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INCREASING CROPPING INTENSITY AND CROP PRODUCTIVITY OF FOUR CROPS BASED MUSTARD-BORO-T. AUS-T. AMAN CROPPING PATTERN

A. Barman[1], S. Shome[2], M.R. Khatun[1], M.M. Masud[1] and S. Akther[1]

[1]Soil Science Division, BARI, Gazipur, Bangladesh
[2]Department of Agronomy, SAU, Dhaka, Bangladesh
Corresponding E-mail: alakbarman.sau@gmail.com

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Abstract

A field trial on soil test based (STB) fertilizer doses was conducted during the year of 2017-2018 and 2018-2019 in Jashore region (AEZ-11) to find out the most suitable fertilizer doses for four crop based cropping pattern considering the agronomic feasibility and economic return of the system. The experiment consisted of eight different treatments viz. T_1: 100% NPKSZnB (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: Native fertility. Randomized complete block design (RCBD) with three replications was followed. Data revealed that seed yield of mustard was remarkably influenced by fertilizer treatments while grain yield of other components of the cropping system was not affected significantly by the treatments except control or native fertility. It was observed that 25% more NPK over 100% STB dose provided the highest yield of all the component crops. The highest rice equivalent yield (3.34 t ha^{-1}) was recorded from T_6 and the lowest (1.88 t ha^{-1}) from T_8 treatment. Maximum gross return (Tk. 420000/ha) and marginal benefit cost ratio (4.08) were also obtained from T_6 treatment. So, 25% NPK+ 100% STB dose of fertilizer could be followed for productive and remunerative rice based cropping system Mustard-Boro-T. Aus-T.Aman in AEZ-11.

Introduction

Bangladesh is one of the highest populous countries of the world with the annual growth rate of about 1.37% (BBS, 2019). On the other hand, available agricultural land of Bangladesh is decreasing with an alarming rate of about 1% per year (Hossain *et al.*, 2014). Rate of cropland shifting to non-agricultural land (housing, industry, etc.) is formidable as it is associated with the food security of the country (Islam *et al.*, 2018). Meeting the challenge of ensuring food security through horizontal expansion of land is not possible due to decrease in agricultural land. So intensifying land use system through multiple cropping or by growing more and more crops on the same piece of land in a calendar year is a promising option to feed this teeming millions.

Rice based cropping system consisting of Boro-Fallow-T. Aman is a popular cropping pattern of Bangladesh (Parvin *et al.*, 2017). Inclusion of Mustard and short duration T. Aus variety in this cropping pattern could increase the cropping intensity of our country up to 400% as well as improve the socio-economic condition of the farmer. However, the advantage of including extra crops in rice based cropping systemcould depends upon the selection of variety and appropriate agronomic management practices such as fertilizer management (Hossain *et al.*, 2014). Aziz *et* *al.* (2013) reported that multiple cropping system effects soil carbon and nitrogen status, and also improve soil functional properties. Nevertheless, continuous cropping causes nutrient mining from soil while a blanket fertilizer dose for all regions without considering the soil nutrient status leads to tremendous damage to soil, environment and economy. Sultana *et al.* (2015) opined that actual recommended fertilizer dose is higher than actual need of fertilizer and this gap creates soil nutrient imbalance.As soil fertility is a major determinant for the success and failure of a crop production system, time demands a suitable fertilizer recommendation based on soil testing for promising four crops based cropping pattern which is agronomically feasible and economically profitable. As such, the present study was undertaken to find out the most suitable fertilizer dose for Mustard-Boro-T.Aus-T.Aman cropping pattern at AEZ-11 considering both the yield and economic return of the system.

Materials and Methods

Initial soil status

The field experiment was executed at the central farm of RARS, Jashore (AEZ 11) during 2017-18 and 2018-19. The initial soil samples from 0-15 cm depth was collected and analyzed before establishing the experiment. Initial soil status of experimental field is presented in Table 1.

