain, straw and total was significantly influenced by different planting techniques during both the years of experimentation. The maximum uptake of potassium (20.46 and 22.65 kg ha^{-1}) in rice grain, (87.00 and 92.02 kg ha^{-1}) in rice straw and total uptake (107.46 and 114.67 kg ha^{-1}) were recorded under conventional transplanted rice (P_4). However, the lowest potassium uptake in grain and straw (16.54, 18.76 and 74.14, 80.00 kg ha^{-1}) was found under P_2(reduced tillage transplanted rice) during 2019 and 2020, respectively.

The nitrogen scheduling treatments also had significant effect on potassium uptake (in grains, straw and total) during both the years. The maximum potassium uptake (23.95 and 27.03 kg ha^{-1}) in grain, (96.07 and 102.14 kg ha^{-1}) in straw and total uptake were recorded with N_6 (Real Time N Management through LCC) followed by N_4, N_2, N_5 and N_3. However, the lowest potassium uptake of 8.62, 9.06 and 50.61, 54.88 kg ha^{-1} was found under N_1 (control) treatment during 2019 and 2020, respectively.

The higher N and P uptake in grain because of its chemical composition due to higher amino acid and protein content in grain require more N and P, whereas, higher K content in straw is because of its higher content is required for providing strength to stem by forming cellulose, lignin and pectin. The higher NPK uptake was mainly because of higher grain and straw yield in concerned treatments. Similar trend has been observed by Mahajan *et al.* (2011); Wang *et al.* (2011) and Bhuyan *et al.* (2012). The higher uptake of NPK in grain was because of more availability of these nutrients, which encouraged the crop growth and finally higher grain and biomass yield. Similar result has been reported by Sharma *et al.* (2007); Raj *et al*. (2014); Liu *et al.* (2016) and Yousaf *et al.* (2016).

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3.3 Profitability of rice

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Gross return (Rs. ha^{-1})

In term of gross return, among the different planting techniques, the highest gross return (93658 and 98705 Rs. ha^{-1}) was observed in conventional transplanted rice (P_4) followed by furrow irrigated raised beds (P_1) and unpuddled transplanted rice (P_3). The lowest gross return was found in reduced tillage transplanted rice (P_2) during both the year. Among nitrogen scheduling treatments, the highest gross return (100763 and 107404 Rs ha^{-1}) was observed in N_6 (gross return) followed by N_4 (120% RDN (50% B + 25% AT + 25% PI), N_2 (100% RDN (50% B + 25% AT + 25% PI), N_5 (120% RDN (40% B + 35% AT + 25% PI) and N_3 (100% RDN (40% B + 35% AT + 25% PI) and the lowest gross return (53494 and 56339 Rs ha^{-1}) was obtained with N_1 (control) in the year 2019 and 2020, respectively.

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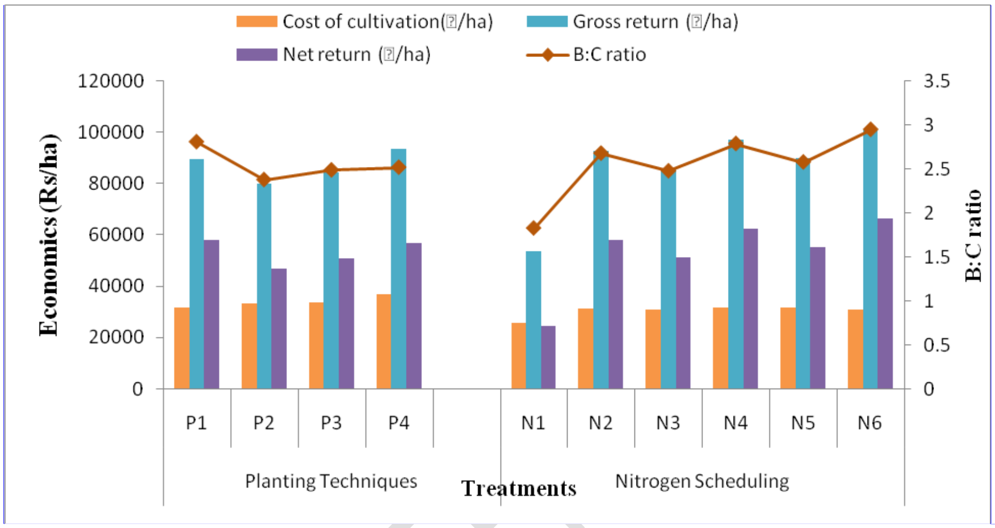

