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Impact of crop establishment methods on productivity, profitability and water use efficiency of rice-wheat cropping system under eastern indo Gangetic plains

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Abstract
An experiment was conducted at the farmers field of District Barabanki, Basti and Gorakhpur during 2018-19, 2019-20 and 2020-21 to find out the best crop establishment methods in rice –wheat cropping system and water use efficiency. Rice sown with drum seeder in puddled condition gave highest grain yield among the rice establishment methods tested. Rice sown with drum seeder recorded 8.8, 15.0, and 25.7% higher grain yield over farmer practice in Basti and Gorakhpur Barabanki locations, respectively. Wheat planted in Rice (UPMTP) - Wheat (ZT) cropping system registered 4.6 t ha^{-1} grain yields, markedly higher than Farmers practice (FP). Zero tillage wheat sowing method after rice obtained 13.5 10.4, and 12.5% higher yield over the farmers practice in Barabanki, Basti and Gorakhpur locations. Treatment unpuddled mechanical transplanted rice - zero tillage wheat recorded highest rice equivalent yield 9.9 t $ha^{-1}yr^{-1}$. Treatments rice direct seeded rice (DSR) – wheat (ZT) followed by rice sown with drum seeder (DMS) –wheat (ZT) and rice (UPMTP) –wheat (ZT) obtained higher net return and B: C ratio respectively. However, compared with traditional practice of cultivation farmers much convinced with rice sown either dry direct seeded or mechanical transplanted, drum seeding and wheat by zero tillage technology, especially in terms of independency of agricultural labourers, yield potential and benefit-cost ratio. Results from this study revealed that conventionally tilled (CT) and transplanting of rice could be successfully replaced by adoption of the profitable DSR - wheat (ZT) in –rice-wheat system.

Keywords: Crop establishment methods, gangetic plains, UPMTP, DSR

Introduction
The rice-wheat rotation is the most prevalent cropping system of Indo-Gangetic Plains (IGP) covering an area of 14 million hectares (m ha) of which about 10.5 m ha lies in India. A large proportion of world population relies on rice and wheat for daily caloric intake, income and employment. Rice-wheat cropping system is one of the major cropping systems in South Asia (Singh *et al*., 2010) [19] providing food for more than 400 million people. The rice–wheat production systems are fundamental to employment, income, and livelihoods for hundreds of millions of rural and urban population of South Asia (Saharawat *et al*., 2010) [19]. This system covers about 10.5 million hectares in India contributes 26% of total cereal production, 60% of total calorie intake and about 40% of the country's total food basket (Sharma *et al*., 2015) [20]. In India rice occupies nearly 43.8 million hectares area, 177.6 million tonnes production and productivity of 4057 kg/ha, whereas, wheat has 29.3 mha area,103.6 mt production, and 35.33 kg /ha productivity (FAOSTAT,2021) Rice is the most important staple food in Asia, where more than 90% of the world"s rice is grown and consumed. The parh to success has been affected by declining soil health (Mondal *et al*., 2020) [21], ground water resources (Bhatt *et al*., 2016) [2], monocropping of cereal- cereal system, increasing climate variabilities (Jain *et al* 2014) [22] and changing socio- economic dynamics (Dubey. *et al*., 2020) [23].
Tillage is one of the basic inputs of crop production, actually tillage alters the rhizosphere environment by modifying most of the physical properties of the soil, *viz*. bulk density and soil strength, hydraulic conductivity and aggregates stability, infiltration rate and porosity due to formation, destruction and rearrangement of soil particles and aggregates and alternation in clod size distribution (Kurothe *et al*., 2014) [10].

In the conventional systems involving intensive tillage, there is gradual decline in soil organic matter by quicker oxidation and burning of crop residues causing pollution, greenhouse gases emission, and loss of valuable plant nutrients. However, the extent of the impacts of tillage is variable depending upon the inherent soil characteristics and climatic conditions. Puddling effects adversely on soil- physical condition for establishment and raising the succeeding crops (Bhatt *et al*., 2015) [2]. This practice is water, capital and energy intensive, and deteriorates soil health (Das *et al*., 2014) [10].

