Bangladesh J. Nuclear Agric, 38(1): 93-100, 2024 *ISSN 0258-7130*
DOI: https://doi.org/10.3329/bjnag.v38i1.76570

PRODUCTIVITY AND PROFITABILITY OF FOUR CROPS BASED CROPPING PATTERN IN JHENAIDAH DISTRICT OF BANGLADESH

M.R. Sultana[1], M.A. Ullah[1]*, S.T. Abir[2] and M.S. Rahman[3]

Abstract

A field experiment was carried out at the farmers' field in the Kaliganj upazila for two consecutive years (2021-22, 2022-23). The experiment carried out in a multi-location testing site in the Jhenaidah district, under the Jashore region. The objective of the experiment was to enhance cropping intensity and productivity by incorporating T. Aus into the existing cropping pattern. The current cropping sequence consisted of T. Aman-Mustard-Mungbean, while the suggested cropping sequence included T. Aman-Mustard-Mungbean-T. Aus. The research findings showed that the rice equivalent yield (REY) in the suggested cropping pattern was 21 t ha^{-1}, representing a 31.25% increased over the yield of existing pattern (16 t ha^{-1}). The greater gross return (Tk. ha^{-1}), gross margin (Tk. ha^{-1}), and slightly higher marginal benefit cost ratio obtained from this four-crop-based cropping pattern suggest that the proposed pattern could be recommended for higher productivity and economic benefit in other parts of the Jashore region.

Keywords: Cropping pattern, Rice, Mustard, Mungbean, Cropping intensity

Introduction

Bangladesh is a highly populated country in the world, with a population density of 1119 people per sq. km. It has an area of 1,47,570 sq km and has a population of around 169.82 million, growing at a rate of 1.22% each year (BBS 2022).

Bangladesh, an agrarian country, is located in the world's largest delta, formed by the Ganga Brahmaputra and the Sundarbans, and intersected by other rivers and streams. The region benefits from fertile alluvial soil. The climate and soil conditions are optimal for cultivating a diverse range of crops year-round. Approximately 57% of its entire land area is suitable for agriculture. In order to cater to the needs of the large population, the majority of the land has been allocated for agricultural purposes. Notwithstanding this achievement, a considerable portion of the population faces a shortage of land that they can effectively manage, which poses challenges for engaging in agriculture. Due to population pressure, urbanization, and other non-agricultural activities, the agricultural community is deeply worried about the yearly conversion of a particular fraction (0.47%) of arable land from agricultural to non-agricultural purposes.

[1]Plant Breeding Division, Bangladesh Institute of Nuclear Agriculture (BINA), Sub-station, Magura
[2]Agricultural Engineering Division, Bangladesh Institute of Nuclear Agriculture (BINA), Sub-station, Magura
[3]Entomology Division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh
***Corresponding authors' email:** maullah09@gmail.com

The primary obstacle faced by the country, even with minor enhancements to the existing agricultural system, would be the need to increase food production while utilizing a less amount of land (Nasim *et al*., 2018). Over time, due to the growth of the service sector and the industrial sector, the contribution of the agricultural sector to the GDP has decreased, but the size of the agricultural sector has increased. At present, the agriculture sector contributes about 11.38% to the country's GDP and 45.4% people employed of the total labor force (BBS, 2022) in this sector.

Food security and adequate nutrition are the basic needs of every human being. Every human being need food security and sufficient nourishment as fundamental necessities. No nation can have a robust economy if its citizens are afflicted by hunger and malnutrition. Ensuring access to essential food and achieving a well-rounded nutritional intake are significant obstacles faced by developing countries like Bangladesh.

