

NUTRIENT MANAGEMENT FOR MUSTARD AS RELAY CROP WITH T. AMAN RICE UNDER GANGES TIDAL FLOODPLAIN

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Abstract

The field experiment was carried out at Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Rahmatpur, Barishal during two consecutive *Rabi* seasons of 2019-2020 (Y_1) and 2020-2021 (Y_2) to develop nutrient management package for mustard as relay crop with *T. aman* rice for higher yield and economic return of the crop under Ganges Tidal Floodplain. The treatments of the experiment were: T_1 = 100% Recommended dose (RD: 90-27-16-15-1.5-1-1 kg/ha N-P-K-S-Mg-Zn-B), T_2 = 75% of RD, T_3 = 50% of RD, T_4 = 25% of RD, and T_5 = (72-22-13-12-1.5-0.8-0.8 kg/ha N-P-K-S-Mg-Zn-B, respectively) on soil test based (STB). Fertilizer dose for previous *T. aman* rice was: 75-10-18-4-1 kg/ha N-P-K-S-Zn, respectively. The variety of mustard was BARI Sarisha-14. The experiment was laid out in a randomized complete block design with three replications. The experimental results revealed that nutrient management packages had significant effect on plant height, number of siliqua/plant, seed yield and straw yield in Y_1 . On the other hand, in Y_2 , number of siliqua/plant, number of seed/siliqua, seed yield and straw yield differed significantly by the nutrient packages. The maximum seed yield was obtained from T_1 treatment (1235 kg/ha) in Y_1 , which was at par to that of T_2 (1183 kg/ha) and T_5 (1112 kg/ha), respectively. In Y_2 , the maximum seed yield was found in T_2 (1228 kg/ha) that was statistically at par to that of T_1 (1225 kg/ha) and T_5 treatment (1189 kg/ha). The results further revealed that 75 - 100% RD of fertilizers as well as soil test based (STB) fertilizer dose gave similar seed yield. The fertilizers applied in previous *T. aman* rice had residual effect in succeeding mustard crop. Therefore, application of 75% RD or STB fertilizer dose along with residual fertilizer nutrients produced almost higher yield as per full dose of fertilizers. In average of two years, the highest gross return (Tk. 82524 /ha) and total variable cost (Tk. 53643/ha) were found in treatment T_1 (100% RD) but the treatment T_2 gave the highest gross margin (Tk. 29354 /ha) with BCR (1.57), which was closely followed by T_1 (1.54) and T_5 treatments (1.48, respectively).

Keywords: Mustard, relay crop, *T. aman* rice, nutrient management.

Introduction

Mustard is an important oilseed crop in Bangladesh covering an area of 2.70 lac hectare with annual production of 3.12 lac metric ton. The total annual demand of edible oil in the country is 14.60 lac metric ton where the local production (mainly

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mustard, sesame and sunflower oil) is only 2.36 lac metric ton and deficit about lac 12.24 metric ton (BBS, 2020). In the Ganges Tidal Floodplain that comprises of mostly southern region of Bangladesh, about 29.45 and 55.10% lands remain fallow during *Rabi* and *Kharif-1* seasons, respectively due to delay harvest of *T.aman* rice, soil and water salinity, drought, tidal flooding, water logging etc. (Rahman, 2015). Relay mustard with *T. aman* rice is a traditional cropping pattern in Bangladesh. Relay cropping is a complex suite of different resource-efficient technologies, which possesses the capability to improve soil quality, to increase net return, to increase land equivalent ratio, as well as control the weeds and pest infestation (Tanveer *et al.*, 2017). In southern region, late harvest of previous *T.aman* rice under rice based cropping systems, makes delay the sowing time (January) of mustard due to unfavourable field capacity (*zoh* condition) of soil. On the other hand, late sowing of mustard after conventional tillage causes moisture deficit at early growth stage of the plant, which is not favourable for getting reasonable yield. Relay cropping of mustard under zero tillage condition with preceding *T.aman* rice using residual soil moisture help in timely seeding of mustard crop (at least 15 days earlier as compared to conventional method of seeding) that provides favourable environment for proper growth and development of the crop plant. Farmers traditionally cultivate relay mustard based on their indigenous knowledge and perception, which is not given satisfactory yield (Mian *et al.*, 2016). However, nutrient management package for relay mustard is yet to be developed considering the residual effect of preceding application of fertilizer nutrients in *T.aman* rice towards increasing the crop productivity and soil fertility. Therefore, the experiment was undertaken to develop nutrient management package for mustard as relay crop with *T.aman* rice under Ganges Tidal Floodplain in Bangladesh.