Fig. 3a: Economics of rice as influenced by different planting techniques and nitrogen scheduling (2019)

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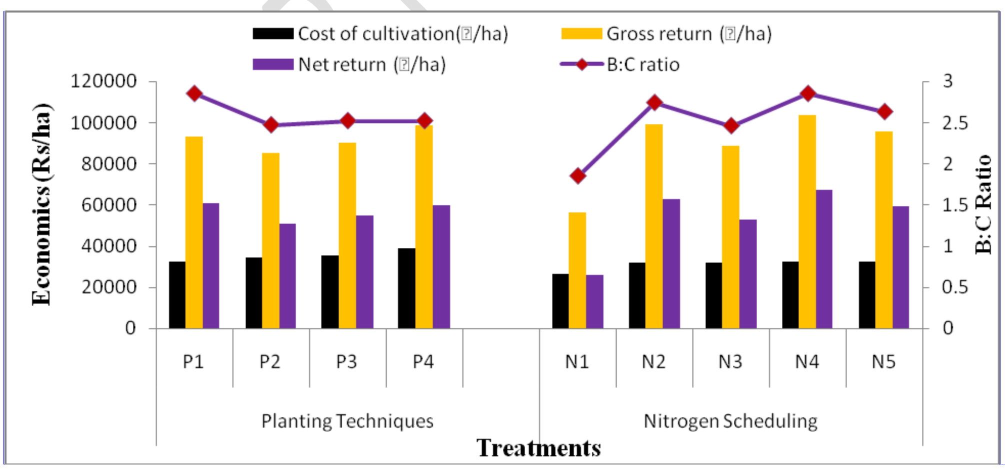

Fig. 3b: Economics of rice as influenced by different planting techniques and nitrogen scheduling (2020)

Net return (Rs. ha^{-1})

Among the different planting techniques, the net return was highest in furrow irrigated raised beds (P_1) followed by conventional transplanted rice (P_4) and unpuddled transplanted rice (P_3). The lowest net return was found in reduced tillage transplanted rice (P_2) during both the year. Among nitrogen scheduling treatments, the highest net return (66546 and 71812 Rs ha^{-1}) was observed in N_6 (Real Time N Management through LCC) followed by N_4 (120% RDN (50% B + 25% AT + 25% PI), N_2 (100% RDN (50% B + 25% AT + 25% PI), N_5 (120% RDN (40% B + 35% AT + 25% PI) and N_3 (100% RDN (40% B + 35% AT + 25% PI) and the lowest net return (24235 and 25747 Rs ha^{-1}) was obtained with N_1 (control) in the year 2019 and 2020, respectively.

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Benefit: Cost ratio

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Among the different planting techniques, the B: C ratio was highest in furrow irrigated raised beds (P_1) followed by conventional transplanted rice (P_4) and unpuddled transplanted rice (P_3). The lowest B:C ratio was found in reduced tillage transplanted rice (P_2) during both the year. Among nitrogen scheduling treatments, the highest B:C ratio was observed in N_6 (Real Time N Management through LCC) followed by N_4 (120% RDN (50% B + 25% AT + 25% PI), N_2 (100% RDN (50% B + 25% AT + 25% PI), N_5 (120% RDN (40% B + 35% AT + 25% PI) and N_3 (100% RDN (40% B + 35% AT + 25% PI) and the lowest B:C ratio (1.83 and 1.85) was obtained with N_1 (control) in the year 2019 and 2020, respectively.

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These economic findings corroborate the findings of Sarnaik (2010), Ravi *et al.* (2007), Stalin *et al.* (2008) who also reported that the adoption of real-time N management viz., the LCC 4 -based N management is a profitable proposition for N fertilization strategy in rice. Similar result also reported by Kadiyala *et al.* (2012); Naresh *et al.* (2015) and Kumar *et al.* (2016).

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4. CONCLUSION

The data recorded from two-year field experimentation, revealed that basmati rice crop gave the highest yield under conventional puddled transplanted condition with real time nitrogen management through LCC, however the net return was associated with FIRBs. Therefore, it may be concluded that transplanting of rice on FIRBs with real time nitrogen management through LCC might be a better option to get higher productivity and profitability of basmati rice.

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