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FERTILIZER RECOMMENDATION FOR FOUR CROP BASED CROPPING PATTERN: POTATO- BORO- T. AUS-T. AMAN UNDER AEZ – 11

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Abstract

A field experiment on Potato-Boro-T. Aus-T. Aman cropping pattern was conducted in the High Ganges Floodplain Soil of Jashore (AEZ - 11) during 2014-2015 and 2015-2016 to find out optimum fertilizer management for intensive cropping pattern, in relation to soil health.There were eight different treatments viz. T_1=100% NPKSZnB (STB= Soil Test Based), 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, and T_8=Native fertility (control) as individual crop management. The experiment was laid out in randomized complete block design with three replications. Results revealed that the tuber yield of potato, grain yields of boro, T. Aus and T. Aman were significantly influenced by the fertilizer treatments. The maximum tuber yield (25.70 and 24.80 t ha^{-1}), grain yields of boro (6.50 and 6.31 t ha^{-1}), T. Aus (3.13 and 3.10 t ha^{-1}) and T. Aman (3.95 and 3.98 t ha^{-1}) was obtained from the T_6 treatment where 25% additional NPK was added with 100% STB in both the year. These yields were statistically similar with that produced by all other fertilizer treatments except the native fertility treatment. Highest rice equivalent yield (REY) of 12.63 t ha^{-1} was obtained from T_6 treatment whereas lowest REY of 5.93 t ha^{-1} was obtained from control.

Introduction

Feeding the enormous population of Bangladesh is a great challenge for the farmers and agricultural scientists. At present the total cultivable land of Bangladesh is 8.5 million hectare which is decreasing gradually because cultivable land is used as non-agriculture (BBS, 2012). The present cropping intensity is 190% and that can be increased up to some extent by improving the present cropping pattern, incorporating short duration crops and through management of cultivation practices (ORC, 2013). Most of the major cropping patterns practiced around the country are comprised of two to three crops a year. Recently four crop based cropping pattern has been introduced in many AEZs.

But intensive land use without appropriate soil management has caused depletion of soil fertility in Bangladesh. The present system of fertilizer application is mostly based on the nutrient requirement of individual crops ignoring the carry-over effect of the organic or inorganic fertilizers applied to the preceding crop. For maintaining soil quality and attainable crop yields for such intensive cropping pattern, proper fertilizer management is required. Considering the above facts, the present study was undertaken to find out judicious fertilizer recommendation for Potato- Boro-T. Aus- T. Aman cropping pattern for AEZ-11.

Materials and Methods

The field experiment was conducted at the central farm of RARS Jashore (AEZ - 11) during 2014-2015 and 2015-2016. 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 Jashore

pH	OM (%)	Ca	Mg	K	Total N %	P	S	B	Cu	Fe	Mn	Zn
		meq100 g^{-1} soil				$\mu g\ g^{-1}$						
7.7	0.92	7.8	3.4	0.18	0.048	15	13	0.14	3	29	5	1.8
Critical level		2.0	0.5	0.12	0.12	10	10	0.2	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, 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 as individual crop management. The unit plot size was 2.5m × 3.0m. Potato (var. Diamant) was used as test crop for the first component of the pattern. Potato seeds were a spacing of 60 x 25 cm on November 11, 2014 and November 10, 2015. Fertilizer N-P-K-S-Zn and B were supplied from urea, TSP, MP, Gypsum, Zinc sulphate and Boric acid respectively. All P K S Zn B and $^1/_2$ of N were applied at the time of final land preparation. The remaining half of N was applied as top dress at 30–35 days after sowing. Two irrigations and other intercultural operations were done as and when required.

The potato was harvested on January 29, 2015 and January 30, 2016. Data on yield and yield contributing characters of potato were recorded and statistically analyzed.

After potato, Boro rice var. BRRI dhan28 was transplanted on February 3, 2015 and February 2, 2016 maintaining 20 x 15 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 12 May, 2015 and 14 May, 2016. For T. Aus rice, var. BRRI dhan48 was used transplanting was done on 15 May 2015 and 17 may 2016 maintaining 20 x 15 cm plant 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. T. Aus rice was harvested on 25 July, 2015 and 26 July, 2016.