Materials and Methods

The field experiment was carried out at Regional Agricultural Research Station (RARS), Bangladesh Agricultural Research Institute (BARI), Rahmatpur, Barishal, Bangladesh during two consecutive *Rabi* seasons of 2019-2020 and 2020-2021 to develop nutrient management package for mustard as relay crop with *T.aman* rice (monsoon rice) under Ganges Tidal Floodplain (AEZ 13). The experimental site was situated in the latitudes 22°47'6.50629''N and longitudes 90°17'30.977''E. The land topography was medium high land and soil texture was loamy. The treatments of the experiment were: T₁ = 100% Recommended dose (RD: 90-27-16-15-1.5-1-1 kg/ha N-P-K-S-Mg-Zn-B, respectively) [BARC, 2018], T₂ = 75% of RD, T₃ = 50% of RD, T₄ = 25% of RD, and T₅ = Nutrient dose on soil test based (STB: 72-22-13-12-1.5-0.8-0.8 kg/ha N-P-K-S-Mg-Zn-B, respectively) t. The variety of mustard was BARI Sarisha-14. Mustard seeds were broadcasted at the rate of 6 kg/ha on 26 November, 2019 and 21 November, 2020 as relay crop with previous *T.aman* rice (var. BRRI dhan52) before 15 days of rice harvest (in standing rice crop). The experiment was laid out in randomized complete block design with three replications. The initial soil moisture of the experimental land

was 32% on oven dry basis at the time of mustard seeding. Before seeding of mustard, soil samples of the experimental plots were taken for analysis of plant nutrient in the laboratory. The soil samples were tested in the laboratory of Soil Resource Development Institute (SRDI), Barishal. The analysis results of the soil samples are presented below:

Table 1. Nutrient status of the soil sample of the experimental field at RARS, Rahmatpur, Barishal

Soil pH	Salinity (dS/m)	Organic matter (%)	Nitrogen (%)	Potassium (meq /100g soil)	Phosphorus ($\mu\text{g/g}$ soil)	Sulphur ($\mu\text{g/g}$ soil)	Boron (ppm)	Zinc (ppm)
7.60	0.72	0.11	0.006	0.13	17.20	1.30	0.45	1.12
Critical level (CL)		1.00	0.12	0.12	10.00	10.00	0.20	0.60
Nutrient status against CL		Below	Below	Above	Above	Below	Above	Above

The experimental plots were fertilized as per the treatment specifications for relay mustard crop. Fertilizer dose for previous *T.aman* rice was: 75-10-18-4-1 kg/ha N-P-K-S-Zn, respectively. The fertilizer nutrient requirement based on soil test results was calculated following the formula as suggested by BARC, 2018:

