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EFFECT OF CROP ESTABLISHMENT METHOD AND FERTILIZER MANAGEMENT ON YIELD PERFORMANCE OF *BORO* RICE (var. BRRI dhan28) IN T. *AMAN*-MUSTARD-*BORO* RICE CROPPING PATTERN

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Abstract

The Study was carried out at the Salpoborian village under Sadr papilla of Mymensingh from February to June 2014 to assess the effect of crop establishment method and fertilizer management on the yield performance of *Boro* rice (var. BRRI dhan28) in T. *Aman*-Mustard-*Boro* rice cropping pattern. The experiment comprised three crop establishment methods viz. traditional puddled-transplanting (TPT), unpuddled-one pass in dry condition (UDC), unpuddled-zero tillage (UZT) and five levels of fertilizers viz., 100-60-40-60-10 N-P-K-S-Zn kg ha^{-1} at recommended (RD) dose (F_1), N-K-S-Zn at RD plus 50% P (F_2), N-P-S-Zn at RD plus 50% K (F_3), P-K-S-Zn at RD plus 75% N as Guti urea (2.7 g/4 hills) (F_4), P-K-S-Zn at RD plus 75% N as pilled urea (F_5). The experiment was laid out in a split -plot design with 4 replications with crop establishment method in the main- plots and fertilizer management in the sub-plots. Grain yield was not significantly influenced by crop establishment method, fertilizer management and their interactions. However, numerically the maximum grain yield of 3.19 t ha^{-1} was found in both unpuddled-one pass in dry condition (UDC) and unpuddled-zero tillage (UZT) with 3.32 t ha^{-1} in P-K-S-Zn at RD plus 75% N as pilled urea (F_5) and 3.47 t ha^{-1} in unpuddled-one pass in dry condition with P-K-S-Zn at RD plus 75% N as pilled urea and traditional puddled-transplanting with P-K-S-Zn at RD plus 75% N as pilled urea. Similar higher gross margin (Tk. 26629 and Tk. 27428) and benefit cost ratio (1.61 and 1.60) was also observed in UZT × F_4 and UDC × F_5, respectively. So, it can be concluded that unpuddled-zero tillage with P-K-S-Zn at RD plus 75% N as Guti urea (UZT × F_4) and unpuddled-one pass in dry condition with P-K-S-Zn at RD plus 75% N as prilled urea (UDC × F_5) is the beneficial technique for *Boro* rice (var. BRRI dhan28) cultivation in T. *Aman*-Mustard-*Boro* rice cropping pattern.

Introduction

About 72.31% of total cropped area of Bangladesh is used for rice production, with annual production of 36.60 million tons from 11.42 million ha of land (BBS, 2020). Rice crop area is decreasing day by day due to high population pressure. In our country, the dominant cropping pattern, T. *Aman* (wet season rice) -Fallow-*Boro* (dry season rice) plays an important role which covers about 1.8 million ha (about 22% of the total land) of land. Bangladesh Agricultural Research Institute (BARI) developed high yielding yellow seeded mustard (*Brassica campestris*) varieties, BARI Sarisha14 and BARI Sarisha15 recommended for T. *Aman*-Mustard-*Boro* rice cropping pattern. Increasing demand for the rice-mustard-rice cropping system led to the innovation of alternative crop establishment method and fertilizer application for *Boro* rice. Different crop establishment methods are generally followed in the field. Among them zero and minimum tillage crop establishment methods have some advantages like time, labor, low plough and water cost over traditional puddle system. Different types of agricultural tools are used in farming for initial land preparation which among the crop production factors contributes up to

20% (Khurshid *et al.*, 2006). During such cultivation, sub-soil compaction is usually caused by tillage system specifically through mechanical practices. Repeated ploughing may result in plough pan formation in cultivated soil due to use of heavyweight tillage machineries. Plough pans are formed in the same profile under power tiller and country plough treatment mostly in rice field (Islam *et al.,* 2005). Puddling is advantageous for rice cultivation but imposes limitations for upland crops. Under the conventional tillage system, a plough pan layer is developed that may impose changes in soil physical properties and may lead to a decrease in soil physical quality (Bertolino *et al.*, 2010). Adoption of minimum tillage and non-puddled transplanting might be an alternative to puddled transplanting to overcome negative impacts such as excess water requirement, formation of hardpan, soil fertility deterioration etc. (Sayre and Hobbs, 2004; Singh *et al.*, 2014). This technology has possible to allow saving in labor, energy, water and time during rice establishment as well as improving soil fertility (Islam *et al.*, 2012).