Puddling leads to the formation of a hard-pan at shallow depths deteriorates soil physical properties and delays planting of a succeeding wheat crop. Timely planting of wheat is crucial as yield reductions of 1–1.5% per day occur for each day after the optimum sowing date, November 15 in the IGP (Jat *et al*., 2009) [8]. Therefore, it is imperative that alternate method of growing crops that is more water efficient and less labour intensive to be developed to enable farmers to produce more with less cost of production. Huge labours are needed to accomplish transplanting of rice seedlings and mostly it is delayed to a greater extent due to unavailability of adequate labours during transplanting peak. Thus, late planted rice takes more time to reach the maturity, which not only reduces the rice yield but also delays sowing of succeeding crop particularly wheat but direct seeding of rice can reduce the labour and water requirement, shorten the duration of crop by 7-10 days and provide comparable yield with transplanted rice (Mishra *et al*., 2012) [14]. In plains of Eastern India, sowing of wheat gets delayed due to wet condition after rice harvesting which takes much time to come in working condition, also tillage in such soils require more time, labour and energy. On the other hand, zero tillage minimizes loss on account of delayed sowing as it advances the wheat sowing by 10-15 days and also saves the time and cost involved in field preparation. Conventional methods of wheat sowing, which requires excessive tillage delays the sowing and reduce the yield, but the same can be accomplished efficiently with use of improved machines, *viz*. zero till ferti-seed drill and rotavator etc. to save the time, fuel, energy and cost (Bohra and Kumar, 2015) [3]. Therefore, the present investigation was envisaged with an objective to identify a suitable combination of crop establishment method for maximum productivity and profitability from rice –wheat cropping system.

Materials and Methods

Experimental site

A farmers' participatory field experiment was established in the year 2019 at Barabanki, Basti and Gorakhpur districts of Uttar Pradesh under Narendra Dev University of Agriculture & Technology, Ayodhya, with rice (*Oryza sativa* L.)–Wheat (*Triticum aestivum* L.) cropping system. The region has a semi-arid to sub-humid climate with an average annual temperature of 19.3 °C. The highest mean monthly temperature (40.7 °C) is recorded in May, and the lowest mean monthly temperature (4.5 °C) is recorded in January. The average annual rainfall is about 1050 to 1080 mm of which around 87% is acknowledged for the duration of monsoon period. Remaining 13% rainfall is received during the non-monsoon period in the wake of western disturbances and thunder storms. The experimental soils were sandy loam/ loam in texture having pH (7.80-8.60), EC (0.16-0.38dSm^{-1}), organic carbon (0.27 -0.29%), available N (102-252 kg/ha), available P_2O_5 (10.0-26.5 $kgha^{-1}$) available K (110-265 $kgha^{-1}$), available S (10.3-23.5 $kgha^{-1}$), DTPA- extractable Zn (0.46-.62 $mgkg^{-1}$), Fe (2.90-6.25 $mgkg^{-1}$), Mn (3.44-8.60 $mgkg^{-1}$) and Cu (0.65-1.58 $mgkg^{-1}$) and available B (0.20-0.32 $mgkg^{-1}$).

Experimental design and management

A comprehensive description of unlike tillage systems is essential to compare effect of tillage on environmental concert (Derpsch *et al*., 2014) [5]. The experiment was laid out in farmers' participatory mode and farmer is treated as replication. The experimental design was randomized block design keeping five crop establishment methods *viz*., T_1= manual transplanted rice- wheat conventional practices (CTPR)- (CSW) FP;T_2= puddled direct wet seeded rice by drum seeder-wheat zero tillage (PDSR)-(ZTW); T_3= unpuddled direct seeded rice by zero till cum ferti seed drill - wheat zero tillage (DSR)-(ZTW); T_4=unpuddled rice transplanted by machine-wheat zero tillage (UMTPR)- (ZTW) and T_5= unpuddled rice transplanted by machine– wheat roto till (UMTPR) – (RTW). A uniform dose of 150 kg N, 60 kg P_2O_5, 40 kg K_2O and 5 kg Zn ha^{-1} was applied for rice and wheat crops in all the treatments through urea (46% N), DAP (18% N and 46% P_2O_5), muriate of potash (60% K_2O) and $ZnSO_4$ respectively. Half of total nitrogen and full dose of P_2O_5, K_2O and Zn were applied to rice crop as basal (sowing/transplanting) and remaining half dose of nitrogen in the form of urea was top dressed in two equal splits, at active tillering and panicle initiation stage, respectively. Rice variety NDR 3112 and wheat variety HD 2967 was used for sowing / transplanting with recommended seed rate.

