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DEVELOPMENT OF FERTILIZER RECOMMENDATION OF FOUR CROPS GROWN UNDER THE CROPPING PATTERN: MUSTARD-BORO- T. AUS- T. AMAN IN AEZ - 8

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Abstract

A field experiment on mustard- boro- T. aus- T. aman cropping pattern was conducted in the soil of Jamalpur (AEZ - 8) during two consecutive years 2014-2015 and 2015-2016 with the objectives of finding out suitable fertilizer requirements for a four crops pattern mustard- boro- T. aus- T. aman. The experiment was conducted in RARS (AEZ-8), Jamalpur. There were eight treatments in the study viz. T_1: 100% soil test based (STB) NPKSZnB, T_2: T_1 + 25% N, T_3: T_1 + 25% NP, T_4: T_1 + 25% NK, T_5: T_1 + 25% PK, T_6: T_1 + 25% NPK, T_7: 75% of T_1, T_8: Native fertility. The experiment was laid out in randomized complete block design with three replications. Data revealed that the seed yield of mustard, grain yield boro, T. aus and T. aman were significantly influenced by application of 25% extra NPK consistently. The highest seed yield of mustard and grain yield of boro, T. aus and T. aman was obtained from the T_6 treatment where 25% additional NPK was added over the 100% STB. The lowest yield was recorded for the native fertility treatment in both years.

Introduction

Feeding the enormous population is one of the greatest challenges for Bangladesh. At present the total cultivable land of Bangladesh is 8.5 million hectares which is decreasing gradually because of non-agricultural use. According to BBS (2016) around 3795 and 1688 thousand ha of land remain under double and triple cropped area, respectively. There exists an ample scope to expand crop production vertically through increasing cropping intensity against present crop intensity 190%. Incorporating short duration crops and through management of cultivation practices and sowing time, present cropping intensity can be increased up to 400%. In order to produce more food within a limited area, the cropping intensity should be increased producing three or more crops on the same land in a year. Most of the popular cropping patterns practiced around the country comprise of two to three crops a year (Islam, 2018).

However, intensive land use without appropriate soil management has caused depletion of soil fertility (FRG, 2012). So, proper fertilizer management is very

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important considering the residual effect of the nutrients. Organic or inorganic sources of nutrients applied to preceding crop can benefit the succeeding crop to a great extent (Hegde, 1998). At present fertilizer application is mostly based on the nutrient requirement of individual crops ignoring the carry-over effect of fertilizers applied to the preceding crop. For maintaining of soil quality and attainable crop yield, it is required to apply proper amount of fertilizers and minimize the misuse of soil resources which is possible by knowing actual situation of soil physical, chemical and biological condition through observation, investigation and soil testing. Considering the above facts, the present study was undertaken with the long-term objectives to find out judicious nutrient recommendation for Mustard-Boro-T. Aus-T. Aman cropping pattern in AEZ - 8.

Materials and Methods

The field experiment was conducted at the central farm of RARS Jamalpur (AEZ - 8) during 2014-15 and 2015-16. The initial soil samples, collected before establishing the experiment from a depth of 0-15 cm were analyzed in the laboratory following standard methods. Initial values of some important soil chemical parameters of the experimental soil are presented in Table 1.

Table 1. Chemical properties of experimental soil (initial) at RARS Jamalpur

Location	pH	OM (%)	Ca	Mg	K	Total N (%)	P	S	B	Cu	Fe	Mn	Zn
			meq $100g^{-1}$				$\mu g\ g^{-1}$						
Jamalpur	7.2	0.92	6.7	2.3	0.071	0.057	7.6	3.7	0.19	1.8	41	6.4	0.9
Critical Level		-	2.0	0.5	0.12	0.12	10	10	0.20	0.2	4	1	0.6

The experiment was laid out in a randomized complete block design with three replications. Eight different treatments viz. T_1: 100% STB (Soil Test Based Fertilization) of recommended fertilizer dose according to Fertilizer Recommendation Guide (BARC, 2012), T_2: T_1+ 25% N, T_3: T_1+ 25% NP, T_4: T_1+ 25% NK, T_5:T_1+ 25% PK, T_6:T_1+ 25% NPK, T_7: 75% of T_1, T_8: Native fertility was selected for different plots randomly. The unit plot size was 4.2m × 3.0m. Mustard crop (var. BARI Sarisha-14) was used as test crop for the first component of the pattern. Mustard seeds were sown in line with 30cm row to row on November 06, 2014 and November 04, 2015.

