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Evaluation of different crop establishment method of rice on growth, yield and economics of rice cultivation in agro-climatic condition of eastern Uttar Pradesh

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Abstract
Scarcity of irrigation water, shortage of farm laborers and increasing cost of rice cultivation in conventional transplanting in puddled soil, forcing rice farmers to explore the alternatives of transplanting. The field experiments were conducted at Instructional Farm of Krishi Vigyuan Kendra, Ambedkar Nagar, Uttar Pradesh to study the different crop establishment techniques on growth yield and economics of rice in agro-climatic condition of eastern Uttar Pradesh during kharif 2014 & 2015. The experiment was laid out in a randomized block design with four replications and short duration ricevariety Sushk Samrat was used as test variety. Variety specific package of practices were adopted for the realization of full potential of the tested rice variety. The treatment structure comprises of dry seeded rice with drum seeder (DSR); wet drum seeding after dry tillage (NWSR), wet drum seeding on puddled soil (WSR) and transplanting after puddling (PTR). Among rice crop establishment methods direct seeded rice with drumseeder (DSR) was found most economic feasible method with high grain yield. Direct-seeded rice with drum seeder (DSR) had shorter crop duration, required less water and therefore had higher water-use efficiency than the transplanting method.

Keywords: crop establishment, DSR, NWSR, WSR, PTR

1. Introduction
Rice (*Oryza sativa* L.) is one of the most important and widely cultivated cereal crops of the world. Of the total global rice production, 90% was produced and consumed in Asia and South East Asia. It is not only the staple food for the rice eating population of the world but also the major source of dietary energy. Rice eating population of Indian sub continent got more than 40% of calorie requirement from the rice. In India, it is grown on an area of about 44.4 m ha with a total production of 104.0 m t and productivity of 2.4 t /ha during 2015-16. Uttar Pradesh is the 2nd largest producer of the rice after West Bengal. Annual rice production of the state is about 14416 thousand tons from an area of 5.90 m ha. The average rice productivity of the state was 2.04 t/ha which very less than the national average. The rice production in eastern part the province became vulnerable due scarcity of farm labourors, changing climatic conditions coupled with frequent drought & flood, deteriorating soil health and unavailability of irrigation water. Manual transplanting of the seedlings into puddle soil is the most common method of rice crop establishment used by the majority of farmers of Asian countries. Puddling is a process of cultivating soil in standing water, consumes a large quantity of water (Bouman and Tuong, 2001) [9]. Changing climatic condition and depletion of ground water table rapidly resulted in scarcity of irrigation water (Mahajan *et al*., 2011, 2012) [32, 34]. There is a threat that Asian rice growers will probably have inadequate access to irrigation water in the future (Tuong and Bouman, 2003; Mahajan *et al*., 2013) [39, 33]. This scarcity of irrigation water, threatens the sustainability of rice production in irrigated environments (Chauhan *et al*., 2012, 2014b) [16, 17]. Shortage of farm labourers during the peak season of rice transplanting in many rice growing regions of the Asia was also observed (Mahajan *et al*., 2013; Pandey and Velasco, 2005) [33, 36] which is aggravating the problem for rice production in irrigated environment. Shortage of the laborers at the time of transplanting results in delays in transplanting, lower grain yield, and delays in sowing/planting of the next crop. Puddling also has deteriorating effects on the soil texture/structure, which adversely affect the subsequent non rice crop (Timsina and Connor, 2001) [38]. Scarcity of irrigation water and shortage of farm laborers triggers the search for such alternative rice crop establishment methods having high water productivity than conventional puddled transplanting. Direct seeded rice (DSR) is one of the few options available for rice crop establishment having high water productivity.