Among the production factors affecting crop yield, fertilizer is the single most important factor that plays a dominant role in yield increase if other production factors are not limiting. An increasing in the yield of rice by 70-80% may be obtained from proper application of N fertilizer (IFC, 1982). The efficiency of nitrogen use by rice plant is very low, the recovery of being only 30-50% (De datta and Crasswell, 1982). Phosphorus influences the flowering, photosynthesis, N-fixation, ripenning and quality of rice. Potassium in rice plays an effective role in root development and ripenning and impacts resistance to diseases (Tisdale and Nelson, 1996). Application of potassium in appropriate rate and time helps spikelets formation or grain of rice (Zheng et al.,1995). BRRI dhan28 is a highly yield potential variety with life cycle of 135-140 days. So, the present study is to examine the response of this variety to application of different rates of N, P, K, S and Zn fertilizers in different crop establishment method.

Materials and Methods

Experimental Site

The experiment was carried out at the farmers field, Swalpobarian (24.7960 N latitude and 90.3130 E longitude) Khagdahar, Mymensingh, during the Boro season of 2014 (February-June) to assess the effect of crop establishment method and fertilizer management on the performence of Boro rice. The experimental area belongs to the non-calcareous dark grey soil under Agro-ecological Zone of the Old Brahmaputra Floodplain (AEZ-9) (UNDP and FAO, 1988). The land was medium high and the soil was silty loam and well drained and its general fertility level is low.

Experimental Treatments and Design

The experiment comprised three rice establishment methods *viz.* traditional puddled (double tillage with laddering) transplanting (TPT), unpuddled-one pass in dry condition (UDC), unpuddled-zero tillage (UZT) and five fertilizer managements *viz.* 100-60-40- 60-10 kg N-P-K-S-Zn ha^{-1} as recommended (RD) dose (F_1), N-K-S-Zn at RD plus 50% P (F_2), N-P-S-Zn at RD plus 50% K (F_3), P-K-S-Zn at RD plus 75% N as Guti urea (2.7g USG/ 4 hill) (F_4), P-K-S-Zn at RD plus 75% N as prilled urea (F_5). The experiment was laid out in a Split- plot design with 4 replications where plant establishment methods in the main- plots and fertilizer management in the sub-plots. Each plot size was 80 m^2 (10.0 m×8.0 m).

Crop Husbandry

After harvest of Mustard, the experimental field was prepared as per treatment protocol. Traditional puddled transplanting- land was puddled with 2 tillages' followed by laddering for land leveling. Unpuddled transplanting-land was prepared with single pass in dry condition with no laddering and submergence in water for two days, then direct transplant the seedling on third day.

Unpuddled-zero tillage with no laddering, and submergence the land in water for two days, and then direct transplant the seedling on third day. Weeds and stubble of the previous crop were collected and removed by hand from the field. The land was prepared finally 24 February 2014. About 50-day-old seedlings were uprooted carefully from the nursery bed. Before uprooting the seedlings, nursery beds were slightly irrigated for easier uprooting. Uprooted seedlings were transplanted in the unit plots on 25 February 2014 at the rate of two seedling hill^{-1} maintaining spacing 20 cm×15 cm. The experimental plots were fertilized as per the fertilizer treatment. The fertilizer N, P, K, S and Zn was applied @ 100, 60, 40, 60 and 10 kg ha^{-1} in the form of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate, respectively. The entire amounts of triple super phosphate, half of muriate of potash, gypsum and zinc sulphate were applied as basal dose at final land preparation. Urea was applied at three splits in the form of prilled urea and one split in the form of urea super granule (USG). Urea was top-dressed in three equal installments. The first and second splits were top dressed at 15 DAT (after seedling recovery) and maximum tillering stage (30 DAT), respectively. Urea super granule (USG) was applied at the centre of four hills in every alternate row by Guti urea applicator at 15 DAT (Days after transplanting). The third split of urea and half of MoP were applied before the panicle initiation stage (45 DAT). Three weeding were done by hand pulling as necessary to keep the plots weed-free. Weeding was done at 25, 35 and 45 DAT, respectively. Experimental plots were irrigated as and when necessary to enhance tillering and weed control. Flood irrigation was given to maintain a level of standing water 2-4 cm till the maximum tillering stage and after that, a water level of 4-5 cm was maintained up to grain filling stage. Excess water was drained out from the plots 15 days before the harvest. No chemical was used to protect the plant. But parching was used to allow birds for pest control. A logo system (every ten lines after one row gap was maintained) was followed in every plot for proper aeration and naturally minimize the insect and pest. The bunds around individual plots were repaired as and when necessary, so that water did not move between the plots.