$$F_r = U_r - \frac{C_i}{C_s} \times (S_t - L_s),$$

Where, F_r = Fertilizer nutrient required for given soil test value, U_r = Upper value of the recommended fertilizer nutrient for the respective STV1 class, C_i = Units of class intervals used for fertilizer nutrient recommendation, C_s = Units of class intervals used for STV1 class, S_t = Soil test value and L_s = Lower limit of the soil test value within STV1 class. Thus, the calculated soil test base fertilizer dose for mustard was 72-22-13-12-0.8-0.8 kg/ha N-P-K-S-Zn, respectively. Half amount of N fertilizer (urea) and full amount of other nutrients were applied as basal, five days before sowing seeds of mustard. The rest amount of urea was top dressed after 23 days after emergence of seedling (i.e. before flowering) followed by irrigation. Irrigation was applied two times, one at 23 days after emergence (DAE), i.e. before flowering stage and another at 55 DAE (during siliqua formation). Other intercultural operations were done as and when necessary following the recommended production technologies of mustard (BARI, 2019). Data were collected on different parameters such as plant population/m², days to maturity, plant height, number of siliqua /plant, number of seed/siliqua, 1000-seed weight and seed yield. Data were analyzed statistically using windows based computer software of Statistix 10 version and then the mean differences were adjudged with Duncan's Multiple Range Test (DMRT) as suggested by Gomez and Gomez (1984). Besides, economic analysis was done based on the existing market prices of inputs, products and bi-products.

Results and Discussion

Effect of nutrient management on yield and yield contributing characters of mustard as relayed with *T.aman* rice

During, 2019-2020 (Y_1 , nutrient management package had significant effect on plant height, number of siliqua/plant, seed and straw yield but no significant effect was observed on plant population/m², days to maturity, number of seed/siliqua and 1000-seed weight (Table 2). Number of siliqua/plant, number of seed/siliqua, seed yield and straw yield differed significantly but no significant effects were observed in plant population/m², days to maturity, plant height and 1000-seed weight in Y_2 (2020-2021). In Y_1 , treatment T_1 (100% RD) produced the maximum plant height (68.27 cm), which was similar to that of T_2 (75% RD) and T_5 (STB). The plant height of treatment T_3 (50% RD) was statistically similar to T_4 (25% RD), which was 51.67 and 47.53 cm, respectively. The number of siliqua/plant attained the maximum (12.69) in T_1 , which was statistically at par to that of T_5 (12.44) followed by T_2 (12.12) and T_3 (10.29). The lowest number of siliqua /plant was found in T_4 treatment (8.40). In Y_2 , the maximum number of siliqua /plants was recorded in treatment T_1 (30.07), which was at par to that of T_2 and T_5 treatments (21.80 and 20.93, respectively). The treatment T_4 (25%RD) gave the lowest number siliqua/plant (10.87) and it was statistically identical to that of T_3 (15.13). The treatment T_1 gave the maximum number of seed /siliqua (30.07) and it was statistically similar to that of T_2 and T_5 treatments (24.93 and 24.33, respectively) in Y_2 . The treatment T_3 (50%RD) showed the lower number of seed/siliqua (19.07), which was statistically similar to that of T_5 treatment (21.87). In Y_1 , seed yield became the maximum in T_1 treatment (1235 kg/ha), which was statistically similar to that of T_2 (1183 kg/ha) and T_5 (1112 kg/ha). The treatment T_3 gave the seed yield of 866 kg/ha but the lowest yield was obtained from T_4 (613 kg/ha). The maximum seed yield (1228 kg/ha) was obtained from T_2 that was statistically at par to that of T_1 (1225 kg/ha) and of T_5 treatment (1189 kg/ha) in Y_1 . The seed yield obtained from T_3 treatment was 950 kg/ha while T_4 gave the lowest yield of seed (614 kg/ha). In Y_1 , treatment T_1 gave the maximum yield of straw (4321 kg/ha), which was statistically identical to that treatment T_2 (4141 kg/ha) followed by T_5 treatment (3891 kg/ha) and the lowest yield (2144 kg/ha) was obtained from T_4 treatment. On the other hand, treatment T_2 showed the maximum yield of straw (4457 kg/ha) in Y_2 that was statistically identical to that of T_1 and of T_5 treatments (4413 and 4268 kg/ha, respectively) in Y_2 . The results further revealed that 75-100% RD of fertilizers as well as soil test based (STB) fertilizer dose gave similar yields of seed. The fertilizers particularly P-K-S-Zn as applied in previous *T.aman* rice had residual effect in succeeding mustard crop. Therefore, application of 75% RD or STB fertilizer dose along with residual fertilizer nutrients produced almost higher seed yield as per full dose of fertilizers. The results of the present investigation are in agreement with the findings by Das *et al.* (2010) that application of full dose of inorganic fertilizer application to maize not only