Fertilizer N-P-K-S-Zn and B were supplied from urea, TSP, MoP, gypsum, zinc sulphate and boric acid, respectively. All PKSZnB and half of N were applied at the time of final land preparation. The remaining half of N was applied as top dress at 30 days after sowing. Two irrigations and other intercultural operations were done as and when required.

Mustard was harvested on January 22, 2015 and January 20, 2016. Data on yield and yield contributing characters of mustard were recorded and statistically analyzed.

After mustard, boro rice (BRRI dhan28) was transplanted in the plots on January 26, 2015 and January 25, 2016 with 20 cm × 20 cm spacing. All fertilizers including 1/3rd of N were applied before transplanting. Rest of N was applied in two installments at 15 and 45 days after transplanting. Boro rice was harvested on 02 May, 2015 and 01 May, 2016. For T. aus rice, BRRI dhan48 was used in the experiment. Transplanting was done on 05 May 2015 and 04 may 2016 with a row to row spacing of 20 cm and plant to plant spacing of 15 cm. All fertilizers including 1/3rd of N were applied before transplanting. Rest of N was applied in two installments at 15 and 45 days after transplanting. Aus rice was harvested on 26 July, 2015 and 25 July, 2016.

For T. aman rice, the variety BINA Dhan-7 was used in the experiments. Transplanting was done on 29 July 2015 and 28 July 2016 with a row to row spacing of 20 cm and plant to plant spacing of 15 cm. Aman rice was harvested on November 02, 2015 and November 03, 2016.

Ten plants were randomly collected prior to harvest from each plot excluding border plants after attaining the maturity of the crops to collect data on yield attributes. Data on grain and straw yield were recorded from 3 m^2 area. Statistic 10 was used to analyze data LSD was used determine the significant differences between the treatments at 5% level of probability. Rice equivalent yield (REY) was computed as yield of individual crop multiplied by market price of that crop divided by market price of rice.

$$\text{Rice equivalent yield (t ha}^{-1}\text{yr}^{-1}\text{)} = \frac{\text{Yield of individual crop} \times \text{Market price of that crop}}{\text{Market price of rice}}$$

Results and Discussion

Mustard

The highest plant height (108.67 cm and 106.71 cm in 2014-2015 and 2015-2016, respectively) was recorded from the treatment T_6 where 25% extra NPK was added over the 100% STB fertilizer rate which was statistically similar to those recorded in treatment T_3 and T_4. The lowest plant height (96.87 and 94.57 cm in 2014-2015 and 2015-2016, respectively) was noted in the control or native fertility treatment. Number of branches, pods per plant, pod length, seed per pod etc were influenced by the treatments where extra NPK were added (except control and T_7). Seed yield as well as stover yield were recorded maximum in T_6 (Table 2). The results were consistent in the following year 2015-2016 (Table 3). Similar trend of increased yield in mustard due to added fertilizers in 3 or 4 cropping patterns was also documented by Chowdhury *et al.* (2017), Saha *et al.* (2016) and Mollah *et al.* (2011).

Table 2. Yield and yield contributing characters of mustard at Jamalpur during the *rabi* season of 2014-15

Treatment	Plant height (cm)	No. of branches	No. of pods plant^{-1}	Pod length (cm)	No. of seeds pod^{-1}	Ineffective pods plant^{-1}	1000 seed weight(g)	Seed yield	Stover yield
								(t ha^{-1})	
T_1	103.13 c	6.80 cd	73.53 de	4.60 bc	35.86 c	16.00 ab	3.40 cd	1.26 cde	2.33 b
T_2	104.53 b	7.73 bc	83.53 c	5.20 ab	40.40 ab	14.33 bc	3.66 bc	1.46 bcd	2.40 b
T_3	105.27 ab	8.20 b	97.47 b	5.53 a	40.53 ab	14.06 bc	3.83 b	1.73 ab	2.53 b
T_4	105.03 ab	8.00 b	96.33 b	5.54 a	40.46 ab	14.00 bc	3.70 bc	1.50 bc	2.46 b
T_5	104.00 b	6.53 de	77.00 cd	5.40 a	39.40 ab	12.66 cd	3.46 bcd	1.46 bcd	2.40 b
T_6	108.67 a	9.46 a	106.20 a	5.93 a	41.80 a	11.00 d	4.26 a	1.86 a	2.80 a
T_7	102.67 c	6.40 de	69.00 ef	4.09 c	33.86 c	17.66 a	3.20 de	1.16 de	2.26 b
T_8	96.87 d	5.53 e	65.33 f	4.06 c	31.33 d	18.33 a	2.96 e	1.06 e	1.70 c
CV (%)	7.14	8.41	4.57	8.35	7.65	9.48	6.60	9.15	6.87