Data collection

The crop was harvested at full maturity when about 90% of the seeds become golden yellow in color. The crops were harvested on 11 May 2014. The harvested crop of each plot was separately bundled and threshed by pedal thresher. Grains were sun-dried and cleaned properly. Moisture was adjusted at 14% moisture during weight. Straws were also sun dried properly. Finally grain and straw yields converted to t ha^{-1}.

Statistical analysis

Data were compiled and tabulated in proper form for statistical analysis. The recorded data on different parameters were analyzed with the help of computer package CropStat 7.2. The mean differences among the treatments were tested with Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Plant height, total tillers hill^{-1} and non-effective tillers hill^{-1}were significantly influenced by crop establishment method (Figure 1, 2 and Table 1). The maximum plant height (83.10 cm) was obtained from TPT, followed by unpuddled-one pass in UDC and the shortest plant (78.95 cm) from UZT. It is observed that the decreasing number of tillages found to produce a negative effect on plant height (Figure 1).

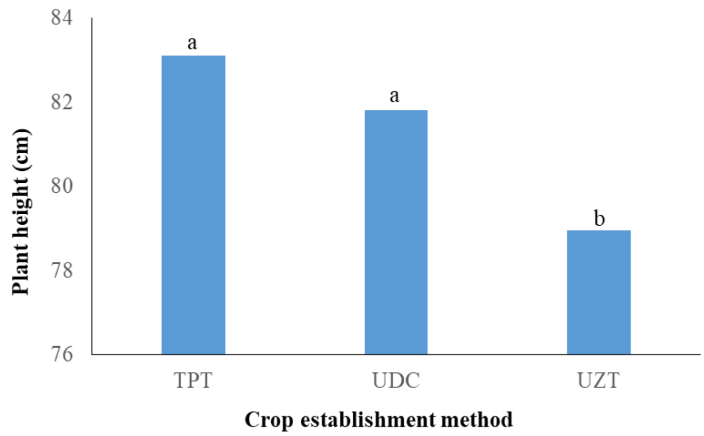

Fig. 1. The plant height of *Boro* rice (cv. BRRI dhan28) as influenced by different crop establishment method ($p<0.05$). TPT: Traditional puddled-transplanting, UDC: Unpuddled-dry cultivation, UZT: Unpuddled-zero tillage].

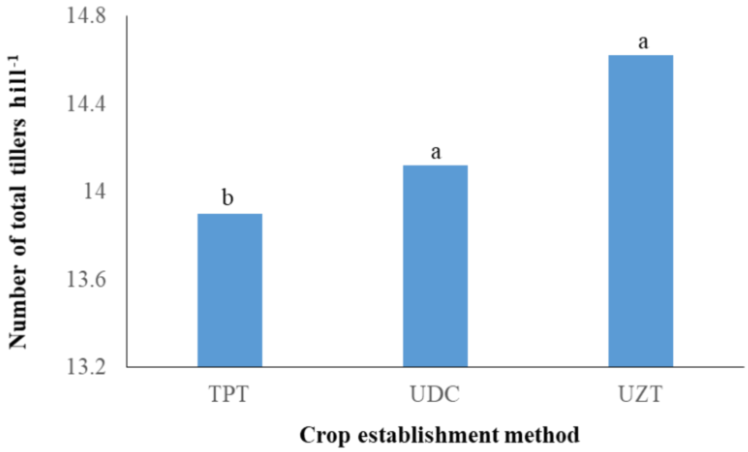

Fig. 2. Number of total tillers hill^{-1} of *Boro* rice as influenced by different crop establishment method ($p<0.05$). TPT: Traditional puddled-transplanting, UDC: Unpuddled-one pass in dry condition, UZT: Unpuddled-zero tillage.