Rice was transplanted on June 15th to 27th and wheat was sown on November 10th to 20th during experimentation. The herbicide glyphosate (1 kg ha^{-1}) was applied in zero-till treatments before the seeding to knock down the weeds, pendimethalin 1 kg ha^{-1} (pre- emergent) *fb* bispyribac 250 g ha^{-1} at 20 DAS/DAT were applied by using knap sack sprayer with flat fan nozzle for weed control in rice and for wheat, Sulfosulfuran 33g + 20 g/ha metsulfuron was applied at 30 DAS. The crop was harvested at maturity stage. First, the border rows were harvested and separated. Later, crop from net plot was harvested and sun dried. The harvested material from each net plot was carefully bundled, tagged and brought to the threshing floor separately. Threshing was done plot wise and grains were cleaned, dried and weighed separately for each net plot and computed in terms of kg ha^{-1} at 14% moisture level. The straw yield was also recorded plot wise after sun drying and computed to kg ha^{-1}.Test weight (g) of 1000-seeds from each plot was recorded. The data recorded for different crop parameters were analysed using analysis of variance (ANOVA) technique (Gomez and Gomez, 1984) [24] for complete randomized block design. Where ANOVA was significant, the treatment means were compared using LSD procedure at 5% level of significance.

Results and Discussion

Effect of crop establishment methods on rice crop

Highest fertile tillers (347 &375) was recorded when rice sown with drum seeds in puddled condition at Basti and Burbank but at Gorakhpur it was highest (356) when transplanted with machine in puddled condition. In general higher 1000 grain weight was recorded under puddled field when rice sown/transplanted conventional or mechanical (Table 1). Highest grain yield (48.2, 51.2 and 52.6 q/ha) recorded with rice sown in puddled condition by drum seeder at Basti, Gorakhpur and Barabanki, respectively. Sowing of rice with drum seeder, mechanical transplanting of rice in unpuddled, puddled condition and dry direct seeded method of crop establishment were at par but yielded significantly higher over conventional method of transplanting (FP) at Gorakhpur and Barabanki location but at Basti, difference was not makeable. However, similar rice yield under puddled transplanted rice and unpuddled transplanted rice under zero tilled condition was reported in the Eastern gangetic plains [27]. Higher grain yield with unpuddled transplanted rice over puddled rice was also recorded Husain *et al* On the basis of mean yield across the district, rice sowing with drum seeder recorded highest grain yield (56.6 q/ha) followed by mechanical transplanting in puddled condition, (49.3 q/ha), mechanical transplanting in un- puddled condition and dry direct seeding by ZT machine using stale bed technique. Sowing of rice with drum seeder recorded highest increase in yield 8.8, 15.0 and 25.7 percent over farmers practice at Bast, Gorakhpur and Barabanki location, respectively. Higher grain yield in drum seeder sown crop might be due to optimum plant population and depth of sowing with appropriate other yield attributes. Poor performance in conventional method of transplanting (FP) was due to less effective tillers /m^2 and other yield attributing characters. Similar or high yield attributes and yield of rice were reported earlier by many researchers [Ladha *et al*., (2009) and Jat *et al*., (2009) [8] Yadav *et al*., (2014)] [25].