To tackle national issues such as food security, poverty reduction, and job creation, it is essential to prioritize sustainable crop production in Bangladesh. This can be achieved by increasing cropping intensity in a rice-based cropping system. The main concern of the next century is to enhance the productivity per unit of land area by 50% through effective resource management. To improve food production in a limited space, there are two key ways: i) increasing cropping intensity, which means producing three or more crops on the same plot of land during a year; and ii) implementing optimal management techniques to maximize the productivity of each crop. The recent development of short-duration varieties of rice, mustard, potato, pulse, and jute has created opportunities to cultivate four different crops on the same plot of land within a year. To enhance rapeseed-mustard output under the existing rice-based cropping strategy, a potential improvement of 25-30% can be achieved by replacing traditional varieties with high yielding, short-duration cultivars such as Binasarisha-9 and BARI Sarisha-14. Pulses are important legume crops that are commonly grown without the application of fertilizer due to their ability to meet their nitrogen needs through symbiotic fixation of atmospheric nitrogen in the soil (Islam, 1991; Zapata *et al*., 1987; Fried and Middleboe, 1977). Nevertheless, in a rice-based cropping system, pulses contribute a substantial amount of nitrogen to the subsequent non-legume crops (Rachie and Roberts, 1974; Ahlawat *et al*., 1981; Kurtz *et al.*, 1984; Sharma and Prasad, 1999). The potential use of T. Aus in the T. Aman-Mustard-Mungbean cropping system has the capacity to benefit the rural poor by generating employment opportunities and augmenting their income, while simultaneously enhancing the production of these crops on the country's fallow and underutilized land regions. Considering all of this, the purpose of the current experiment was to examine the feasibility of enhancing crop yield and intensity by growing four different crops in a single year on the same plot of land. Bangladesh Institute of Nuclear Agriculture (BINA) has introduced T. Aman, mustard, mungbean, and T. Aus rice crops into the existing cropping system to promote food security, alleviate poverty, manage resources, and improve farmers' livelihoods by increasing incomes, creating employment opportunities, and encouraging women's involvement in agriculture.

Materials and Methods

The trial was conducted at the farmers' field in Bolidapara, specifically at the Kaliganj multi-location testing site in Jhenaidah district. It spanned from July to June of both 2021-22 and 2022-23, with the aim of incorporating T. Aus into the T. Aman-Mustard-Mungbean cropping pattern. A randomized complete block design with three dispersed replications was used to set up the experiment. The area of the land was 1 bigha (33 decimal). The experiment had two treatment variables: the existing cropping pattern, which consisted of T. Aman, Mustard, and Mungbean, and the suggested cropping pattern, which included T. Aman, Mustard, Mungbean, and T. Aus.

Aman rice was the initial crop in the crop rotation series. The management of fertilizer and the implementation of intercultural activities like as weeding, mulching, irrigation, and pest management were carried out in accordance with the methods described by Rahman *et al*. (2008). The 22 days old seedling of the local rice variety Shubhol lota was transplanted with a spacing of 20 cm × 15 cm during the first week of August in the existing cropping pattern. The seedlings of Aman rice variety Binadhan-17, which were 22 days old, were transplanted in the first week of August according to the suggested cropping pattern, with consistent spacing. T. aman rice was harvested in the first week of November in two consecutive years.

Mustard was the second crop in the sequence. The seeds of an Indian mustard variety were planted during the second week of November using both patterns. The mustard variety Binasarisha-9 was sown with a spacing of 30 cm × 5 cm in the desired pattern. In accordance with Mondal and Wahhab's (2001) recommendations, fertilizer management and intercultural practices such as weeding, mulching, irrigation, and pest control were carried out. The Mustard variety was harvested in the first week of February. Only the seed yield was collected from the entire plot.

Mungbean was the third crop in both patterns. The BARI Moog-6 was planted in the first week of March following the existing pattern. The fertilizer management and intercultural operations were conducted in accordance with the methods described by Afzal *et al*. (2008). Due to variations in the maturation time of pods, three separate rounds of picking were conducted in BARI Moog-6. For the suggested pattern, the Binamoog-8 released by BINA was planted in the second week of February with a spacing of 25 cm × 8 cm. The BARI Moog-6 was harvested between the 14^{th} and 18^{th} of May, whereas the Binamoog-8 was picked up during the third week of April. Only the seed yield was collected from the entire plot. Eighty percent of the pods from the Binamoog-8 plants are fully developed and ready for harvesting during the first picking. After the second picking, the Binamoog-8 plants are plowed into the soil as green manure. They are permitted to decompose until the T. Aus plants are transplanted into the soil.

Transplanted T. Aus rice was the fourth crop in the suggested cropping sequence. The control of fertilizers and the implementation of intercultural activities like as weeding,

mulching, irrigation, and pest management were carried out in accordance with the methods described by Haque *et al*. (2011). The seedlings of Binadhan-19, which were 20 days old, were transplanted with a spacing of 20cm × 15cm in the last week of April, according to the specified cropping pattern. The grain yield and straw yields were obtained from the entire plot.

