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Four Crops Pattern for Greater Economic Return and Productivity

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ABSTRACT

Subsistence crop production has been commercialized these days. To sustain profit, choosing the feasible cropping pattern (CP) with short duration, high yielding, and more market price-based crops that fit in season and field is crucial. Reflecting the above objective, an evaluation of a four crops-based cropping pattern was undertaken to depict the economic return and yield. The experiment was set following Randomized Complete Block Design with three dispersed locations at Santhia Upazila of Pabna district, Bangladesh, from July 2020 to 2021. Three CPs i.e. CP_1: Transplanted Aman rice (cv. Binadhan-7)—Mustard (cv. Binasarisha-9)— Mungbean (cv. Binamoog-8) —Transplanted Aus rice (cv. Binadhan-19); CP_2: T. Aman (cv. Binadhan-17)—Lentil (cv. Binamasur-8)—Stem amaranth— Sesame (cv. Binatil-2); CP_3 (Control): T. Aman (cv. Shorna) – Wheat (cv. BARI Gom 33) – Jute (cv. JRO 524) were used as treatments. Inspections unveiled that, maximum REY (23.68 t/ha), gross margin (3,81,936 Tk/ha) and BCR (2.10) were obtained from CP_2. Whereas the minimum REY (15.13 t/ha), gross margin (2,27,688 Tk/ha) and moderate BCR value (1.79) was attained with CP_1. CP_3 had the least BCR (1.61) but a judicious level of gross margin (2,62,915 Tk/ha). Therefore, four CP system ultimately yields more economic return.

Keywords: *Cropping intensity, Four crops cropping pattern, Pulse and oil crops, BCR, REY, Pabna.*

INTRODUCTION

The green revolution has markedly changed the production of crops through the introduction of high-yielding short-duration varieties. As the population increases the need for food will also increase. The average cereal crop production of Bangladesh was 59,181,920 Mton during 2019 from an area of 12,302,025 Mha (FAOSTAT, 2021). The country has gained tremendous success over the last few years in terms of increasing crop yields. The average cultivable area of Bangladesh was 7,967,000 ha, and land under permanent crops was 830,000 ha in 2019 (FAOSTAT, 2021).

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Due to industrialization, urbanization and other development activities, croplands are decreasing at a rate of 1% (Hossain *et al*., 2015). By 2050, the projected population of this country will be 194.23 million (Hossain and Islam, 2017). To meet the food requirements, crops' yield has to be increased by 2 times compared to the existing. Pabna is agriculturally a promising and forwarded district of Bangladesh, as almost all types of crops are grown here. The total area of Pabna is 237,651 hectares (ha) among this, unavailable for cultivation is 80,162 ha; cultivable waste and current fallow consist of 2000 acres each. Interestingly, most of the lands are doubled cropped (95,142 ha), followed by tripled (44,534 ha) and single-cropped (15,789 ha) area (BBS, 2020). National mean cropping intensity (CI) of Bangladesh is nearly 2% (FAO, 2016); whereas CI of Pabna district is about 2.2% (BBS, 2020). Upgrading the existing CI to 4% is challenging but not impossible (Chowhan *et al*., 2021). Four crops cultivation in a unit land requires proper crop calendar planning, seasonal consideration, weather factors, incorporation of short-maturity HYVs and accurate agronomic management.

The suitable area for mustard cultivation is 63,082 ha in the whole Pabna district and 4,906 ha in Santhia Upazila (BARC, 2021a). Whereas very suitable lands for lentil, mung bean & black gram and *Aman* rice cultivation is 75,133 ha, 27,047 ha and 61,134 ha respectively (BARC, 2021b; BARC, 2021c; BARC, 2021d). Total cultivable land area under Santhia Upazila of Pabna district is not less than 28,000 ha (BARC, 2021e). Among them, very suitable area for growing lentil, mung bean and black gram and *aman* rice holds 8,957 ha, 7,147 ha and 7,131 ha, respectively (BARC, 2021b; BARC, 2021c; BARC, 2021d).