T_1: 100% STB (N_{138} P_{25} K_{60} $S_{15}Zn_{02}B_{02}$ kg/ha), T_2: T_1 + 25% N, T_3: T_1 + 25% NP, T_4: T_1 + 25% NK, T_5: T_1 + 25% PK, T_6: T_1 + 25% NPK, T_7: 75% of T_1, T_8: control.

Table 3. Yield and yield contributing characters of mustard at Jamalpur during the *rabi* season of 2015-16

Treatment	Plant height (cm)	No. of branches	No. of pods plant^{-1}	Pod length	No. of seeds pod^{-1}	Ineffective pods plant^{-1}	1000 seed weight (g)	Seed yield	Stover yield
								(t ha^{-1})	
T_1	100.34 c	6.71cd	72.44de	4.78bc	36.85bc	15.10 ab	3.33 cd	1.18cde	2.25b
T_2	102.23 b	7.64bc	82.42 c	5.18ab	39.43ab	13.23 bc	3.54bc	1.37bcd	2.32 b
T_3	103.17 b	8.12 b	96.36 b	5.47a	39.58ab	13.16 bc	3.73 b	1.65ab	2.45 b
T_4	105.03 ab	7.98b	95.14 b	5.44a	39.49ab	13.20 bc	3.60 bc	1.42bc	2.38 b
T_5	102.00 b	6.44 de	76.06 cd	5.36 a	38.47ab	11.76 cd	3.36 bcd	1.38bcd	2.31 b
T_6	106.71 a	9.38 a	105.08 a	5.86 a	40.81 a	10.10 d	4.16 a	1.78 a	2.72 a
T_7	100.57 c	6.32 de	68.34ef	4.04 c	32.84 c	16.76 a	3.10 de	1.09 de	2.18 b
T_8	94.57 d	5.43e	64.18 f	4.02 c	30.37 c	17.43 a	2.87 e	0.98 e	1.62 c
CV (%)	9.11	7.89	5.79	7.74	7.89	8.73	7.87	8.97	7.13

T_1: 100% STB (N_{138} P_{25} K_{60} $S_{15}Zn_{02}B_{02}$ kg/ha), T_2: T_1 + 25% N, T_3: T_1 + 25% NP, T_4: T_1 + 25% NK, T_5: T_1 + 25% PK, T_6: T_1 + 25% NPK, T_7: 75% of T_1, T_8: control.

Boro Rice

The second component of the cropping pattern was boro rice. In 2015, the tallest plant (96.42 cm) was observed in T_5 treatment which was statistically at par with T_4 and T_6. Growth and yield contributing characters eg. plant height, number of tillers, number of panicles and panicle length and grain yield were recorded higher for the treatment with extra NPK. The plant growth and yield were recorded minimum in control (Table 4). Insufficient nutrient content of T_7 (75% of STB) might be resulted lower yield. Similar trend of results was observed in the following year, 2015-2016 (Table 5). This result was also in agreement with Hasan *et al.* (2017), Yoseftabar (2012) and Chaudhary *et al.* (2011) who reported an increase of N, P and K fertilizer doses from STB recommended doses significantly increased yield and yield contributing parameters like effective tillers hill^{-1}, panicle length, filled grains panicle^{-1} and 1000-grain weight of rice.