Table 1. Chemical properties of experimentalsoil (initial) at the RARS, Jashore

pH	OM	Ca	Mg	K	Total N %	P	S	B	Cu	Fe	Mn	Zn
	(%)	meq/100 g soil				µg g^{-1}						
7.7	0.92	12	3.4	0.19	0.048	15.1	18.0	0.14	2.1	38	5.0	2.0
Critical level		2.0	0.5	0.12	Very low	7.0	10	0.2	0.2	4.0	1.0	0.6

Experimental details

The experiment was conducted in a Randomized complete block design with three replications. Eight different treatments viz. T_1: 100% NPKSZnB (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: Native fertility was applied in different plots having size of 4.2m x 3m each. The STB fertilizer dose for mustard, boro, T.Aus and T.Aman is $N_{138}P_{22}K_{25}S_0Zn_{1.85}$, $N_{186}P_{30}K_{23}S_{30}Zn_0$, $N_{90}P_{15}K_{2.17}S_{23}Zn_0$ and $N_{159}P_{30}K_7S_{24}Zn_0$, respectively. 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 30 cm row to row on November 06, 2017 and November 07, 2018. Fertilizer N-P-K-S-Zn and B were supplied from urea, TSP, MP, Gypsum, Zinc sulphate and Boric acid respectively. All PKSZnB and $^1/_3$ of N were applied at the time of final land preparation. The remaining two third of N were applied as top dress at 30 and 60 days after sowing. Three irrigation and other intercultural operations were done as and when required. The mustard was harvested on January 28, 2018 and January 27, 2019. After mustard, BRRI dhan28 was transplanted in the same plots on February 3, 2018 and February 2, 2019 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. For T. Aus rice, the variety BRRI dhan48 was used in the experiment. Transplanting was done on May 15, 2018 and May 14, 2019 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. For T. Aman rice, the variety BRRI dhan57 was used in the experiments.Transplanting was done on July 29, 2018 and July 28, 2019 with a row to row spacing of 20 cm and plant to plant spacing of 15 cm. T. Aman rice was harvested on November 4, 2018 and November 5, 2019.

Data collection and analysis

Data on yield and yield contributing characters were recorded and analyzed using Statistix 10 software. The means were separated using least significant difference (LSD) at the 5% level of significance. Rice equivalent yield is determined by the following equation

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

Economic analysis

Gross return from this rice based cropping system was calculated by multiplying the yield of crops with their market price. Total variable cost included the fertilizer cost. Gross margin was calculated by subtracting the variable cost from the gross return. Marginal Benefit Cost Ratio (MBCR) was calculated by dividing the marginal value product by total variable cost.

Results and Discussion

Mustard

Data regarding yield and yield contributing characters of mustard as influenced by the fertilizer rate has been presented in Table 2 & 3. In both the experimental years (2017-2018 and 2018-2019), 25% NPK+100% STB gave highest plant height, no. of branches plant^{-1}, no. of pods plant^{-1}, no. of grains pod^{-1}, 1000 seed weight (g) and stover yield while no fertilizer gave the lowest value of these parameters. In the two consecutive years, about 46% and 48% more yield was obtained than 100% STB dose while 25% more NPK was added to 100% STB dose. The native nutrient treatment produced the lowest mustard seed yield (0.91 and 0.96)t ha^{-1} in Jashore during the year of 2017-18 and 2018-19. Alike trend of increased yield in mustard due to added fertilizers in 3 or 4 cropping patterns was also reported by Barman *et al.* (2019) and Saha *et al.* (2016). Dobermann *et al.* (2013) opined that site-specific plant nutrient management (STB in our study) can increase yield as well as nutrient use efficiency of crop rotation.