Rice is the vastly cultivated crop in Bangladesh which covers 70% of the total agricultural lands (Chowhan *et al*., 2019). Socio-economic and cultural conditions are the main factors for such a huge production area. But continuous rice farming might not uniformly utilize all the soil nutrients and thereby create a deficiency or adequacy of certain nutrients. Soil pH is another important factor as a huge volume of water is needed for rice production. Thus, to maintain a homogeneous balance of soil-plant nutrients and resources mixed type of crop (pulse, oil seed, vegetable etc.), incorporation is imperative for sustaining soil health and crop yields. T. *Aman* rice-Mustard-Mungbean-T. *Aus* rice-based four crops CP was found to be more profitable with less production cost which might fit to the existing two or three crops CP (Hossain *et al*., 2015 ; Mondal *et al*., 2015). Lentil–Mungbean–T. *Aus* rice–T. *Aman* rice depended four crops CP in Faridpur and high barind tract of Rajshahi are agronomically and economically feasible (Hossain *et al*., 2018 ; Ahmed *et al*., 2019). Potato–Mungbean–Jute–T. *Aman* rice is also a potential CP in the northern region of the country specially Nilphamari (Chowdhury *et al*., 2018).

Today there are available crop varieties of cereals, pulses, oil seeds, vegetables and fiber crops from different private seed companies as well as research organizations. All these varieties greatly contribute to introduce four crops CP. Considering the above potentialities and limitations, the current study was undertaken to justify the advantage(s) of four crops based CP in terms of profit, yield and time duration requirement in a cropping cycle.

MATERIALS AND METHODS

This field experimentation was setup in July 2020 at the farmers field of Sholabaria village of Santhia Upazila under Pabna district. Agro-Ecological Zone (AEZ) of the site was 12 which is low Ganges river floodplain. Soils of this region are silt loams and silty clay loams on the ridges and silty clay loam to heavy clays in lower sites. General soil types predominantly include calcareous dark grey soils and calcareous brown flood plain soils. Organic matter content is low in ridges and medium in the basins. Soil are calcareous in nature having neutral to alkaline in reaction.

Normal fertility level is low to medium, CEC, K and Zn status is low to medium. Mean weather data (2020-21) of Pabna district is presented in Fig. 1 (PRC, 2021). Block farming approach was followed for experimentation. The following three cropping patterns (CP) were laid for the experimentation—

CP_1 = Transplanted *Aman* rice (cv. Binadhan-7)—Mustard (cv. Binasarisha-9)— Mungbean (cv. Binamoog-8) —Transplanted *Aus* rice (cv. Binadhan-19)
CP_2 = T. Aman (cv. Binadhan-17)—Lentil (cv. Binamasur-8)—Stem amaranth— Sesame (cv. Binatil-2)
CP_3 (Control) = T. Aman (cv. *Shorna*) – Wheat (cv. BARI Gom 33) – Jute (cv. JRO 524)

Each CP plot consisted of 0.33 acre and for three CPs there were total 0.99 acre total land used. Seeds of *Shorna* rice, wheat, jute, stem amaranth were collected from seed market(s). In the case of rice (*Aus* and *Aman*), land preparation, sowing, transplanting, weeding, mulching, irrigation, pest control and other necessary agronomic managements were applied as per the methods of Chowhan et al. (2021) and Chowhan et al. (2019). For sowing and cultural management of sesame, lentil and mustard procedures described by Chowhan et al. (2021) were followed. Mustard, lentil and wheat was planted through relay cropping with *Aman* rice i.e. under zero tillage (ZT). Specifically, for ZT mustard seeding, methods illustrated by Chowhan and Islam (2021) was followed. Agronomic management practices in the wheat field was ensured as per the description of Mian et al. (2021). Mungbean was sown in the trial plot according to Islam et al. (2020). Production and field management of jute was done as per the methods imitated by Debnath et al. (2018). For cultivation of stem amaranth, procedures of Pramanik et al. (2021) were employed. All fertilizers were applied considering high yield goal with 'medium' soil analysis interpretation level according to stages of crop growth (Ahmmed *et al*., 2018; FRG, 2012). After finishing each season, respective crop(s) were harvested and data on production, yield, gross return, variable cost, gross margin, REY (Rice Equivalent Yield) and BCR (Benefit Cost Ratio) were recorded. Later, the results of each crop with CP were summarised separately and the mean performance was determined.