For T. Aman rice, the variety Binadhan-7 was transplanted on 29 July 2015 and 30 July 2016 maintaining 20 x 15 cm plant spacing. T. Aman rice was harvested on November 5, 2015 and November 7, 2016.

Predetermined plant parameters data were taken as per experimental design. Statistix 10 was used to determine the significant differences between the treatments. Rice equivalent yield (REY) using formula given by Ahlawal & Sharma (1993), Where,

Rice equivalent yield (t $ha^{-1}yr^{-1}$) =

$$\frac{\text{Yield of Each Crop (t ha}^{-1}\text{) x Economic value of Respective crop Tk. ha}^{-1}}{\text{Crop market price of rice}}$$

Results and Discussion

Potato

Yield and yield contributing characters of potato as influenced by the fertilizer (Tables 2a and 2b) for two years. Fertilizer treatments significantly influenced plant height, tubers plant^{-1}, tuber wt. plant^{-1}, tuber yield (t ha^{-1}) of potato. The highest plant height (66.40 and 65.87 cm), tubers plant^{-1} (11.26 and 11.06), tuber weight plant^{-1} (0.58 kg and 0.56 kg) was recorded from the treatment T_6 where 25% extra NPK was added with 100% STB fertilizer rate in two consecutive years. The lowest plant height (38.60 and 39.24 cm), tubers plant^{-1} (6.40 and 6.12) and tuber weight plant^{-1} (0.24 and 0.23 kg) was obtained from control followed by extra 75% of 100% STB. The highest tuber yield of potato (25.70 t ha^{-1} and 24.80 t ha^{-1}) was produced from the treatment T_6 which out yielded all other treatments. The control treatment produced the lowest tuber yield (10.75 t ha^{-1}and 12.95 t ha^{-1}) of potato. Saha *et al.* (2016) recorded higher tuber yield of potato from 20% more than the STB dose in potato-maize-T. Aman cropping pattern at AEZ-3. Ali *et al.* (2009) documented lowest number of tubers plant^{-1}, tuber wt. plant^{-1} and tuber yield from control treatment in potato-boro- T. Aman cropping pattern and Mollah *et al.* (2011) had lowest yield from control treatment in potato-mungbean-T. Aman rice cropping pattern. Chowdhury *et al.* (2017) reported 64.3% higher tuber yield of potato in four crop cropping pattern over three crop based cropping pattern.

Table 2a. Plant height, yield and yield contributing characters of potato as influenced by fertilizer management at Jashore during 2014-2015

Treatments	Plant height (cm)	Tubers plant^{-1} (no)	Tuber wt. plant^{-1} (kg)	Tuber yield (t ha^{-1})
T_1	62.13 de	8.00 bc	0.40 de	17.89 cd
T_2	63.86 cd	9.00 bc	0.48 bc	21.27 b
T_3	66.06 ab	9.46 b	0.50 b	22.78 b
T_4	64.20 bc	9.13 bc	0.48 bc	21.72 b
T_5	63.40 cd	8.66 bc	0.44 cd	18.58 c
T_6	66.40 a	11.26 a	0.58 a	25.70 a
T_7	60.93 e	7.86 cd	0.37 e	16.00 d
T_8	38.60 f	6.40 d	0.24 f	10.75 e
CV (%)	6.86	9.75	6.41	5.94

T_1: 100% STB (N_{157} P_{16} K_{35} $S_{7.2}$ $Zn_{0.71}$ $B_{0.85}$ 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: native fertility (control).