enhanced productivity of maize-mustard cropping system, but also this nutrient management option had considered able residual effect on succeeding mustard in terms of yield and income. Similar findings were also found by Uddin *et al.* (2003) who noted that after application of full recommended dose NPKS in the preceding mustard, a reduced dose (50%) of PK along with a full N in the succeeding *boro* (spring rice) and *T.aman* rice gave a similar yield to when recommended NPKS or NPK was used.

Relay cropping of mustard under zero tillage condition with previous *T.aman* rice ensured the timely sowing of mustard crop that helped to become necessary vegetative growth of the plant. On the other hand, application of balanced dose of fertilizers helped in improving the yield contributing characters and seed yield of mustard under favourable growing conditions (air temperature, rainfall etc.).

Table 2. Effects of nutrient management on mustard as relayed with *T.aman* rice at RARS, Rahmatpur, Barishal during 2019-2020 and 2020-2021

Treatment	Plants/m ² (no.)		Days to maturity		Plant height (cm)		Siliqua/plant (no.)	
	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂
T ₁ = 100%RD	192.13	189	71	82	68.27a	67.73	12.69a	29.87a
T ₂ = 75%RD	190.33	190	70	81	61.20ab	51.80	12.12ab	21.80ab
T ₃ = 50%RD	190.00	188	70	81	51.67b	66.60	10.29ab	15.13bc
T ₄ = 25%RD	173.00	175	70	81	47.53b	59.13	8.40b	10.87c
T ₅ = STB	183.00	181	70	80	56.53ab	69.53	12.44a	20.93a-c
CV (%)	8.95	9.74	8.95	1.57	14.58	13.04	20.08	18.27

Table 2. Contd.

Treatment	Seed/siliqua (no.)		1000-seed wt. (g)		Seed yield (kg/ha)		Straw yield (kg/ha)	
	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂
T ₁ = 100%RD	19.15	30.07a	2.63	2.63	1235a	1225a	4321a	4413a
T ₂ = 75%RD	19.27	24.93ab	2.63	2.63	1183ab	1228a	4141ab	4457a
T ₃ = 50%RD	17.39	19.07b	2.55	2.55	866b	950b	3032bc	3396bc
T ₄ = 25%RD	16.64	21.87b	2.53	2.53	613c	614c	2144c	2244c
T ₅ = STB	18.67	24.33ab	2.62	2.62	1112ab	1189ab	3891ab	4268ab
CV (%)	6.12	12.01	2.88	2.82	11.32	10.12	11.87	12.53

Means followed by the same letters within each column do not differ significantly by DMRT

Note: Y₁ = 2019-2020; Y₂ = 2020-2021; RD = Recommended dose, STB = Soil Test Based, CV = Coefficient of Variation

Air temperature data presented in Figure 1 and 2 revealed that the maximum temperature range was 25-28°C and the minimum temperature was 13-15°C during the crop growing period (December to February) in both the years (Y₁ and Y₂). Although small amount of rainfall occurred during the crop growing period but application of irrigation water as per requirement promoted the growth of the crop that helped in getting higher yield of mustard (Figure 3 and 4).