Economic evaluation entailed gathering information on pricing, quantity of inputs used, and output obtained (seed, straw, by-products etc.). Seed, fertilizer, labor and pesticides were among the inputs utilized. At current market prices, the output and inputs were estimated. Net income, benefit-cost ratio, REY were calculated using the individual results. Changes in management (family labor and operator's) costs and gross margin was used to calculate net income. To compare CPs, the yield of all crops was adjusted into REY using the current market price of each crop (Rahman *et al*., 2020). BCR was measured from the formula given below (Kamrozzaman *et al*., 2016).

$$\text{REY (t/ha)} = \frac{\text{Yield of individual crop (Kg)} \times \text{market price of that crop(Tk/Kg)}}{\text{Market price of rice (Tk/kg)} \times 1000}$$

$$\text{BCR} = \frac{\text{Gross return}}{\text{Total (variable) cost of cultivation}}$$

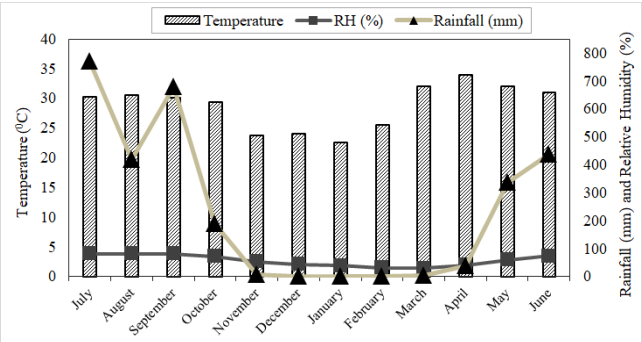

Fig. 1. Average weather data of Pabna district during July 2020 to June 2021. (Source: PRC, 2021).

RESULTS AND DISCUSSION

Crop and time management

In the first cropping pattern (CP_1), the initial crop was *aman* rice (Table 1) who's variety was Binadhan-7; it was sown in the seedbed 27 days prior to transplanting, i.e. seedlings were transplanted in the main (experimental) field 27 DAS (days after sowing). It was harvested at a duration of 119 days after attaining maturity. Later, after 7 days of harvesting *aman* rice mustard seed were sown under ZT in the *rabi* season with the remaining residual soil moisture after harvesting T. *Aman* rice. Binasarisha-9 was harvested at 93 days after seeding when it gained about 75% seed maturity. Next crop in CP_1 was mungbean and variety was Binamoog-8. It was sown immediately just after cutting mustard i.e in the 4th day after harvesting Binadarisha-9. Last crop of CP_1 was Binadhan-19 which was direct seeded after the end of mungbean's life cycle. Here the time available was only 3 days for the aus rice (Binadhan-19) to set up the unit plot. Summation of total days where land was reserved by crops were 345 days and sum of turn around time was 20 days in CP_1. All the varieties included here were short duration and high yielding. Else four crops adjustment would not be possible. BINA (2020) reported that the typical duration of Binadhan-7 was 121 days, Binasarisha-9 was 85 days, Binamoog-8 was 62 days and Binadhan-19 was 98-104 days at Pabna region. Current findings affirm the results except Binasarisha-9's duration. Deviation in the maturity days might be due to climatic, soil and soil nutrition factors.

The first crop of CP_2 was also *aman* rice but here the variety was Binadhan-17 (Table 1); it required a maturity duration of 91 days in the field after sowing 26 days old seedlings. Binamasur-8 as *rabi* lentil crop in the next sequence was directly seeded under ZT as relay crop with *aman* rice to save time. It was ready to harvest at 102 days after seeding. After 7 days of lentil harvesting stem amaranth was broadcasted in the ploughed land. Within 50 days this vegetable was fully harvested as it retained a marketable yield. On 3rd day sesame (Binatil-2) was broadcasted. Binatil-2 reached to harvesting stage at 92 days after seeding. Total field cropping duration of CP_2 was 335 days and total turn around time was 30 days. According to BINA (2020), mean duration of Binadhan-17, Binamasur-8 and Binatil-2 in Pabna and Jashore region was 116 days, 100 days and 95 days, respectively. Azad et. al. (2020) stated that high yielding stem amaranth varieties such as BARI Data-1 and BARI Data-2 had a average duration of 50-60 days for stem yield.