Table 2b. Plant height yield and yield contributing characters of potato as influenced by fertilizer management at Jashore during 2015-2016

Treatments	Plant height (cm)	Tubers plant^{-1} (no)	Tuber wt. plant^{-1} (kg)	Tuber yield (t ha^{-1})
T_1	61.92 de	8.30 bc	0.38 de	16.97 cd
T_2	62.35 cd	9.10 bc	0.45 bc	20.92 b
T_3	65.12 ab	9.54 b	0.47 b	21.89 b
T_4	63.33bc	9.19bc	0.45bc	20.84 b
T_5	62.54 cd	8.42bc	0.40 cd	17.86 c
T_6	65.87 a	11.06 a	0.56 a	24.80 a
T_7	59.83 e	7.14 cd	0.35 e	15.92 d
T_8	39.24 f	6.12d	0.23 f	12.95 e
CV (%)	7.79	9.63	5.98	6.22

T_1: 100% STB (N_{157} P_{16} K_{35} $S_{7.2}$ $Zn_{0.71}$ $B_{0.85}$ 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: native fertility (control).

Boro

The second component of the cropping pattern was Boro rice. Plant height, yield and yield components of Boro rice have been presented in Tables 3a and 3b. Most of the studied parameters of Boro rice were significantly influenced by fertilizer treatments. In 2015, the maximum plant height (96.21 cm) was obtained from T_5 treatment which is statistically at par with T_2, T_3, T_4 and T_6. In 2016, the maximum plant (96.02 cm) was recorded from T_6 treatment which is statistically at par with T_2, T_3, T_4 and T_5. Tillers hill^{-1}, panicles hill^{-1}, panicle length and straw yields were significantly higher over control treatment.

Table 3a. Plant height, yield and yield contributing characters of Boro rice as influenced by fertilizer management during 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	87.12c	19.92a	19.23a	19.60a	22.50	6.35a	5.50ab
T_2	91.01ab	19.81a	19.01a	19.61a	23.31	6.23a	5.61ab
T_3	92.10ab	20.02a	19.12a	19.91a	22.03	6.24a	6.26 a
T_4	95.11a	19.91a	19.21a	19.92a	21.50	6.43a	5.82ab
T_5	96.21a	20.22a	19.32a	19.60a	21.90	6.12a	5.80ab
T_6	94.24a	20.12a	19.62a	19.81a	23.31	6.15a	6.50 a
T_7	88.04bc	20.02a	19.22a	19.31a	21.21	5.78a	5.24ab
T_8	78.18d	15.11b	14.42b	16.50b	20.91	4.34b	4.36 b
CV (%)	3.68	2.98	2.86	2.11	4.25	9.94	10.43

T_1: 100% STB (N_{186} P_{30} K_{23} S_{30} 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 or native fertility.

Table 3b. Plant height, yield and yield contributing characters of Boro rice as influenced by fertilizer management during 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	86.04c	19.85a	19.15a	19.50a	22.41	6.20a	5.40ab
T_2	89.78ab	19.73a	19.02a	19.51a	23.23	6.13a	5.56ab
T_3	90.98ab	20.00a	19.06a	19.80a	22.02	6.22a	6.31 a
T_4	94.02a	19.84a	19.10a	19.83a	21.40	6.40a	5.72ab
T_5	95.05a	20.18a	19.23a	19.55a	21.80	6.01a	5.70ab
T_6	96.02a	20.13a	19.52a	19.70a	23.24	6.03a	6.31 a
T_7	87.08bc	20.02a	19.11a	19.24a	21.13	5.71a	5.15ab
T_8	77.06d	15.04b	14.55b	16.41b	20.80	4.36b	4.32b
CV (%)	5.34	3.48	3.12	2.12	5.18	9.72	9.16

T_1: 100% STB (N_{186} P_{30} K_{23} S_{30} 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 or native fertility.