Table 1. Effect of crop establish method on the crop characters, yield components and yield of *Boro* rice (cv. BRRI dhan28)

Crop establishment method	Effective tillers hill^{-1} (no.)	Non effective tillers hill^{-1} (no.)	Panicle m^{-2} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	Sterile spikelets panicle^{-1} (no.)	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw Yield (t ha^{-1})	Harvest Index (%)
TPT	12.02	1.88a	286.05	21.26a	115.12	6.01	22.24	3.18	2.99	51.54a
UDC	12.47	1.64b	288.50	21.39a	117.57	5.34	22.32	3.19	2.98	51.69a
UZT	12.78	1.83a	284.75	20.87b	115.06	5.41	21.77	3.19	3.12	50.49b
Level of significance	NS	*	NS	*	NS	NS	NS	NS	NS	*
CV (%)	19.1	6.0	3.7	3.2	5.2	18.2	3.5	12.0	12.9	2.8

TPT = Traditional puddled-transplanting, UDC= Unpuddled-one pass in dry condition, UZT= Unpuddled-zero tillage. * = Significant at 5% level of probability, NS = Not significant

The maximum number of total tillers hill^{-1} (14.62) was obtained from UZT which was at par with UDC and the lowest one (13.90) was counted from TPT (Figure 2). A similar result on number of total tillers hill^{-1} due to crop establishment method has also been reported by Hobbs *et al.* (1997). The maximum number of non-effective tillers hill^{-1} (1.88) was found from TPT which was at par with UZT and the lowest (1.64) was found from UDC. Crop establishment method was not significantly influenced the number of effective tillers hill^{-1} and panicles m^{-2} (Table 1). Numerically the highest number of effective tillers hill^{-1} (12.78) and maximum number of panicle m^{-2} (288.50) were found from UZT and UDC, respectively. The length of panicle was significantly influenced by the crop establishment method (Table 1). The maximum panicle length (21.39 cm) was obtained from UDC which was statistically identical with TPT and the shortest panicle (20.87 cm) from UZT. Grains panicle^{-1}, sterile spikelets panicle^{-1}, 1000-grain weight, grain yield and straw yield were not significantly influenced by crop established method. Numerically, higher grain yield (3.19 t ha^{-1}) was found in both UDC and UZT crop establishment system compare to TPT system. The highest harvest index (51.69%) was found in UDC which was at par with TPT and the lowest one (50.49 (3.19 t ha^{-1}) was found in UZT.

Plant height was significantly affected by the effect of fertilizer management. The maximum t plant (83.25 cm) was obtained from F_1 which was at par with F_2, F_3, and F_5 (Figure 3). The shortest plant height (78.25 cm) was obtained in F_4. Here, it is observed that reduced fertilizer dose found to produce a negative effect on plant height (Figure 3). Similar result on plant height due to fertilizer doses have also been reported in previous studies (Singh *et al.*, 2006; Paul *et al.*, 2020 and Paul *et al.*, 2021), who noticed that higher fertilizer application significantly increased plant height. The other crop characters, yield components and yield were not significantly influenced by fertilizer management (Table 2). Numerically grain yield (3.32 t ha^{-1}), straw yield (3.15 t ha^{-1}) and harvest index (51.35%) were found when fertilized with F_5 (Table 2).