DSR technology has been recognized as the principal method of rice crop establishment since 1950's in Asian countries. In DSR technology crop was established from seeds sown in the field rather than by transplanting seedlings from the nursery. Direct seeding can be done by sowing of pre-germinated seed into a puddled soil (wet seeding) or standing water (water seeding) or prepared seedbed (dry seeding). Development of high yielding short duration varieties, improved nutrient and weed management practices encouraged the rice farmers to shift from conventional puddled transplanting to direct seeded rice (DSR). Farmers of many Asian countries were adopting DSR technology over conventional puddled transplanting (CPTR) since DSR method of rice establishment requires less labour, time, drudgery and cultivation cost (Bhushan *et al*., 2007; Pandey and Velasco, 2002) [8, 37]. Direct seeding requires about 34% of the total labour cost of transplanted rice (Ho Nai-Kin and Romli 2002) [29] and 29% of the total cost of transplanted rice production without any yield loss. Farmers usually practice direct seeding of rice by broadcast method. It can also be done by drilling the seeds in line either manually or with the use of drill machine by sowing in line either manually or with the use of simple plastic made implement known as drum seeder (Balasubramanian *et al*., 2003) [4].

In view of the above observations Direct Seeded Rice (DSR) technology was evaluated in agro-climatic condition of eastern Uttar Pradesh.

2. Material and Methods

A field experiment was conducted at Instructional Farm of Krishi Vigyan Kendra, Ambedkar Nagar, Uttar Pradesh to evaluate the direct seeded rice (DSR) technology in agro-climatic condition of eastern Uttar Pradesh during kharif 2014 and 2015. The soil of the experimental field was alfisol having clayey loam in texture. Physico chemical analysis of the soil shows that it is slightly alkaline in nature having pH 7.3 while the organic carbon content in soil is very low (0.37 %). %. The available nitrogen in the soil was found 212 kg/ha while soil is deficient in phosphorous (available P_2O_5 (kg/ha) - 27). The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. The experimental material was comprised of four rice establishment methods viz. dry seeded rice with drum seeder (DSR); wet drum seeding after dry tillage (NWSR), wet drum seeding on puddled soil (WSR) and transplanting after puddling (PTR) as treatments. The short duration rice variety Sushk Samrat was used as test variety. DSR was sown on 1st week of July in both the year of study. The rice seeds were sown at 40 kg $ha^{-1}$with the help of DRR drum seeder at a row spacing of 20 cm and depths of 1–2 cm. For all establishment methods except DSR, the seeds were soaked in water for 24 h. The seeds were then incubated for 8-10 hours prior to sowing by a drum-seeder on puddled (WSR) and nonpuddled soil (NWSR), and on the seedbed for raising nursery for the transplanted treatments. The 21 days old seedlings were transplanted at the spacing of 20 cm × 15 cm geometry on well-puddled soil. Variety specific recommended dose of fertilizer (100:60:40:20 kg NPK $ZnSO_4$/ha) was applied for the proper growth of the crop in all the treatments. Full dose of phosphorous, potash & Zinc sulphate and half dose of nitrogen were applied as basal dose while the remaining half dose of nitrogen was applied in two equal splits at tillering and panicle initiation stage of the crop. The soil was kept near saturation from sowing to 21 DAS in the direct-seeded plots, while it was kept under flooded conditions (2–3 cm) from transplanting to 8 DAT in the transplanted plots. The plots were then kept under alternate wet and drying (AWD)

Data on yield and ancillary characters were recorded and subjected to analysis of variance and differences among treatments means were separated using Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1994) [25]. Economics different crop establishment methods was also analyzed and presented in table - 2

3. Results and Discussions

Effect of different crop establishment methods on yield and contributing traits

On the perusal of two years pooled data presented in table -1 it was found that method of rice crop establishment significantly affected the yield and yield contributing traits of the test variety Sushk Samrat in agro-climatic condition of eastern Uttar Pradesh. Mean Germination % of the rice variety was influenced by the method of crop establishment, it was found maximum in the treatment transplanting after puddling - PTR (95 %) while minimum in dry seeded rice with Wet drum seeding after dry tillage - NWSR (79%). Days to 50% flowering was also varied with the method of rice crop establishment. It was observed highest in the experimental plots established through most commonly used method of rice establishment i.e. transplanting after puddling – PTR (83 days) followed by Wet drum seeding after dry tillage – NWSR (80 days) and Wet drum seeding on puddled soil – WSR (78 days).