The crop yield data was carefully recorded and statistically evaluated using the R computer program. The gross economic return was determined based on the current market price of the goods. Rice equivalent yield (REY) was determined as follows: REY = [yield of the non-rice crop (kg) × price of the non-rice crop (Tk. Kg^{-1})]/price of rice grain (Tk. kg^{-1}).

Results and Discussion

a. Yield and productivity of cropping pattern

Yield and economic performance of proposed and existing cropping pattern during 2021-22 and 2022-23 are presented in Table 1 and Table 2. The two years average grain yield of T. aman and seed yield of Mustard, Mungbean and T. Aus in proposed cropping pattern of T. Aman (Binadhan-17) - Mustard (Binasarisha-9) - Mungbean (Binamoog-8) - T. Aus (Binadhan-19) were recorded as 6.25, 1.64, 1.61 and 4.80 t ha^{-1}, respectively, where in the existing cropping pattern of T. Aman, Mustard and Mungbean produced 5.43, 1.25 and 1.41 t ha^{-1} yield, respectively. The results clearly indicated that higher yield of T. Aman, Mustard, Mungbean and T. Aus in proposed cropping pattern as compared to the existing cropping pattern.

Grain yields of T. Aman rice (var: Shubhol lota) in existing pattern were 5.50 and 5.37 t ha^{-1} in two years respectively. Average grain yield of Shubhol Lota was 5.43 t ha^{-1} and mean straw yield was 7.0 t ha^{-1}. Seed yield of mustard (var: Indian) were 1.25 and 1.24 t ha^{-1} in two years, respectively and mean seed yield was 1.25. Seed yield of Mungbean (var: BARI Moog-6) were 1.39 t ha^{-1} in the first year and 1.42 t ha^{-1} in the following year and mean seed yield was 1.41 t ha^{-1}.

In case of proposed cropping pattern, grain yield of T. Aman (var: Binadhan-17) were 6.27 and 6.23 t ha^{-1} in two years, respectively. Average grain yield of Binadhan-17 was 6.25 and mean straw yield was 7.5 t ha^{-1}. Seed yield of mustard (var: Binasarisha-9) were 1.63 and 1.65 t ha^{-1} in two respective years. Average seed yield of Binasarisha-9 was 1.64. Seed yield of Mungbean (var: Binamoog-8) were 1.59 tha^{-1} in the first year and 1.63 tha^{-1} in the following year.

Table 1. Performance of different crops at existing and proposed cropping pattern during 2021-22 and 2022-23 at Bolidapara, Kaliganj, Jhenaidah, Jashore (Average over two year's data)

Parameters	Crop	Variety	Planting Date	Harvesting Date	Duration	Grain Yield (tha^{-1})	Straw Yield (tha^{-1})
Existing Cropping Pattern	T. Aman	Shubhol lota	1-3 August	5-7 November	96	5.43	7.0
	Mustard	Indian	13-15 November	9-11 February	88	1.25	-
	Mungbean	BARI Moog-6	6-10 March	14-18 May	69	1.41	-
Proposed Cropping Pattern	T. Aman	Binadhan-17	1-3 August	2-4 November	93	6.25	7.5
	Mustard	Binasarisha-9	9-11 November	4-6 February	87	1.64	-
	Mungbean	Binamoog-8	12-14 February	18-20 April	66	1.61	-
	T. Aus	Binadhan-19	27-29 April	21-23 July	85	4.80	7.0
LSD (0.5%)			-	-	1.97	0.14	-
CV			-	-	1.19	2.43	-

Table 2. Rice equivalent yield (REY) from existing and proposed cropping pattern during 2021-22 and 2022-23 at Kaliganj Upazila, Jhenaidah, Jashore

Patterns	REY ($t\ ha^{-1}$) of different crops							
	T. Aman (Shubhol Lota)	Mustard (var: Indian)	Mungbean (BARI Moog-6)	T. Aman (Binadhan-17)	Mustard (Binasarisha-9)	Mungbean (Binamoog-8)	T. Aus (Binadhan-19)	Total ($t\ ha^{-1}$)
Existing Pattern	5.43	3.42	5.51	-	-	-	-	14.36
Proposed Pattern	-	-	-	6.25	4.10	5.75	4.80	20.90

Price: T. Aman (Shubhol Lota: Tk. 32/kg, Binadhan-17: Tk. 35/kg), Mustard: Tk. 87.5/kg, Mungbean: Tk. 125/kg, T. Aus: Tk. 35/kg, Straw: Tk. 2/kg.