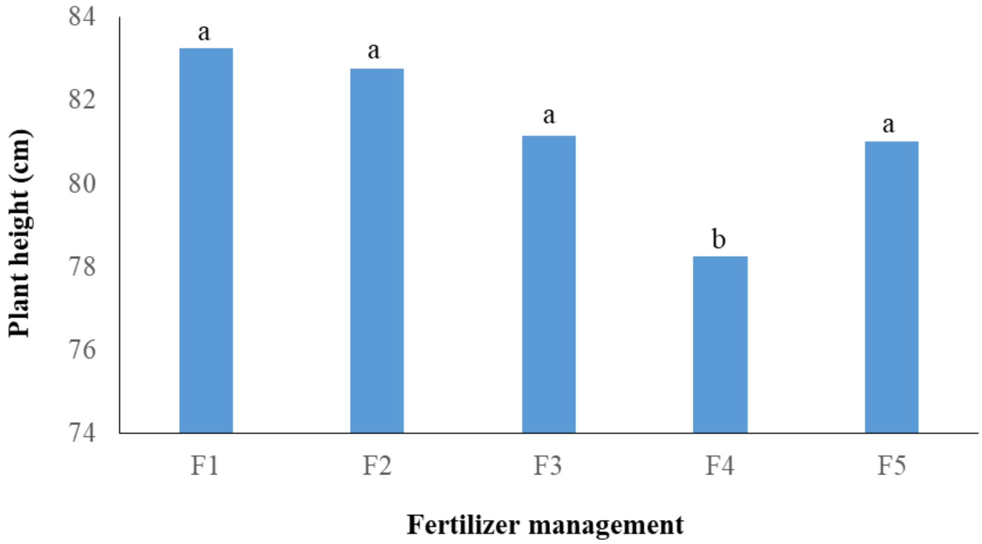

Fig. 3. The plant height of *Boro* rice as influenced by fertilizer management ($p<0.05$). F_1: N, P, K, S, Zn at recommended (RD) dose, F_2: N, K, S, Zn at RD plus 50% P, F_3: N, P, S, Zn at RD plus 50% K, F_4: P, K, S, Zn at RD plus 75% N as Guti urea, F_5: P, K, S, Zn at RD plus 75% N as prilled urea.

Table 2. Effect of fertilizer management on the crop characters, yield components and yield of *Boro* rice (cv. BRRI dhan28)

Crop establishment method	Effective tillers hill^{-1} (no.)	Non-effective tillers hill^{-1} (no.)	Total tillers hill^{-1} (no.)	Panicles m^{-2} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	Sterile spikelets panicle^{-1} (no.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw Yield (t ha^{-1})	Harvest Index (%)
F_1	12.39	1.88	14.28	286.16	21.24	115.20	5.46	22.10	3.07	2.91	51.35
F_2	12.14	1.71	13.86	282.50	20.84	113.54	5.71	21.90	3.08	2.94	51.22
F_3	12.95	1.80	14.76	287.08	21.22	117.20	6.23	22.08	3.25	3.12	50.92
F_4	12.25	1.90	14.15	288.16	21.45	119.48	4.98	22.24	3.21	3.05	51.32
F_5	12.38	1.63	14.02	288.25	21.12	114.16	5.56	22.23	3.32	3.15	51.37
Level of significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	6.0	19.1	6.0	3.7	3.2	5.2	18.2	3.5	12.0	12.9	2.8

F_1= N, P, K, S, and Zn at recommended (RD) dose, F_2= N, K, S, and Zn at RD plus 50% P, F_3 = N, P, S, and Zn at RD plus 50% K, F_4 = P, K, S, and Zn at RD plus 75% N as Guti urea, F_5 = P, K, S, and Zn at RD plus 75% N as prilled urea. NS= Not significant

Table 3. Effect of interaction between crop establish method and fertilizer management on the crop characters, yield components and yield of *Boro* rice (cv. BRRI dhan28)

Crop establishment method	Plant height (cm)	Effective tillers hill^{-1} (no.)	Non- effective tillers hill^{-1} (no.)	Total tillers hill^{-1} (no.)	Panicles m^{-2} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	Sterile spikelets panicle^{-1} (no.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest Index (%)
TPT × F_1	84.50	12.07	1.91	13.98	286.50	20.98	115.53a	5.54a	22.10	3.00	2.83	51.48
TPT × F_2	84.25	12.28	1.91	14.20	281.00	20.91	110.65b	5.66a	22.16	3.08	2.92	51.47
TPT × F_3	84.25	12.28	1.66	13.95	287.50	20.91	121.17a	6.55a	22.21	3.21	3.01	51.51
TPT × F_4	80.00	11.59	2.04	13.63	287.50	21.66	121.16a	5.83a	22.37	3.16	2.97	51.56
TPT × F_5	82.50	11.87	1.88	13.75	287.75	21.83	107.08b	6.47a	22.36	3.47	3.25	51.68
UDC × F_1	84.25	12.37	1.70	14.07	287.00	21.66	115.31a	5.21b	22.65	3.01	2.77	52.12
UDC × F_2	86.00	12.24	1.58	13.82	287.00	21.20	114.65a	6.97a	22.21	3.08	2.92	51.47
UDC × F_3	81.25	13.08	1.71	14.79	287.00	21.58	120.12a	5.93a	22.37	3.25	3.03	51.60
UDC × F_4	76.00	12.45	1.87	14.32	288.50	21.58	116.74a	3.60c	22.36	3.13	2.95	51.56
UDC × F_5	81.50	12.20	1.37	13.57	293.00	20.95	121.01a	5.00b	22.05	3.47	3.25	51.68
UZT × F_1	81.00	12.74	2.03	14.78	285.00	21.08	114.76a	5.64a	21.56	3.21	3.15	50.46
UZT × F_2	78.00	11.91	1.63	13.57	279.50	20.40	115.31a	4.51b	21.34	3.08	2.98	50.74
UZT × F_3	78.00	13.49	2.03	15.53	286.75	21.16	110.32b	6.20a	21.65	3.28	3.32	49.64
UZT × F_4	78.75	12.70	1.78	14.49	288.50	21.12	120.53a	5.51b	22.00	3.33	3.22	50.85
UZT × F_5	79.00	13.08	1.66	14.74	284.00	20.58	114.40a	5.22b	22.30	3.03	2.95	51.48
Level of significance	NS	NS	NS	NS	NS	NS	8.69	*	NS	NS	NS	51.47
CV (%)	3.7	6.0	19.1	6.0	3.7	3.2	5.2	18.2	3.5	12.0	12.9	51.56