Table 1. Field management of the cropping patterns (CP_1-CP_2) with control (CP_3) at Santhia, Pabna during 2020-21.

Parameters	**CP_1**			
Crop	Rice (*Aman*)	Mustard	Mungbean	Rice (*Aus*)
Variety	Binadhan-7	Binasarisha-9	Binamoog-8	Binadhan-19
Spacing (cm^2)	20 × 20	Broadcast	Broadcast	Direct seeded
Date of sowing/ transplanting	20 Jul.20	27 Oct.20	01 Feb. 21	10 April 21
Irrigation (no.)	2	1	1	1
Weeding (no.)	2	1	1	1
Field duration (days)	92	93	65	95
Turn around time (days)	06	07	04	03
Date of harvesting	20 Oct.20	28 Jan.21	7 April 21	15 Jul.21
Parameters	**CP_2**			
Crop	Rice (*Aman*)	Lentil	Stem Amaranth	Sesame
Variety	Binadhan-17	Binamasur-8	local	Binatil-2
Spacing (cm^2)	20 × 20	Broadcast	Broadcast	Broadcast
Date of sowing/ transplanting	18 Jul.20	24 Oct. 20	10 Feb. 21	07 April, 21

Irrigation (no.)	1	1	1	0
Weeding (no.)	2	1	1	1
Field duration (days)	91	102	50	92
Turn around time (days)	13	07	07	03
Date of harvesting	17 Oct. 20	03 Feb. 21	04 April, 21	07 Jul. 21
Parameters	**CP_3**			
Crop	Rice (*Aman*)	Wheat	Jute	Fallow
Variety	*Shona*	BARI Gom 33	JRO 524	-
Spacing (cm^2)	20 × 20	Broadcast	Broadcast	-
Date of sowing/ transplanting	31 July 2020	17 Nov. 20	16 Mar. 21	-
Irrigation (no.)	2	2	2	-
Weeding (no.)	2	1	2	-
Field duration (days)	100	98	127	-
Turn around time (days)	09	09	22	-
Date of harvesting	08 Nov. 20	22 Feb. 21	21 July, 21	-

CP_3 or farmers' practiced CP's (Table 1) starting crop was *aman* rice which was sown at 29 DAS and it's field duration was 100 days. After 9 days wheat was sown by broadcasting directly as relay cropping with *Shorna (aman)* under ZT. End crop CP_3 was jute and variety was JRO 524. Between BARI Gom-33 (wheat) and jute there was a gap of 22 days. JRO 524 was harvested at 127 days after seeding and processed to extract the fibre. Chowhan et. al. (2021) reported that *Shorna* had a field duration of 99 days during *aman* season at Magura. Which was closely related to the present result. Azad et. al. (2020) mentioned that, duration of BARI Gom-33 was 110-115 days. variation in maturity in CP_3 might be due to direct seeding in ZT with relay cropping in *aman* rice thus life cycle may have reduced. Ferdous et. al. (2020) reported that, fibre yield of JRO 524 was increased up to 110 days with the effect of field duration. But, delayed maturity of jute in CP_3 might be due to soil moisture, prevailing weather, environmental and soil nutrition factors.