Table 3. Economic performance of existing and proposed cropping pattern at Jhenaidah, Jashore

Parameters	Existing Cropping Pattern	Proposed Cropping Pattern
	T. Aman- Mustard- Mungbean	T. Aman- Mustard-Mungbean-T.Aus
Rice Equivalent Yield (tha^{-1})	14.36	20.90
Gross Return (Tk. ha^{-1})	473385	760500
Total cost (Tk. ha^{-1})	260329	331982
Gross Margin (Tk. ha^{-1})	213056	428518
BCR	1.82	2.29

Average seed yield of Binamoog-8 was 1.61 t ha^{-1}. Straw yield of mustard and mungbean was not calculated for both the pattern as straw of mustard was used by the farmer as biofuel and mungbean plants were ploughed down into soil as green manure. Grain yield of T. Aus were 4.79 and 4.81 t ha^{-1} in two years, respectively. Mean grain yield of Binadhan-19 was 4.80 t ha^{-1} and mean straw yield was 7.0 t ha^{-1}.

The total productivity of two distinct cropping patterns was assessed using the Rice Equivalent Yield (REY) metric, which was derived from the yields of the individual crops. The rice equivalent yield varied across different cropping pattern. The findings of a two-year study on four crop-based cropping pattern revealed that the suggested cropping pattern yielded a much higher average REY of 20.90 t ha^{-1} compared to the existing cropping pattern, which yielded an average of 14.36 t ha^{-1}. The rice equivalent yield in the improved cropping pattern was 45.54% higher compared to the existing cropping pattern. This increase was attributed to the addition of one cereal crop (T. Aus) and the utilization modern cultivars and other advanced technologies in the proposed cropping pattern. The findings of this study align with the research conducted by Naher *et al*. (2016) and Hossain *et al*. (2014), which concluded that using short duration varieties and implementing an improved four crop based cropping pattern can significantly enhance total production and profitability compared to the existing pattern used by farmers.

b. Economic analysis

An economic analysis was carried out using the current market price of the commodities as the basis. The productivity of various cropping systems was evaluated based on their rice equivalent output. The economic analysis of the productivity of proposed and current cropping patterns, as presented in Table 3, revealed that there were variations in the gross returns between the two cropping patterns. The suggested T. Aman- Mustard- Mungbean - T. Aus cropping pattern yielded a higher gross return of Tk. 760500 ha^{-1} and a higher gross margin of Tk. 428518 ha^{-1} compared to the existing cropping pattern. The proposed cropping pattern T. Aman – Mustard – Mungbean – T. Aus resulted in a higher economic return due to an increase in total productivity compared to the present cropping pattern. The T. Aman- Mustard- Mungbean- T. Aus cropping pattern exhibited a higher BCR (2.29) compared to the farmers' existing cropping pattern (1.82). According to other experts (Mondal *et al*., 2014), the implementation of a cropping pattern based on four crops will be crucial in ensuring the country's food security in the future.

c. Crop Duration

The average duration of the existing cropping pattern for T. aman rice, excluding the 22 days seedling phase, is 253 days. However, the suggested cropping plan required a total of 331 days to complete the cycle, not including the 22-day seedling age for T. Aman rice and the 20 days seedling age for T. Aus rice (Table 1). The proposed pattern consisting of T. Aus could be easily fitted into the cropping pattern.

Conclusions

Based on two years average results of the cropping pattern research, it may be concluded that four crop based cropping pattern T. Aman–Mustard–Mungbean–T. Aus is agronomically feasible and economically profitable compared to existing farmers cropping pattern T. Aman–Mustard–Mungbean. Due to its higher productivity and cost-effectiveness, the proposed cropping pattern is recommended for implementation in other suitable areas to enhance crop production in the Jashore region of Bangladesh. As a result of growing four crops on the same plot of land in a single year, more jobs for male and female labours could be created. Moreover, it also enhances cropping intensity and productivity.

References

Afzal, M.A., Bakar, M.A., Hamid, A., Uddin, M.J. and Haque, M.N., 2008. Strengthening of pulses and oil seed research programme in Bangladesh, BARI, Gazipur-1701. Publication no, 17, p.64.

Ahlawat, I.P.S., Singh, A. and Saraf, C.S., 1981. Effects of winter legumes on the nitrogen economy and productivity of succeeding cereals. Experimental Agriculture, 17(1), pp.57-62.