Table 2. Yield and yield contributing characters of Mustard during 2017-2018

Treat ment	Plant height (cm)	No. of branches	No. of pods plant^{-1}	Pod length (cm)	No. of grains pod^{-1}	Ineffective pods plant^{-1}	1000 - seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1	82.03b	5.53de	63.53de	4.00bc	32.53c	9.33bcd	3.40cd	1.10c	2.26b
T_2	84.67ab	6.73bc	73.53c	4.40ab	35.46abc	11.00abc	3.66bc	1.12c	2.30b
T_3	87.60a	7.00b	87.46b	4.53ab	36.80ab	9.00cd	3.83b	1.43b	2.43ab
T_4	85.86ab	6.86bc	86.33b	4.53ab	35.53abc	8.00d	3.70bc	1.23c	2.36b
T_5	82.80b	5.80cd	67.00cd	4.40ab	34.40bc	11.66ab	3.46bcd	1.21c	2.30b
T_6	89.33a	8.46a	96.20a	4.93a	38.40a	7.00d	4.26a	1.61a	2.70a
T_7	75.66c	5.40de	59.00ef	3.93bc	28.53d	12.66a	3.20de	1.01d	2.16b
T_8	61.86d	4.53e	55.33f	3.60c	25.00e	13.33a	2.96e	0.91d	1.56c
CV (%)	2.91	9.13	5.19	9.18	5.94	9.14	6.60	6.93	6.85

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 or native fertility.

Table. 3. Yield and yield contributing characters of Mustard during the year 2018-2019

Treat ment	Plant height (cm)	No. of branches	No. of pods plant^{-1}	Pod length (cm)	No. of grains pod^{-1}	Ineffective pods plant^{-1}	1000-seed weight (g)	Seed yield	Stover yield
								(t ha^{-1})	
T_1	95.28bc	5.98 cd	71.33de	4.65bc	36.75 bc	15.02 ab	3.32 cd	1.16 cde	2.23b
T_2	97.19 b	6.88 bc	81.31 c	5.04 ab	39.32 ab	13.12 bc	3.53 bc	1.35 bcd	2.30 b
T_3	98.12 ab	7.74 b	95.25 b	5.32a	39.44 ab	13.08 bc	3.72 b	1.63 ab	2.43 b
T_4	100.01 ab	6.96b	94.03b	5.35a	39.42ab	13.10 bc	3.61 bc	1.41 bc	2.36 b
T_5	97.00 b	5.76 de	75.02cd	5.28 a	38.43ab	11.87 cd	3.35 bcd	1.36 bcd	2.30 b
T_6	101.62 a	8.86 a	104.04 a	5.74 a	40.72 a	10.02 d	4.15 a	1.72 a	2.70 a
T_7	95.13 b	5.62 de	67.22ef	4.02 c	32.76 c	16.62 a	3.11de	1.07de	2.16 b
T_8	90.12 c	4.87e	62.04f	4.01 c	30.31c	17.32 a	2.86 e	0.96 e	1.60 c
CV (%)	2.97	9.42	6.88	6.98	8.23	7.32	6.98	9.11	7.96

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 or native fertility.

Boro

The second component of the cropping pattern was Boro rice. The yield contributing characters and grain yield of Boro rice are presented in Table 4 and Table 5. Most of the yield contributing characters, straw and grain yield of Boro rice was significantly influenced by the different fertilizer treatments. Highest plant height was recorded from T_6 treatment which was statistically at par with T_2, T_3, T_4 and T_5. In both the experimental years, 25% NPK with 100% STB gave highest no. of tiller hill^{-1}, no of panicle hill^{-1}, panicle length, grain and straw yield which was statistically similar with all other treatments except control plot or treatment. But numerically T_6 treatment produced highest grain yield (6.28 and 6.34 t ha^{-1}) in both the consecutive years. Fertilizer has no significant effect on 1000-grain weight. Barman *et al.* (2019) also reported highest boro rice yield from 25% extra NPK over 100% STB dose in four crop based cropping pattern.