Table 4. Yield and yield contributing characters of boro rice during the year 2015

Treatments	Plant height (cm)	No. of tiller	No. of panicle	Panicle length (cm)	1000-grain wt.(g)	Straw yield	Grain yield
		hill^{-1}				(t ha^{-1})	
T_1	88.33c	19.98a	19.27a	19.66a	22.50	6.40a	5.51ab
T_2	91.07b	19.89a	19.05a	19.64a	23.32	6.27a	5.62ab
T_3	92.12b	20.07a	19.18a	19.95a	22.08	6.73a	6.22 a
T_4	95.30a	19.99a	19.25a	19.96a	21.50	6.22a	5.83ab
T_5	94.76ab	20.25a	19.35a	19.62a	21.98	6.07a	5.81ab
T_6	96.42a	20.12a	19.68a	19.81a	23.38	6.87a	6.29 a
T_7	88.29c	20.08a	19.25a	19.31a	21.24	5.87a	5.20ab
T_8	78.98d	15.15b	14.48b	16.52b	20.99	4.67b	4.30 b
CV (%)	10.35	12.58	7.36	6.86	8.27	9.42	9.67

T_1: 100% STB (N_{158} P_{34} K_{123} S_{52} Zn_{03} kg/ha), T_2: T_1 + 25% N, T_3: T_1 + 25% NP, T_4: T_1 + 25% NK, T_5: T_1 + 25% PK, T_6: T_1 + 25% NPK, T_7: 75% of T_1, T_8: control.

T. aus rice

T. aus rice was transplanted as the third crop of the pattern. The variety used was BRRI dhan48 is a short duration variety. Yield and yield contributing characters were significantly influenced consistently by fertilizer treatments in both years (Table 6 and 7). The highest plant height was recorded from the treatment T_3 while the lowest plant height was obtained from the control or native fertility treatment. The highest grain yields of T. aus rice (3.14 t ha^{-1} in 2015 and 3.10 t ha^{-1} in 2016) were noted in the treatment T_6 where 25% additional NPK was

added with the 100% STB rates. The native fertility treatment produced the lowest grain yield and the results were consistent in both the years.

Table 5. Yield and yield contributing characters of boro rice during the year 2016

Treatments	Plant height (cm)	No. of tiller	No. of panicle	Panicle length (cm)	1000 grain wt.(g)	Straw yield	Grain yield
		hill^{-1}				(t ha^{-1})	
T_1	85.44c	19.84a	19.16a	19.52a	22.43	6.22a	5.41ab
T_2	89.03ab	19.72a	19.00a	19.50a	23.25	6.15a	5.57ab
T_3	90.75ab	20.01a	19.21a	19.72a	22.01	6.32a	6.05 a
T_4	93.72a	19.83a	19.12a	19.85a	21.42	6.30a	5.73ab
T_5	94.55a	20.17a	19.08a	19.57a	21.82	6.03a	5.71ab
T_6	93.92a	20.11a	19.57a	19.82a	23.26	6.42a	6.08 a
T_7	86.88bc	20.01a	19.15a	19.28a	21.16	5.73a	5.17ab
T_8	76.96d	15.03b	14.57b	16.43b	20.81	4.38b	4.34b
CV (%)	13.45	11.42	7.31	8.92	4.23	10.32	9.73

T_1: 100% STB (N_{158} P_{34} K_{123} S_{52} Zn_{03} kg/ha), T_2: T_1 + 25% N, T_3: T_1 + 25% NP, T_4: T_1 + 25% NK, T_5: T_1 + 25% PK, T_6: T_1 + 25% NPK, T_7: 75% of T_1, T_8: control.

Table 6. Yield and yield contributing characters of T. aus rice during the year 2015

Treatments	Plant height (cm)	No. of tiller	No. of panicle	Panicle length (cm)	1000-grain wt.(g)	Straw yield	Grain yield
		hill^{-1}				(t ha^{-1})	
T_1	81.13c	16.73a	16.22a	16.64a	19.52	4.44a	2.84ab
T_2	90.45ab	16.73a	16.01a	16.61a	19.34	4.22a	2.87ab
T_3	94.42a	17.21a	16.32a	16.61a	19.91	4.02a	2.91ab
T_4	93.32a	16.73a	16.21a	16.92a	19.51	4.61a	2.85ab
T_5	90.22ab	17.00a	16.12a	16.94a	19.02	4.02a	2.83ab
T_6	92.87a	17.13a	16.61a	16.82a	19.32	4.04a	3.14 a
T_7	86.19bc	17.01a	16.22a	16.31a	19.48	3.82a	2.12b
T_8	76.41d	15.11b	14.41b	14.52b	19.91	2.42b	1.91 b
CV (%)	9.43	8.78	6.36	7.92	4.27	11.46	9.87

T_1: 100% STB (N_{168} P_{15} K_{60} S_{37} Zn_{01} kg/ha), T_2: T_1 + 25% N, T_3: T_1 + 25% NP, T_4: T_1 + 25% NK, T_5: T_1 + 25% PK, T_6: T_1 + 25% NPK, T_7: 75% of T_1, T_8: control.