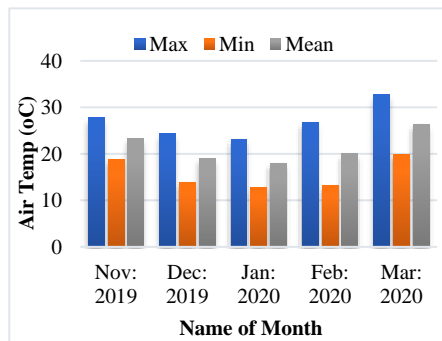


Fig. 1. Monthly air temperature during the cropping season (2019-2020).

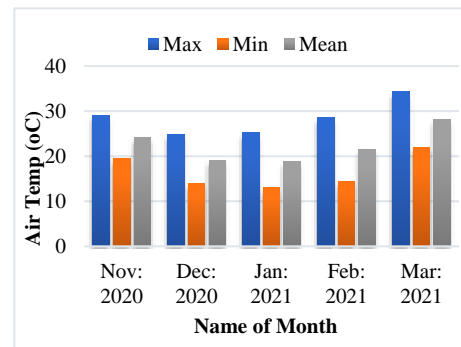


Fig. 2. Monthly air temperature during the cropping season (2020-2021).

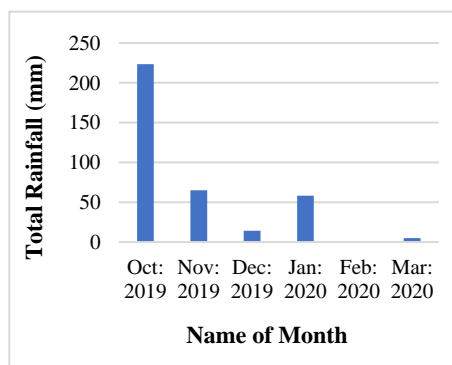


Fig. 3. Monthly total rainfall during the cropping season (2019-2020)

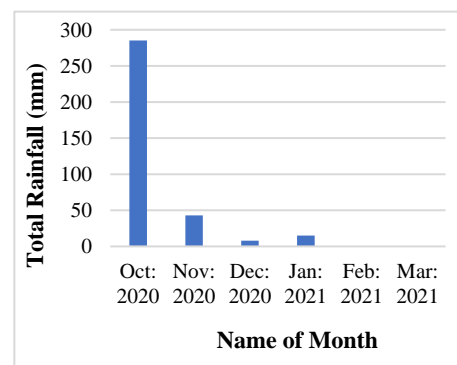


Fig. 4. Monthly total rainfall during the cropping season (2020-2021)

Economic return

The economic analysis of nutrient management of mustard as relayed with *T.aman* rice revealed that the gross return became the maximum (Tk. 82723/ha) in T₁ (100% RD) but slightly lower gross return (Tk. 79271/ha) from treatment T₂ (75% RD) in Y₁ (2019-2020). The treatment T₅ (STB) and T₃ (50% RD) contributed the gross return of Tk. 74490 and Tk. 58033/ha, respectively. The lowest gross return (Tk. 41040/ha) was found in T₄ (25% RD). In Y₂ (2020-2021), the gross return exhibited the maximum (Tk. 82580/ha) in T₂ closely