Effect of crop establishment method on wheat

Different sowing method of wheat had significant variation in yield attributes *viz*. effective tillers /m^2, number of grains /spike, 1000 grain weight and grain yield (Table 2). Wheat sown by zero tillage after unpuddled transplanted rice recorded highest grain yield 44.5, 46.3 and 47.5 q/ha at Basti, Gorakhpur and Barabanki location respectively, followed by zero till wheat sown after dry direct seeded rice. Wheat sown by zero till technique after unpuddled rice recorded 7.3, 7.3 and 9.0 percent higher yield than wheat sown after puddled rice at Basti, Gorakhpur and Barabanki location respectively,. Irrespective of various crop establishment methods and locations, zero till sown wheat gave 7.83% higher yield over conventional sowing of wheat. Higher grain yield under zero till sown wheat were due to more number of effective tillers, grain /panicle and test weight. The possible reason for higher yield attributes and grain yield in zero till sown wheat might be due to the effect in better equilibrium between macro and micro-porosity leading to increased root biomass in the surface soil layer. On an average one week early sowing might be the possible reason for better yield & yield attributing characters in zero till sown wheat. Conventional tillage had obtained the lowest wheat yield because wheat crop suffered the ills of puddling in preceding rice crop resulting in poor rooting due to soil compaction and poor aggregation as reported by other researchers in the region (Jat *et al*., 2009; Kumar and Gathala *et al*., 2011) [8, 26].

Effect of crop establishment method on system productivity

Total productivity of rice –wheat cropping was calculated in rice equivalent yield (REY) for the treatments (Table 3). Rice transplanted by machine in unpuddled condition *fb* zero till wheat recorded highest REY (9.9 t ha^{-1} yr^{-1}). Treatments drum seeded rice then zero till sown wheat and direct seeded rice then zero till wheat were at par with each other and recorded significantly higher yield as compared to farmers practice. These findings are in conformity with the findings of Singh *et al*., (2014) [10]; Bohra and Kumar (2015) [3].

Soil moisture content studies

In general, the profile moisture content was highest at the time of sowing (21%) and it was lowest at the time of crop maturity in all the treatments (Table 4). The increases in profile moisture content are visible from the peaks under tillage practices, difference were because of moisture conserved due to the application of irrigation. The moisture content of conventional tilled plots (T_1) was always lower than zero and reduced tillage plots during the year of study except in the peaks where the moisture content in the profile was always same due to recharging of profile by application of irrigation. In between the season the lowest soil moisture content in conventional tillage crop and rotavator till plots was 51 DAS (14.8%), 73 DAS (14.2%) and 102 DAS (13.3%) respectively. The conventional till crop under all the irrigation application management kept the average profile soil moisture content 1.5% lower than zero tillage plots throughout the crop season except after recharging the soil profile either by application of irrigation or by rainfall. The crop water use increased markedly in conventional till plots (T_1) than zero till plots during the year of study. Maximum WUE was recorded under T_2 PDSR -ZTW followed by T_5 UMTPR- RTW, T_4 UMTPR-ZTW and T_3 DSR-ZTWROT during the year of experimentation. The WP was remarkably low in conventional till plots crop than zero and reduced till crop plots during both the year of study. The highest moisture depletion under the conventional method might be due to less availability of moisture at upper layer and more evaporation from upper surface. Similar results have been reported by Naresh *et al*., (2013a) [15] and Ram *et al*., (2013) [18].

Profitability

Maximum system net return (Rs. 110580/ha) and highest B:C ratio (2.66) recorded in the rice T_3 (DSR) – wheat (ZT) followed by rice T_2 (DMS) – wheat (ZT) and rice T_4 (UPMTP)– wheat (ZT) crop establishment methods, respectively (Table 3). Higher net return as well as B:C ratio in case of DSR was reported by Kumar and Batra (2017) [11]. Better growth and development in DSR than transplanted rice was reported by Alam *et al.* (2018) [12]. Drum seeding which is a type of direct seeding is also reported beneficial by Kumar *et al.* (2018) [13] who found that the B:C ratio was higher in dry seeded rice with drum seeder (1.70) as compared to transplanting after puddling (1.54). Higher grain yield and B:C ratio in zero tilled wheat after rice was also recorded by Pandey *et al.* (2020) 17. This may be because of higher water use efficiency than other tillage establishment practices as well as comparatively higher increase in grain yield than in other treatment. Treatment T_3 was recorded Rs. 26817/ha higher net return over T_1 conventional practices. Higher net return and B: C ratio in rice T_3 (DSR) –wheat (ZT) crop establishment method attributed to lowest cost of cultivation and comparable grain yield among the different crop establishment methods tested. The negative economics and lowest B: C ratio in T_1 was because of its higher cost during experimentation. Similar result was recorded by Naresh *et al*., (2012) [16] and Jat *et al*., (2013) [9].