Table 4. Yield and yield contributing characters of Boro rice during the year 2018

Treatments	Plant height (cm)	No. of tiller hill^{-1}	No. of panicle hill^{-1}	Panicle length (cm)	1000-grain wt. (g)	Straw yield	Grain Yield
						(t ha^{-1})	
T_1	88.39c	18.89a	18.27a	17.66a	21.30	6.10a	5.45ab
T_2	90.07ab	19.19a	18.05a	18.14a	21.42	6.37a	5.61ab
T_3	91.12ab	20.17a	18.18a	18.65a	22.08	6.44a	5.72 a
T_4	95.01a	19.59a	18.25a	18.76a	22.50	6.70a	5.82ab
T_5	95.42a	19.95a	18.35a	19.02a	22.89	6.89a	5.73ab
T_6	93.66a	20.85a	19.68a	19.81a	23.18	6.97a	6.28 a
T_7	89.92bc	20.08a	17.25a	18.31a	21.42	5.27a	5.35ab
T_8	79.98d	15.15b	14.48b	16.45b	20.43	4.67b	4.79 b
CV (%)	3.56	2.87	2.67	1.91	4.54	10.02	9.53

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 or native fertility.

Table 5. Yield and yield contributing characters of Boro rice during the year 2019

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	85.33c	19.74a	19.22a	19.44a	22.36	6.13a	5.43ab
T_2	89.05ab	19.66a	19.02a	19.42a	23.22	6.12a	5.52ab
T_3	90.67ab	20.04a	19.06a	19.74a	22.04	6.18a	5.81a
T_4	93.65a	19.73a	19.11a	19.76a	21.36	6.34a	5.76ab
T_5	94.47a	20.15a	19.18a	19.48a	21.74	6.11a	5.68ab
T_6	93.82a	20.22a	19.48a	19.68a	23.18	6.13a	6.34 a
T_7	86.74bc	20.08a	19.13a	19.22a	21.14	5.67a	5.14ab
T_8	76.82d	15.01b	14.44b	16.32b	20.73	4.32b	4.28b
CV (%)	3.36	2.64	2.45	2.67	5.12	9.86	8.68

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 or native fertility.

T. Aus Rice

Data on yield and yield contributing characters of T. Aus rice was depicted in Table 6 & 7. Both in 2018 and 2019, the tallest plant was recorded for T_6 treatment but it was statistically similar with T_2, T_3, T_4 and T_5 treatment. No of tillers hill^{-1}, no of panicle hill^{-1}, panicle length and straw yield was statistically similar for T_1, T_2, T_3, T_4 and T_5 treatments but for T_8 treatment. 1000-grain weight was not affected by fertilizer dose. During the experimental years of 2018 and 2019, adding 25% NPK over 100% STB provided 44% and 50% higher yield, respectively than 75% of STB dose which was about 68% and 77% higher, respectively compared to native fertility. Barman *et al.* (2020) also reported 64% higher yield from 25% NPK+100% STB dose than no fertilizer. An increase of N, P and K fertilizer doses from STB recommended doses significantly increased yield and yield contributing parameters of rice (Hasan *et al.*, 2017).

Table 6. Yield and yield contributing characters of T. Aus rice during the year 2018

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	82.13c	16.62a	16.18a	16.44a	19.42	4.32a	2.73ab
T_2	91.45ab	16.64a	16.00a	16.51a	19.54	4.08a	2.76ab
T_3	91.22ab	16.98a	16.08a	16.64a	19.62	4.04a	2.70ab
T_4	94.32a	16.64a	16.17a	16.72a	19.71	4.48a	2.74ab
T_5	95.42a	17.12a	16.28a	16.81a	19.81	4.05a	2.80ab
T_6	93.87a	17.21a	16.54a	16.92a	19.92	4.01a	3.03 a
T_7	87.19bc	17.00a	16.18a	16.31a	19.38	3.74a	2.01b
T_8	77.41d	15.02b	14.33b	14.22b	19.21	2.34b	1.20 c
CV (%)	3.87	2.89	3.55	1.86	4.57	10.23	8.11

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 or native fertility.