Table 7. Yield and yield contributing characters of T. aus rice during the year 2016

Treatments	Plant height (cm)	No. of tiller hill^{-1}	No. of panicle hill^{-1}	Panicle length (cm)	1000 grain wt.(g)	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})
T_1	81.00c	15.53a	15.12a	15.64a	19.47	4.34a	2.72ab
T_2	89.12ab	15.63a	15.11a	15.61a	19.31	4.12a	2.75ab
T_3	93.31a	16.33a	15.21a	15.61a	19.56	4.00a	2.82ab
T_4	92.22a	15.83a	15.18a	15.92a	19.42	4.42a	2.71ab
T_5	89.08ab	16.10a	15.04a	15.94a	19.21	4.08a	2.74ab
T_6	91.71a	16.22a	15.43a	15.82a	19.32	4.00a	3.10 a
T_7	85.12bc	16.00a	15.17a	15.31a	19.35	3.72a	2.24b
T_8	75.31d	14.00b	13.83b	13.52b	19.33	2.45b	1.89 b
CV (%)	8.85	7.11	6.36	6.86	4.69	9.46	9.73

T_1: 100% STB (N_{168} P_{15} K_{60} S_{37} Zn_{01} kg/ha), T_2: T_1 + 25% N, T_3: T_1 + 25% NP, T_4: T_1 + 25% NK, T_5: T_1 + 25% PK, T_6: T_1 + 25% NPK, T_7: 75% of T_1, T_8: control.

T. aman rice

The highest plant heights (97.58 and 97.54 cm, respectively in 2015 and 2016) were recorded from the treatment T_6 where 25% extra NPK was added to the 100% STB fertilizer rate which was similar with T_1, T_2, T_3 and T_4 and T_5 The lowest plant height (71.45 cm in 2014-2015 and 71.41 cm in 2015-2016, respectively) was noted in the control. The highest number of tillers hill^{-1} was observed in T_6 treatment both years which was similar with rest of the treatments except T_8 which produced lowest number of tillers hill^{-1}. There were no significant variations among the treatments in case of panicle length and 1000 grain weight.

Table 8. Yield and yield contributing characters of T. aman rice during the year 2015

Treatments	Plant height (cm)	No. of tiller hill^{-1}	No. of panicle hill^{-1}	Panicle length (cm)	1000 grain wt.(g)	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})
T_1	95.28ab	16.22a	15.38ab	23.28	23.29	5.78bc	3.97a
T_2	95.82ab	16.81a	16.28ab	23.32	23.25	6.22abc	4.07a
T_3	97.54a	17.12a	16.46a	23.83	23.82	6.72ab	4.13a
T_4	96.48ab	17.11a	16.29ab	23.58	23.74	6.58ab	4.11a
T_5	96.42ab	17.09a	16.32ab	23.66	23.58	6.32abc	4.10a
T_6	97.58a	17.27a	16.72a	24.12	25.13	7.59a	4.17a
T_7	93.65b	15.88a	15.19b	23.58	23.21	5.29bc	3.72b
T_8	71.45c	9.88b	9.18c	22.49	23.12	3.85c	3.13c
CV (%)	7.12	11.68	8.78	4.33	3.87	10.77	6.83

T_1: 100% STB (N_{135} P_{34} K_{100} S_{40} kg/ha), T_2: T_1 + 25% N, T_3: T_1 + 25% NP, T_4: T_1 + 25% NK, T_5: T_1 + 25% PK, T_6: T_1 + 25% NPK, T_7: 75% of T_1, T_8: control.