TPT= Traditional puddled-transplanting, UDC= Unpuddled-one pass in dry condition, UZT= Unpuddled-zero tillage; F_1= N, P, K, S, and Zn at recommended (RD) dose, F_2= N, K, S, and Zn at RD plus 50% P, F_3 = N, P, S, and Zn at RD plus 50% K; F_4 = P, K, S, and Zn at RD plus 75% N as Guti urea, F_5 = P, K, S, and Zn at RD plus 75% N as prilled urea. * = Significant at 5% level of probability, NS= Not significant

The number of grains panicle^{-1}, sterile spikelets panicle^{-1} and the crop characters and yield components and yield were not significantly influenced by the interaction between crop establishment method and fertilizer management (Table 3). Apparently, the highest grain yield (3.47 t ha^{-1}) was obtained from UDC × F_5 and TPT × F_5 and the lowest grain yield (3.00 t ha^{-1}) from TPT × F_1 where numerically the highest straw yield (3.32 t ha^{-1}) from UZT×F_3 (Table 3). The highest number of panicle m^{-2} (293) in UDC× F_5 and higher number total tillers hill^{-1} in UZT × F_3 might be responsible for higher grain and straw yields UDC × F_5 and UZT× F_3, respectively.

Economic analysis

The highest variable cost (Tk. 49374 ha^{-1}) was obtained from TPT×F_1 because all variable costs were considered in calculation. While the lowest variable cost (43337 BDT ha^{-1}) from UZT × F_2 (Table 4).

Table 4. Economic performance of *Boro* rice under crop establishment method and fertilizer management

Crop establishment method × Fertilizer management	Variable cost (Tk. ha^{-1})	Gross return (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	Benefit-cost ratio (BCR)
TPT × F_1	49374	63297	13923	1.28
TPT × F_2	47872	65189	17316	1.36
TPT × F_3	48360	67665	19305	1.39
TPT × F_4	48516	65734	17218	1.35
TPT × F_5	48126	73281	25155	1.52
UDC × F_1	47101	63063	15962	1.34
UDC × F_2	45599	65189	19590	1.43
UDC × F_3	46087	67646	21559	1.47
UDC × F_4	46243	65637	19394	1.42
UDC × F_5	45853	73281	27428	1.60
UZT × F_1	44839	67938	23099	1.51
UZT × F_2	43337	65150	21813	1.50
UZT × F_3	43825	67041	23216	1.53
UZT × F_4	43981	70610	26629	1.61
UZT × F_5	43669	64331	20662	1.47

The highest gross return (73281 Tk. ha^{-1}) was found in TPT × F_5 and UDC × F_5. The lowest gross return (Tk. 63063 ha^{-1}) was obtained from UDC × F_1. The highest gross margin (27428 BDT ha^{-1}) was found UDC × F_5 followed by UZT × F_4 (Table 4). The higher benefit-cost ratio 1.61 and 1.60 obtained from UZT × F_4 and UDC × F_5, respectively. This might be possibly due to higher gross return and low variable cost of unpuddled crop establishment method and reduced N dose used. So, it can be concluded that unpuddled-zero tillage with P, K, S, and Zn at RD plus 75% N as Guti urea (UZT × F_4) and unpuddled-one pass in dry condition with P, K, S, and Zn at RD plus 75% N as prilled urea (UDC × F_5) could be the beneficial for *Boro* rice (var. BRRI dhan28) cultivation in T. *Aman*-Mustard-*Boro* rice cropping pattern.

Conclusion

From the results of the study, it can be concluded that unpuddled-one pass dry cultivation (UDC) with P, K, S, Zn at RD plus 75% N as prilled urea (UDC × F_5) could be the suitable technique for *Boro* rice (var. BRRI dhan28) cultivation in T. *Aman*-Mustard-*Boro* rice cropping pattern.

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