Table 7. Yield and yield contributing characters of T. Aus rice during the year 2019

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	82.00c	15.44a	15.14a	15.62a	19.42	4.32a	2.71ab
T_2	90.12ab	15.55a	15.12a	15.65a	19.35	4.13a	2.73ab
T_3	90.08ab	16.11a	15.07a	15.96a	19.26	4.06a	2.75ab
T_4	93.22a	15.77a	15.14a	15.97a	19.47	4.47a	2.77ab
T_5	94.31a	16.22a	15.18a	15.68a	19.58	4.08a	2.88ab
T_6	92.71a	16.11a	15.33a	15.89a	19.39	4.09a	3.19 a
T_7	86.12bc	15.98a	15.02a	15.33a	19.31	3.71a	2.21b
T_8	76.31d	14.11b	13.21b	13.66b	19.31	2.40b	1.10 c
CV (%)	4.12	5.03	3.18	2.34	4.55	8.98	9.20

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 or native fertility.

T. Aman

The forth component of the cropping pattern was T. Aman rice. Table 8 and Table 9 represented the experimental data related to yield and yield contributing characters of T. Aman rice. T_6 treatment produced the tallest plant which was statistically similar with all other treatment except T_7 and T_8. Control treatment produced the lowest no. of tillers hill^{-1} while other treatments showed no significant variations in both the consecutive years. There was no significant impact of treatments on panicle length and 1000-grain weight. Highest straw yield was recorded from T_6 and lowest from T_8. During the two consecutive experimental seasons of 2018 and 2019, about 93% and 88% higher yield, respectively was recorded from T_6 treatment than control but it was statistically similar with 100% STB dose and other treatments. Ali *et al.* (2009) observed maximum grain yield from soil test value for HYG while Saha *et al.* (2016) reported higher yield from 20% more from the STB dose in potato-maize-T. Aman cropping pattern of AEZ-3.

Table 8. Yield and yield contributing characters of T. Aman rice during the year 2018

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	96.42ab	15.44a	15.43b	18.41	21.41	5.43ab	3.32a
T_2	96.51ab	17.53a	16.52ab	18.55	21.53	5.53abc	3.45a
T_3	97.64ab	17.61a	16.61ab	18.66	21.62	5.61abc	3.55a
T_4	97.72ab	16.72a	16.72ab	18.73	21.73	4.71bc	3.65a
T_5	98.82a	17.81a	16.81ab	18.84	21.83	5.81ab	3.75a
T_6	98.94a	17.91a	16.91a	18.95	21.93	5.91a	4.08a
T_7	94.32b	16.33a	15.33ab	18.32	21.31	4.31bc	3.23a
T_8	72.21c	9.23b	9.23c	18.20	21.21	3.23c	2.11b
CV (%)	2.88	4.77	4.75	5.12	4.11	10.82	7.32

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 or native fertility.

Table 9. Yield and yield contributing characters of T. Aman rice during 2019

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	95.54ab	15.84a	15.13b	18.44	21.04	5.14ab	3.53a
T_2	95.55ab	16.85a	16.24ab	18.05	21.55	5.05abc	3.54a
T_3	96.56ab	16.74a	16.46ab	18.96	21.26	5.06abc	3.65a
T_4	96.47ab	15.97a	15.58ab	18.67	21.17	4.87bc	3.46a
T_5	97.58a	16.02a	15.87ab	18.38	21.58	5.78ab	3.57a
T_6	97.59a	16.11a	16.09a	18.19	21.59	5.89a	3. 98a
T_7	93.63b	15.74a	15.12ab	18.72	21.33	4.52bc	3.22a
T_8	71.42c	9.63b	9.02c	18.51	21.22	3.81c	2.08b
CV (%)	3.11	4.98	5.21	5.55	4.11	9.22	8.98

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 or native fertility.

Rice equivalent yield

Productivity of different crops on the rice based cropping system was determined by Rice Equivalent Yield (REY) which was calculated from yield of component crops. Average yield of component crops and rice equivalent yield of mustard was depicted in Table 10. From the results of two years research on four crop based cropping pattern, it was observed that the highest REY (3.34 t ha^{-1}) was recorded from T_6 (25% extra NPK over 100% STB dose) and lowest from T_8.