T. Aus

T. Aus rice was transplanted as the third crop of the pattern. The variety used for T. Aus rice was BRRI dhan48, a short duration variety. Most of the yield

contributing characters and grain yield was significantly influenced by fertilizer treatments. The maximum plant height (94.55 and 93.53 cm) was recorded from the treatment T_5 which was statistically identical to T_4, T_6, T_2 and T_3. The lowest plant height (76.54 and 75.53 cm) was obtained from the control. There is no significant variation among the treatments except native fertility treatment in case of number of tillers hill^{-1}, number of panicle hill^{-1}, panicle length and straw yield. The highest grain yield of T. Aus rice (3.13 t ha^{-1} and 6.10 t ha^{-1}) was produced by the treatment T_6 where 25% additional NPK was added with the 100% STB rates (Tables 4a and 4b). The control treatment produced the lowest rice yield. The native fertility treatment produced the lowest grain yield (1.92 t ha^{-1} and 1.84 t ha^{-1}) of T. Aus rice. The maximum grain yield (6.26 t ha^{-1} in 2015 and 6.31 t ha^{-1} in 2016) was obtained from T_6 which followed by other fertilizer variables but significantly different from control (4.36 t ha^{-1} and 4.32 t ha^{-1}). This result was in agreement with Hasan *et al.* (2017) who opined that an increase of N, P and K fertilizer doses from STB recommended doses significantly increased yield and yield contributing parameters of rice (Chaudhary *et al.,* 2011); Yoseftabar, 2012).

Table 4a. Plant height, yield and yield contributing characters of T. Aus rice during 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	81.26c	16.71a	16.21a	16.62a	19.51	4.42a	2.83ab
T_2	90.58ab	16.72a	16.02a	16.63a	19.33	4.21a	2.82ab
T_3	90.35ab	17.01a	16.11a	16.92a	19.01	4.01a	2.82ab
T_4	93.45a	16.72a	16.22a	16.91a	19.52	4.62a	2.83ab
T_5	94.55a	17.23a	16.31a	16.62a	19.92	4.01a	2.92ab
T_6	92.98a	17.11a	16.62a	16.81a	19.31	4.02a	3.13 a
T_7	86.32bc	17.02a	16.21a	16.32a	19.43	3.81a	2.11b
T_8	76.54d	15.13b	14.42b	14.51b	19.92	2.41b	1.92 b
CV (%)	3.56	3.56	4.12	2.27	4.13	9.68	9.45

T_1: 100% STB (N_{190} P_{15} $K_{2.17}$ S_{23} 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 or native fertility.

Table 4b. Plant height, yield and yield contributing characters of T. Aus rice during 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	81.22c	15.51a	15.11a	15.63a	19.45	4.33a	2.74ab
T_2	89.34ab	15.62a	15.12a	15.60a	19.34	4.13a	2.73ab
T_3	89.30ab	16.11a	15.02a	15.92a	19.25	4.04a	2.72ab
T_4	92.44a	15.81a	15.14a	15.91a	19.44	4.44a	2.74ab
T_5	93.53a	16.31a	15.23a	15.62a	19.55	4.03a	2.83ab
T_6	91.92a	16.23a	15.41a	15.81a	19.34	4.02a	3.10 a
T_7	85.34bc	16.01a	15.15a	15.32a	19.34	3.74a	2.22b
T_8	75.53d	14.02b	13.81b	13.51b	19.35	2.43b	1.84b
CV (%)	4.15	3.27	3.15	3.14	4.97	9.32	9.23

T_1: 100% STB (N_{190} P_{15} $K_{2.17}$ S_{23} 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 or native fertility.

T. Aman

The fourth component of the cropping pattern was T. Aman rice. The yield contributing characters and grain yield of T. Aman rice are presented in Tables 5a and 5b. Most of the yield contributing characters and straw and grain yield of T. Aman rice was significantly influenced by fertilizer treatments. High plant height (97.68 and 97.58 cm) was recorded from the treatment T_6 where 25% extra NPK was added over the 100% STB fertilizer rate which was statistically identical with T_5 followed by T_1, T_2, T_3 and T_4. The lowest plant height (71.58 and 71.48 cm) was obtained from the control. The maximum number of tiller hill^{-1} (17.32 and 16.16) was obtained from T_6 treatment which was statistically identical with rest of the treatment except T_8 which produced lowest number of tillers hill^{-1} (9.92 and 9.66) in two years). There is no significant variation among the treatments in case of panicle length and 1000- grain weight. The highest grain yield (3.95 t ha^{-1} and 3.98 t ha^{-1}) was obtained from the treatment T_6 where 25% extra NPK was applied where control treatment produced the lowest grain yield (2.12 t ha^{-1} and 2.17 t ha^{-1}). Ali *et al.* (2009) reported the highest grain yield from 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 of AEZ-3.