Table 1: Yield and yield attributes of rice as affected by crop establishment methods. (Pooled data of 3 years)

Treatments	Effective tillers/m^2	Grain / panicle	1000 grain wt. (g)	Grain yield (q/ha.)	% increase in yield over FP
Basti					
Rice(CTP) – wheat (CS) FP	320	121	19.46	44.3	--
Rice (DMS) – wheat (ZT)	347	125	19.78	48.2	8.8
Rice (DSR) – wheat (ZT)	311	111	18.23	45.3	5
Rice(UPMTP) – wheat (ZT)	344	117	18.63	46.6	2.2
Rice (PMTP) – wheat (RTV)	327	115	20.35	45.4	5.1
CD (*P=0.05*)	15	5	NS	2.4	2.4
GORAKHPUR Rice(CTP) – wheat (CS) FP	320	124	20.7	44.5	
Rice (DMS) – wheat (ZT)	352	136	19.1	51.2	-
Rice (DSR) – wheat (ZT)	311	128	18.6	47.5	15.0
Rice(UPMTP) – wheat (ZT)	356	128	18.2	48.6	6.74
Rice (PMTP) – wheat (RTV)	330	124	20.5	50.2	9.2
CD (*P=0.05*)	16	6	NS	2.3	12.8
Barabanki Rice(CTP) – wheat (CS) FP	310	118	20.6	44.6	
Rice (DMS) – wheat (ZT)	375	139	20.1	52.6	-
Rice (DSR) – wheat (ZT)	350	129	18.8	49.2	25.7
Rice(UPMTP) – wheat (ZT)	359	134	18.6	50.8	10.7
Rice (PMTP) – wheat (RTV)	365	135	20.6	52.4	19.3
CD (*P=0.05*)	17	8	NS	2.7	22.9

Table 2: Yield and yield attributes of wheat as affected by crop establishment methods. (Pooled data of 3 years)

Treatments	Effective tillers/m^2	Grain / panicle (no.)	1000 grain wt. (g)	Grain yield (q/ha.)	% increase in yield over FP
Basti					
Rice(CTP) – wheat (CS) FP	341	42	36.9	40.3	-
Rice (DMS) – wheat (ZT)	352	43	38.3	41.2	2.2
Rice (DSR) – wheat (ZT)	356	46	42.8	44.3	9.9
Rice(UPMTP) – wheat (ZT)	354	44	43.2	44.5	10.4
Rice (PMTP) – wheat (RTV)	345	42	38.7	42.7	5.9
CD (*P=0.05*)	12	3	2.7	2.4	-
Gorakhpur					
Rice(CTP) – wheat (CS) FP	344	36	37.5	40.8	
Rice (DMS) – wheat (ZT)	353	40	38.8	42.3	3.6
Rice (DSR) – wheat (ZT)	362	43	42.3	43.4	6.4
Rice(UPMTP) – wheat (ZT)	364	45	43.8	46.3	13.4
Rice (PMTP) – wheat (RTV)	346	40	39.9	42.5	4.2
CD (*P=0.05*)	12	4	2.1	2.6	-
Barabanki					
Rice(CTP) – wheat (CS) FP	357	41	36.8	42.2	4.3
Rice (DMS) – wheat (ZT)	359	45	38.2	44.0	10.2
Rice (DSR) – wheat (ZT)	364	44	42.1	46.5	12.6
Rice(UPMTP) – wheat (ZT)	372	46	44.5	47.5	2.4
Rice (PMTP) – wheat (RTV)	355	42	34.8	43.2	
CD (*P=0.05*)	17	4	3.2	3.5	

Table 3: Rice equivalent yield, economics and nutrient uptake of rice – wheat cropping system as affected by crop establishment methods (Pooled data of 3 years of 3 district)