REY of mustard was 46% higher than 100% STB dose when 25% more NPK was added to it. Barman *et al.* (2020) also documented higher rice equivalent yield of mustard from 25% NPK+ 100% STB dose. Mondal *et al.* (2015) also claimed of having 49 to 67% higher productivity from the intensified land use system under four cropped based cropping pattern. Inclusion of mustard in rice based cropping pattern increase REY about 45.3-51.6% (Hossain *et al.*, 2014). Naher *et al.* (2016) and Hossain *et al.* (2014) opined that short duration varieties and improved four crop based cropping pattern increases total productivity and profitability over farmers existing pattern.

Table 10. Rice equivalent yield of Mustard-Boro-T. Aus-T. Aman

Treatments	Average yield of crops in the pattern				Rice equivalent yield mustard in the pattern
	Mustard	Boro	T.aus	T.aman	
T_1	1.13	5.44	2.72	3.43	2.26
T_2	1.24	5.57	2.75	3.50	2.48
T_3	1.53	5.77	2.73	3.60	3.06
T_4	1.32	5.79	2.76	3.56	2.64
T_5	1.29	5.71	2.84	3.66	2.58
T_6	1.67	6.32	3.11	4.03	3.34
T_7	1.04	5.25	2.11	3.23	2.08
T_8	0.94	4.53	1.15	2.10	1.88

Price : 1 kg mustard = Tk. 50, 1 kg rice = Tk. 25
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 or native fertility.

Economic analysis

Cost and return analysis was done on the basis of prevailing market price of the commodities. Economics analysis of the cropping pattern Mustard-Boro-T.Aus-T.Aman was delineated in Table 11. It was observed that highest gross return, total variable cost, gross margin and marginal value product was obtained from 25% extra NPK over 100% STB dose. The maximum marginal benefit cost ratio was also gained from T_6 treatment. Although the total variable cost is higher for T_6 but its output value surpassed other fertilizer packages. That's why 25% more NPK with 100% STB dose was the most economically profitable fertilizer package for Mustard-Boro-T.Aus -T.Aman cropping pattern under AEZ-11. Hossain *et al.* (2014) found highest MBCR from Mustard-Boro-T.Aus-T.Aman. Thus four crop based cropping pattern would play a vital role to ensure food security of the country in upcoming days (Mondal *et al.*, 2014) and also improve socio-economic condition of farmers.

Table 11.Economic analysis of the cropping pattern Mustard- Boro-T. Aus-T. Aman

Treatments	Gross return of the system	Total variable cost	Gross margin	Marginal product value (MVP)	Marginal benefit cost ratio (MBCR)
	(Tk./ha)				
T_1	346250	40708	305542	104750	2.57
T_2	357500	42231	315269	116000	2.75
T_3	379000	43252	335748	137500	3.18
T_4	368750	42682	326068	127250	2.98
T_5	369750	42180	327570	128250	3.04
T_6	420000	43703	376297	178500	4.08
T_7	316750	30531	286219	75250	2.46
T_8	241500	0	241500	-	-

Urea= 16 Tk kg^{-1}, TSP= 25 Tk kg^{-1}, MoP= 15 Tk kg^{-1}, Gypsum= 12 Tk kg^{-1}, Zinc sulphate= 200 Tk kg^{-1}
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 or native fertility.

Conclusion

Considering the system productivity, and cost and return analysis of the experiment, it may be concluded that 25% extra NPK with 100% STB dose is agronomically feasible and economically profitable for Mustard-Boro-T.Aus-T.Aman cropping pattern in AEZ-11. So, this fertilizer dose may be followed for a remunerative and productive rice based Mustard-Boro-T. Aus-T. Aman cropping system under Jashore region. Further experimentation will be required under different AEZs' to find out suitable region specific fertilizer packages for this pattern.

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