Table 5a. Plant height, yield and yield contributing characters of T. Aman rice in 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	95.38ab	15.91a	15.22b	18.22	21.02	5.61ab	3.51a
T_2	95.90ab	17.02a	16.31ab	18.31	21.61	5.12abc	3.53a
T_3	96.42ab	17.12a	16.52ab	18.12	21.01	5.32abc	3.62a
T_4	96.59ab	16.91a	16.31ab	18.21	21.82	4.83bc	3.52a
T_5	97.66a	17.12a	16.42ab	18.42	21.91	5.83ab	3.44a
T_6	97.68a	17.32a	16.82a	18.21	21.12	5.92a	3.95a
T_7	93.76b	16.01a	15.41ab	18.31	21.22	4.32bc	3.21a
T_8	71.58c	9.92b	9.22c	18.02	21.32	3.91c	2.12b
CV (%)	3.14	4.86	4.76	4.97	3.76	10.80	3.98

T_1: 100% STB (N_{159} P_{30} K_7 S_{24} 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 or native fertility.

Table 5b. Plant height, yield and yield contributing characters of T. Aman rice in 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	95.50ab	15.81a	15.17b	18.40	21.05	5.17ab	3.58a
T_2	95.53ab	16.82a	16.28ab	18.01	21.54	5.08abc	3.58a
T_3	96.52ab	16.73a	16.45ab	18.90	21.26	5.08abc	3.65a
T_4	96.41ab	15.94a	15.58ab	18.60	21.14	4.87bc	3.47a
T_5	97.56a	16.01a	15.86ab	18.32	21.56	5.78ab	3.55a
T_6	97.58a	16.16a	16.15a	18.11	21.55	5.87a	3.98a
T_7	93.63b	15.73a	15.17ab	18.72	21.34	4.58bc	3.28a
T_8	71.48c	9.66b	9.03c	18.51	21.26	3.87c	2.17b
CV (%)	3.78	5.34	4.98	5.92	3.56	9.87	7.58

T_1: 100% STB (N_{159} P_{30} K_7 S_{24} 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 or native fertility.

Rice equivalent yield

To compare among the treatments, potato yield was converted into rice equivalent yield on the basis of prevailing market price of individual crop. The highest rice equivalent yield was recorded from T_6 treatment due to the highest yield of potato, boro rice, T. Aus rice and T. Aman rice. Treatment T_8 showed lower rice equivalent yield due to lower yield of all the four crops (Table 6). Ali *et al.* (2009) also documented significant difference in rice system yield due to different fertilizer doses.

Table 6. Rice equivalent yield of Potato-Boro-T. Aus-T. Aman cropping pattern

Treatments	Yield of crops in the pattern (t ha^{-1})				Rice equivalent yield (t ha^{-1})
	Potato	Boro	T. Aus	T. Aman	Potato
T_1	17.43	5.45	2.79	3.55	8.72
T_2	21.10	5.59	2.78	3.56	10.55
T_3	22.34	6.41	2.77	3.64	11.17
T_4	21.28	5.77	2.79	3.50	10.64
T_5	18.22	5.75	2.88	3.49	9.11
T_6	25.25	6.29	3.12	3.97	12.63
T_7	15.96	5.20	2.17	3.25	7.98
T_8	11.85	4.34	1.88	2.15	5.93

Price: 1 kg potato = Tk. 10, 1 kg rice = Tk. 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.

Conclusion

From consecutive two years study of four cropping pattern, it could be concluded that STB + 25% extra NPK performed better on the whole pattern basis than all other fertilizer levels and this fertilizer package could be used for Potato-Boro-T. Aus-T. Aman cropping pattern under Jashore region (AEZ-11).

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