Rice equivalent yield, economics and nutrient uptake of rice – wheat cropping system as affected by crop establishment methods (Pooled data of 3 years of 3 district) Treatments	REY (q/ha)	Cost of cultivation (Rs./ha)	Net return (Rs. /ha)	B: C Ratio	Nutrient uptake(Kg/ha)		
					N	P	K
Rice(CTP) – wheat (CS) FP	90.43	81000	83763	2.03	189	91	215
Rice (DMS) – wheat (ZT)	97.67	68200	109754	2.60	206	99	232
Rice (DSR) – wheat (ZT)	97.19	66500	110580	2.66	192	94	217
Rice(UPMTP) – wheat (ZT) Rice	99.73	72800	105908	2.45	209	99	234
(PMTP) – wheat (RTV)	96.73	75300	100942	2.34	201	97	229
CD (*P=0.05*)	06.12				13	4	11

Table 4: Soil moisture content at different crop stages before recharging soil profile as influenced by planting pattern in rice-wheat system

Treatments	Soil moisture content (%)					Total soil moisture depletion	Water use efficiency (q ha^{-1} cm)	
	21 DAS	39 DAS	51 DAS	73 DAS	102 DAS		Rice	Wheat
T_1 CTPR –CSW	14.6	16.6	15.3	14.2	13.8	12.7	1.81	2.89
T_2 PDSR –ZTW	15.6	16.8	15.3	14.5	14.0	11.3	2.14	3.33
T_3 DSR-ZTW	16.1	17.3	15.7	14.9	14.4	12.8	1.92	2.74
T_4 UMTPR-ZTW	14.2	16.5	15.5	14.2	13.8	14.8	1.96	2.86
T_5 UMTPR-RTW	13.3	16.2	15.0	13.8	13.5	12.2	2.02	3.12
Mean	14.6	16.6	15.3	14.2	13.8	12.6	-	-

Conclusion

For getting highest net return /ha/year and B: C ratio, rice (DSR) – wheat (ZT) may be the best crop establishment method which can minimize the cost of cultivation and improve the soil health and water use efficiency under Tarai belt of Eastern Uttar Pradesh.