followed by T₁ treatment (Tk. 82326/ha). The treatments T₅ and T₃ produced the gross returns of Tk. 79869 and Tk. 63791/ha, respectively. The lowest gross return (Tk. 41321/ha) was found in treatment T₄ treatment. In average of two years, the highest gross return (Tk. 82524/ha) was found in treatment T₁ (100% RD). However, slightly lower gross returns were achieved from T₂ and T₅ treatments (Tk. 80926 and 77179/ha, respectively). The average total cost was the highest (Tk. 53643/ha) in T₁ because more inputs were used in this treatment, which cumulative cost was higher. However, slightly reduced total cost was found in T₅ and T₂ treatments (Tk. 51986 and 51572/ha, respectively). Treatment T₄ showed the lowest total cost (Tk. 47431/ha) among the treatments. The gross margin was found to be the maximum (Tk. 30080/ha) in T₁ followed by T₂ (Tk. 28699/ha) in Y₁ while the treatment T₅ (STB) showed the gross margin of Tk. 23504/ha. The minimum gross margin (Tk. 9532/ha) was computed in T₃ treatment but the treatment T₄ produced negative gross margin (Tk. - 5391/ha). In Y₂, the maximum gross margin (Tk. 30008/ha) was found in T₂ treatment followed by T₁ (Tk. 27683/ha) and T₅ (Tk. 26883/ha). But on an average, the treatment T₂ gave the maximum gross margin (Tk. 29354/ha) followed by T₁ and T₅ treatments (Tk. 28882 and 25193/ha, respectively). On the other hand, treatment T₄ showed negative gross margin (Tk. - 6250/ha). In terms of benefit cost ratio (BCR), T₁ and T₂ produced same value (1.57) followed by T₅ treatment (1.46) in Y₁. In Y₂, the maximum value of BCR (1.57) was found in T₂ treatment followed by T₁ and T₅ exhibited the same BCR value (1.51). On an average, treatment T₂ also contributed the maximum BCR (1.57) closely followed by T₁ and T₅ treatments (1.54 and 1.48, respectively). The lowest BCR (0.87) was found in T₄ treatment. The results further revealed that treatment T₂ (75% RD) contributed more economic return in terms of gross margin and benefit cost ratio when mustard was cultivated as relay cropping with previous *T.aman* rice under Ganges Tidal Floodplain.

Table 3. Economic return of nutrient management of mustard as relayed with *T.aman* rice during 2019-2020 and 2020-2021

Treatment	Gross return (Tk./ha)			Total cost (Tk./ha)		
	Y ₁	Y ₂	Average	Y ₁	Y ₂	Average
T ₁ = 100% RD	82723	82326	82524	52643	54643	53643
T ₂ = 75% RD	79271	82580	80926	50572	52572	51572
T ₃ = 50% RD	58033	63791	60912	48501	50501	49501
T ₄ = 25% RD	41040	41321	41180	46431	48431	47431
T ₅ = STB	74490	79869	77179	50986	52986	51986

Table 3. Contd.

Treatment	Gross margin (Tk./ha)			Benefit cost ratio (BCR)		
	Y ₁	Y ₂	Average	Y ₁	Y ₂	Average
T ₁ = 100% RD	30080	27683	28882	1.57	1.51	1.54
T ₂ = 75% RD	28699	30008	29354	1.57	1.57	1.57
T ₃ = 50% RD	9532	13290	11411	1.20	1.26	1.23
T ₄ = 25% RD	-5391	-7110	-6250	0.88	0.85	0.87
T ₅ = STB	23504	26883	25193	1.46	1.51	1.48

Note: Y₁ = 2019-2020; Y₂ = 2020-2021

Prices of input, product and bi-product: Urea Tk. 16, TSP 20, MoP 15, Gypsum 10, Zinc fertilizer 120, Boron fertilizer 120/kg, Labour wage: Tk. 500/man-day (8 hours); mustard seed: Tk. 60 and straw: Tk. 2/kg

Conclusion

Fertilizer nutrients (both macro and micro nutrients) as applied in previous crop contribute residual effect in the succeeding crop. As a result, the application of 75% recommended dose (RD) of fertilizers or soil test based (STB) fertilizer dose along with residual fertilizer nutrients produced almost similar yields of relay mustard as given by the full dose of fertilizers. Because of better nutrient utilization by more healthy and vigorous plants under recommended and balanced level and resulting in more biomass production and yield. In terms of economic return, 75% RD (70-20-12-11-1.3-0.75-0.75 kg/ha N-P-K-S-Mg-Zn-B, respectively) also contributed the highest gross margin and benefit cost ratio when mustard was cultivated as relay cropping with previous *T.aman* rice under Ganges Tidal Floodplain in Bangladesh.

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