The panicle no./ m^2 was significantly affected by method of rice crop establishment. The average panicle no./ m^2 for transplanting after puddling (279) and dry seeded rice with drum seeder (263) were higher and significantly different from Wet drum seeding on puddled soil (234) and Wet drum seeding after dry tillage (202). The higher panicle no./m^2 in transplanting after puddling could have been due to optimal plant spacing. Transplanting in pudlled soil enables ensures optimal spacing for proper plant growth, and good spacing can increase tillers and grain yield over poor spacing and/or other planting methods. Planting methods and growing environment are therefore among major factors influencing yield of the rice crop Proper spacing is said to ensure good water management (Mazid, *et al*., 2003) [35] and photosynthetic activities and assimilate partitioning (Kundu, *et al*., 1993) [31], thereby resulting in good yield in well spaced rice fields.

Planting method had influence on rice grain yield, as transplanting after puddling method recorded significantly higher grain yield 3833 kg/ha) than dry seeded rice with drum seeder (3618 kg/ha). Similar finding was also reported by earlier researchers (Anonymous, 2004) [2]. Higher grain yield in transplanting after puddling might be due to the optimal plant spacing ensure air circulation, water and light which are basic factors necessary for photosynthesis (Baloch *et al*., 2002) [5]. The comparatively low grain yield was recorded with the other methods of crop establishment than transplanting after puddling method could have been due to the exposure of seeds to pest destruction and higher weed infestation.

Economic of different crop establishment methods

It is evident from the economic analysis of different crop establishment methods presented in Table 2 that dry seeded rice with drum seeder (DSR) method proved to be the most profitable treatment in terms of net income (Rs.14290/ha, Kharif 2014 and Rs.15430/ha kharif 2015) and benefit cost ratio (1.67 kharif 2014 and 1.72 kharif 2015) during both the year of study. This might be due to lower cost of cultivation as compared other methods of crop establishment. The lowest net return was fetched from wet drum seeding after dry tillage which was the result of lowest grain yield under this treatment.

Table 1: Effect of different method of crop establishment on yield and ancillary characteristics of rice variety Sushk Samrat during kharif 2014 & 2015

S. No	Treatments	Germination %			Days to 50% flowering			Ear Bearing tillers/m^2			Panicle No. / m^2			Grain yield kg/ha		
		2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
1	Dry seeded rice with drum seeder (DSR)	89	91	90	73	72	73	265	278	272	260	266	263	3550	3685	3618
2	Wet drum seeding after dry tillage (NWSR)	78	80	79	79	80	80	205	215	210	204	200	202	2430	2570	2500
3	Wet drum seeding on puddled soil (WSR)	84	86	85	77	78	78	231	245	238	238	230	234	2845	3030	2938
4	Transplanting after puddling (PTR)	94	96	95	82	84	83	282	295	289	273	285	279	3750	3915	3833
	LSD (5%)	11.55	12.35	11.95	7.85	9.24	8.55	17.35	19.20	18.28	20.15	21.25	20.70	5.75	7.10	6.43

Table 2: Effect of Crop establishment techniques on the economics of rice variety Sushk Samrat

Treatments	Cost of cultivation (Rs./ha)			Gross return (Rs./ha)			Net return (Rs./ha)			BC ratio		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
Dry seeded rice with drum seeder (DSR)	21210	21420	21315	35500	36850	36180	14290	15430	14865	1.67	1.72	1.70
Wet drum seeding after dry tillage (NWSR)	20350	20500	20425	24300	25700	25000	3950	5200	4575	1.19	1.25	1.22
Wet drum seeding on puddled soil (WSR)	21650	21840	21745	28450	30300	29380	6800	8460	7635	1.31	1.39	1.35
Transplanting after puddling (PTR)	24550	25350	24950	37500	39150	38330	12950	13800	13380	1.53	1.54	1.54

4. Conclusion

From this study, it can be concluded that dry seeded rice with drum seeder (DSR) can be an effective agronomic tool for the rice crop establishment in the agroclimatic condition of eastern Pradesh. This method of rice establishment is a faster and easier method of crop establishment and required very less amount of water than the conventional puddled transplanting. Labour saving, reduction in population risk, and crop intensification facilities are the other few advantages of this method of crop establishment.

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