References

1. Anonymous, Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture and Farmer's Welfare. Govt. of India; c2016.
2. Bhatt R, Kukal SS. Soil moisture dynamics during intervening period in rice–wheat sequence as affected by different tillage methods at Ludhiana, Punjab, India. Soil Environ. 2015;34(1):82-88.
3. Bohra JS, Kumar R. Effect of crop establishment methods on productivity, profitability and energetics of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) system. Indian J Agri Sci. 2015;85(2):217-230.
4. Das A, Lal R, Patel D, Idapuganti R, Layek J, Ngachan S, *et al*., Effects of tillage and biomass on soil quality and productivity of lowland rice cultivation by small scale farmers in North Eastern India. Soil Tillage Res. 2014;143:50-58.
5. Derpsch R, Franzluebbers AJ, Duiker SW, Reicosk DC, Koeller K, Friedrich T, *et al*., Why do we need to standardize no-tillage research? Soil Tillage Res. 2014;137:16-22.
6. FAOSTAT. Food and Agriculture Data. Food and Agriculture Organization of the United Nations, Rome; c2021.
7. Hossain MM, Rabbani MAE, Elahi HMT, Sarkar S, Saha CK, Alam MM, *et al*. Options for Rice Transplanting in Puddle and Un-Puddled Soil. 2017 ASABE Annual International Meeting, Spokane, Washington; c2017.
8. Jat ML, Gathala MK, Ladha JK, Saharawat YS, Jat AS, Vipin Kumar, *et al*. Evaluation of precision land levelling and double zero-till systems in the rice-wheat rotation: Water use, productivity, profitability and soil physical properties. Soil Tillage Res. 2009;105:112-121.
9. Jat ML, Gathala MK, Saharawat YS, Tetarwale JP, Gupta Raj. Double no-till and permanent raised beds in maize–wheat rotation of north-western Indo-Gangetic plains of India: Effects on crop yields, water productivity, profitability and soil physical pr operties. Field Crops Res. 2013;149:291-299.
10. Kurothe RS, Kumar G, Singh R, Singh HB, Tiwari SP, *et al*., Effect of tillage and cropping systems on runoff, soil loss and crop yields under semiarid rain-fed agriculture in India. Soil Tillage Res. 2014;140:126-134.
11. Kumar R, Batra SC. A comparative analysis of DSR technology Vs. transplanted method in Haryana. Economic Affairs. 2017;62(1):169-174.
12. Alam MJ, Humphreys E, Sarkar MAR, Yadav S. Comparison of dry seeded and puddled transplanted rainy season rice on the high Ganges River flood plain of Bangladesh. European Journal of Agronomy. 2018;96:120-130.
13. Kumar V, Singh S, Sagar V, Maurya ML. Evaluation of different crop establishment methods of rice on growth, yield and economics of rice cultivation in agro-climatic condition of eastern Uttar Pradesh. Journal of Pharmacognosy and Phytochemistry. 2018;7(3):2295-2298.
14. Mishra JVP, Bhanu C, Subrahmanyam D. Crop establishment, tillage and weed management techniques S, Singh on weed dynamics and productivity of rice (*Oryza sativa*)-chickpea (*Cicer arietinum*) cropping system. Indian J Agri Sci. 2012;82(1):15-20.
15. Naresh RK, Singh SP, Kumar Vineet. Crop establishment, tillage and water management technologies on crop and water productivity in rice-wheat cropping system of North West India. Int J Sci Life Sci Biotech Pharma Res. 2013a;10:1-12.
16. Naresh RK, Singh SP, Singh A, Kamal Khilari, Shahi UP, Rathore RS. Evaluation of precision land leveling and permanent raised bed planting in maize–wheat rotation: productivity, profitability, input use efficiency and soil physical properties. Indian J Agri. Sci. 2012;105(1):112-121.
17. Pandey BP, Khatri N, Pant KR, Yadav M, Marasini M, Paudel GP, *et al*. Zero-till wheat (*Triticum aestivum* L.): A Nepalese perspective. Fundamental and Applied Agriculture. 2020;5(4):484-490.
18. Ram H, Dadhwal V, Vashist KK, Kaur H. Grain yield and water use efficiency of wheat (*Triticum aestivum* L.) in relation to irrigation levels and rice straw mulching in North West India. Agric Water Management. 2013;128:92-101.
19. Saharawat YS, Singh B, Malik RK, Ladha JK, Gathala M, Jat ML, *et al*. Evaluation of alternative tillage and crop establishment methods in a rice– wheat rotation in North Western IGP. Field Crop Res. 2010;116:260-267,
20. Sharma PC, Jat HS, Kumar V, Gathala MK, Datta A, Yaduvanshi NPS, *et al*. A Sustainable Intensification Opportunities under Current and Future Cereal Systems of North-West India. Technical Bulletin: CSSRI/Karnal/ 2015/4. Central Soil Salinity Research Institute, Karnal; c2015. p. 46.
21. Cooper I, Mondal A, Antonopoulos CG. A SIR model assumption for the spread of COVID-19 in different communities. Chaos, Solitons & Fractals. 2020 Oct 1;139:110057.
22. Jain M, Van Gemert J, Snoek CG. University of amsterdam at thumos challenge 2014. ECCV THUMOS Challenge; c2014 Sep.
23. Dubey S, Biswas P, Ghosh R, Chatterjee S, Dubey MJ, Chatterjee S, *et al*. Psychosocial impact of COVID-19. Diabetes & Metabolic Syndrome: clinical research & reviews. 2020 Sep 1;14(5):779-88.
24. Gomez KA, Gomez AA. Statistical procedures for agricultural research. John wiley & sons; c1984 Feb 17.
25. Yadav M, Chatterji S, Gupta SK, Watal G. Preliminary phytochemical screening of six medicinal plants used in traditional medicine. Int. J Pharm Pharm. Sci. 2014;6(5):539-42.
26. Gathala MK, Ladha JK, Kumar V, Saharawat YS, Kumar V, Sharma PK, *et al*. Tillage and crop establishment affects sustainability of South Asian rice–wheat system. Agronomy Journal. 2011 Jul;103(4):961-71.