BARI (Bangladesh Agricultural Research Institute). 2017. Krishi Projukti Hatboi (Handbook on Agro-Technology), 7th edition, Gazipur-1701, Bangladesh.

BBS (Bangladesh Bureau of Statistics). 2022. Gross Domestic Product (GDP) of Bangladesh 2022-23, Ministry of Planning web site. Dhaka. Bangladesh.

BBS (Bangladesh Bureau of Statistics). 2022. Labor Force Survey Report, Bangladesh Bureau of Statistics, Ministry of Planning web site. Dhaka. Bangladesh.

BBS (Bangladesh Bureau of Statistics). 2022. Population and Housing Census 2022, National Report (Volume I), Bangladesh Bureau of Statistics, Ministry of Planning. Dhaka. Bangladesh.

Fried, M. and Middelboe, V., 1977. Measurement of amount of nitrogen fixed by a legume crop. Plant and soil, 47, pp.713-715.

Haque, A.K.G.M.N., Basher, M.K., Islam, M.S. and Khasem, M.A., 2011. Modern Rice Cultivation, 16th edition. Bangladesh Rice research Institute, Gazipur-1701.

Hossain, M.H., Bashir, M.M., Bhowal, S.K., Naher, Q., Zahan, T., Hasan, M.K. and ASMMR, K., 2017. Production technology of four crop based cropping pattern Mustard-Boro-T. Aus-T. Aman rice in Cumilla region (Bengali Booklet). OFRD (On-Farm Research Division), BARI, Bangladesh, p.23.

Hossain, I., Mondal, M.R.I., Islam, M.J., Aziz, M.A., Khan, A.M. and Begum, F., 2014. Four crops based cropping pattern studies for increasing cropping intensity and productivity in Rajshahi region of Bangladesh. Bangladesh Agronomy Journal, 17(2), pp.55-60.

Kurtz, L.T., Boone, L.V., Peck, T.R. and Hoeft, R.G., 1984. Crop rotations for efficient nitrogen use. Nitrogen in crop production, pp.295-306.

Mondal, R.I. and Wahhab, A., 2001. Production technology of oilcrops. Oilseed Research Centre.

Mondal, R.I., Begum, F. and Aziz, A., 2014. Four crop based cropping pattern in one piece of land in a year (T. Aman-Mustard-Boro-T. Aus rice). Bengali Booklet) Bangladesh Agricultural research Institute, Gazipur-170, Bangladesh, p.31.

Mondal, R.I., Begum, F., Aziz, A. and Sharif, S.H., 2015. Crop sequences for increasing cropping intensity and productivity. SAARC J. Agric, 13(1), pp.135-147.

Naher, Q., Amin, M.R., Islam, M.R., Ali, M.A., Choudhury, A.K., Hasan, M.K., Khan, A.S.M.M.R. 2016. Location specific climate resilient agricultural technologies in Banglaesh. OFRD (On-Farm Research Division), BARI, Bangladesh, pp. 37-38.

Nasim, M., Shahidullah, S.M., Saha, A., Muttaleb, M.A., Aditya, T.L., Ali, M.A. and Kabir, M.S., 2017. Distribution of crops and cropping patterns in Bangladesh. Bangladesh rice journal, 21(2), pp.1-5.

OFRD (On-Farm Research Division). 2014. Performance of short duration T.aman rice varieties in the Potato –Mungbean-T.aus- T.aman rice. Annual Research Report, OFRD. pp 49-53.

Rachie, K.O. and Roberts, L.M., 1974. Grain legumes of the lowland tropics. Advances in agronomy, 26, pp.1-132.

Rahman, M.S., Satter, M.A., Begum, N. and Hyder, M.R., 2008. Unnata Krishi Projukti Porichity. Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh.

Saha, A., Nasim, M., Rashid, M.H. and Shahidullah, S.M., 2017. Crop diversity and cropping patterns of comilla Region. Bangladesh Rice Journal, 21(2), pp.91-107.

Sharma, S.N. and Prasad, R., 1999. Effects of sesbania green manuring and mungbean residue incorporation of productivity and nitrogen uptake of a rice-wheat cropping system. Bioresource Technology, 67(2), pp.171-175.

Zapata, F., Danso, F., Hardarson, G. and Fried, M., 1987. Nitrogen Fixation and Translocation in Field-Grown Fababean1. Agron. J. 79(3), pp.505-509.