Table 9. Yield and yield contributing characters of T. aman rice during the year 2016

Treatments	Plant height (cm)	No. of tiller	No. of panicle	Panicle length (cm)	1000 grain wt.(g)	Straw yield	Grain yield
		hill^{-1}				(t ha^{-1})	
T_1	95.52ab	15.82a	15.18b	18.41	21.32	4.81bc	3.48a
T_2	95.51ab	15.98a	15.52ab	18.31	21.56	5.00abc	3.53a
T_3	96.54ab	16.75a	16.43ab	18.73	21.23	5.75ab	3.67a
T_4	96.42ab	16.18a	16.23ab	18.61	21.24	5.12ab	3.57a
T_5	97.52a	16.00a	15.88ab	18.73	21.55	5.02abc	3.58a
T_6	97.54a	16.83a	17.00a	18.91	21.56	5.88a	3. 96a
T_7	93.62b	15.75a	15.18ab	18.12	21.12	4.51bc	3.25a
T_8	71.41c	9.68b	9.06c	18.02	21.07	3.83c	2.26b
CV (%)	6.66	5.67	6.75	5.24	3.90	9.66	7.89

T_1: 100% STB (N_{135} P_{34} K_{100} S_{40} kg/ha), T_2: T_1 + 25% N, T_3: T_1 + 25% NP, T_4: T_1 + 25% NK, T_5: T_1 + 25% PK, T_6: T_1 + 25% NPK, T_7: 75% of T_1, T_8: control.

The highest grain yield (4.17 t ha^{-1} in 2015 and 3.96 t ha^{-1} in 2016) was obtained from the treatment T_6 where 25% extra NPK was applied. The native fertility treatment produced the lowest grain yield (3.13 t ha^{-1} in 2015 and 2.26 t ha^{-1} in 2016) of T. aman rice. Ali *et al.* (2009) reported the highest grain yield from estimated fertilizer dose based on soil test value for HYG and lowest from control treatment. Saha*et al.* (2016) also documented higher yield from 20% more than the STB dose in potato-maize-T. aman cropping pattern at AEZ-3.

Total rice (system) yield

To compare among the treatments, mustard yield was converted into rice equivalent yield on the basis of prevailing market price. The highest rice equivalent yield was recorded from T_6 treatment due to the highest yield of mustard, boro rice, T. aus rice and T. aman rice. T_8 showed the lowest rice equivalent yield due to lower yield of all the four crops (Table 10). Highest total rice (system) yield of 16.79 t ha^{-1} year^{-1} was obtained from T_6 treatment where 25% NPK was added with 100% STB rates. Lowest total rice (system) yield of 10.67 t ha^{-1} year^{-1} was obtained from control i.e. native fertility treatment (T_8). Mollah *et al.* (2008) reported that three years average results of estimated inorganic fertilizers for high yield goal (HYG) gave higher yield performance of crops compared to the other treatments.

Table 10. Average yield, rice equivalent yield and total rice (system) yield (t ha^{-1} year^{-1}) of mustard- boro-T. aus-T. aman cropping pattern

Treatment	Average yield of crops				Rice equivalent yield	Total rice (system) yield
	Mustard	Boro	T.aus	T.aman	Mustard	
T_1	1.22	5.46	2.78	2.78	3.73	12.24
T_2	1.42	5.60	2.81	2.81	3.80	12.64
T_3	1.69	6.14	2.87	2.87	3.90	13.57
T_4	1.46	5.78	2.78	2.78	3.84	12.80
T_5	1.42	5.76	2.79	2.79	3.84	12.76
T_6	1.82	6.19	3.12	3.12	4.07	14.25
T_7	1.13	5.19	2.18	2.18	3.49	10.68
T_8	1.02	4.32	1.90	1.90	2.13	9.14

Price: 1 kg mustard = Tk. 50, 1 kg rice = Tk. 24

T_1: 100% STB, T_2: T_1 + 25% N, T_3: T_1 + 25% NP, T_4: T_1 + 25% NK, T_5: T_1 + 25% PK, T_6: T_1 + 25% NPK, T_7: 75% of T_1, T_8: control treatment.

Conclusion

From this study and foregoing discussion, it was observed that STB+ 25% NPK was profitable on the whole pattern basis than all other fertilizer combinations used in the study. So, STB+ 25% NPK may be recommended for mustard- boro-T. aus-T. aman based cropping pattern under Jamalpur region (AEZ-8).

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