Yield and profitability

The studied CPs had a variation in yield depending on the crop and variety (Fig. 2). It was noticed that modern varieties performed better than older and traditional variety/cultivars in all the patterns. Such as in *aman* season Binadhan-17 gave most grain (5.78 t/ha) and straw yield (6.54 t/ha) over Binadhan-7 and *Shorna*. Second crop of CP_1, CP_2 and CP_3 was oil seed, pulse and cereal (wheat) respectively. Among them, BARI Gom-33 produced maximum grain (4.12 t/ha) and straw yield (5.11 t/ha). Stem amaranth produced the highest yield of 24.65 t/ha in the third sequence of the pattern 2. In the fourth cropping sequence Binadhan-19 yielded a grain and straw yield of 4.12 t/ha and 4.88 t/ha respectively. Over the evaluated cropping patterns CP_2 was found to be most profitable as it generated a BCR of 2.1. The reason of higher BCR was due to more market price of Binadhan-17, Binamasur-8, stem amaranth and Binatil-2 for their seed/grain quality and local demand. Akondo et al. (2020) indicated an utmost grain (6.06 t/ha) and straw yield (6.40 t/ha) of Binadhan-17 from evaluating six modern varieties which closely supports the present outcomes. Ahammed et al. (2015) alluded range of stem amaranth yield between 26.34 t/ha to 68.37 t/ha in 19 genotypes. Whereas, Miah et. al. (2015) found stem amaranth yield 22.49 t/ha through applying mixed cowdung, poultry manure and urea. Sarkar et. al. (2020) mentioned that, BCR of Binamasur-8 on a full cost basis was 1.79. Islam et. al. (2021) conducted a study at 5 districts of Bangladesh on the economic analysis of Binatil-3 and reported a BCR of 1.5 on a full cost basis. Actually, BCR of a crop or CP depends on the market, demand

and buyers willing to pay for a certain crop based on the quality of the produces.

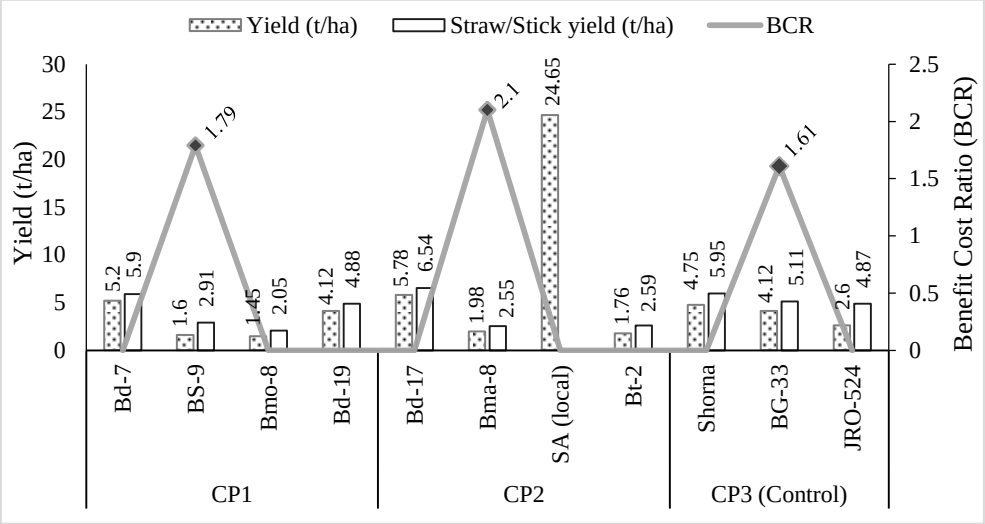

Fig. 2. Yield and BCR of the studied cropping patterns (CP_1 – CP_3).
[Note: Bd; Binadhan, BS; Binasarisha, Bmo; Binamoog, Bma; Binamasur, SA; Stem Amaranth, BG; BARI Gom]

Economic evaluation and Rice equivalent yield

Three patterns (CP_1 – CP_3) had diverse amount of economic expense and gain (Fig. 3). It was observed that, CP_2 obtained the most amount of gross return (7,29,150 Tk/ha) followed by CP_3 (6,97,200 Tk/ha) and CP_3 (5,15,900 Tk/ha). CP_2 combined one cereal, pulse, oil seed and vegetable and due to less cultivation and higher market price more gross return was achieved. Total variable cost (production or cultivation related expenses) was found to be maximum in the controlled pattern CP_3 (4,34,285 Tk/ha) followed by CP_2 (3,47,214 Tk/ha) and least in CP_1 (2,88,212 Tk/ha). Higher production cost in CP_3 was mainly due to lack of using modern technologies i.e tillage, suitable crop varieties and more labour involvement. Gross margin was notably higher (3,81,936 Tk/ha) in CP_2 over the other two patterns (CP_1 and CP_3). Jute enhanced the gross margin amount in CP_3 (2,62,915 Tk/ha) as market price was much for this crop. But, due to high production and processing cost of fibres BCR of CP_3 was ultimately less than CP_1 and CP_2.

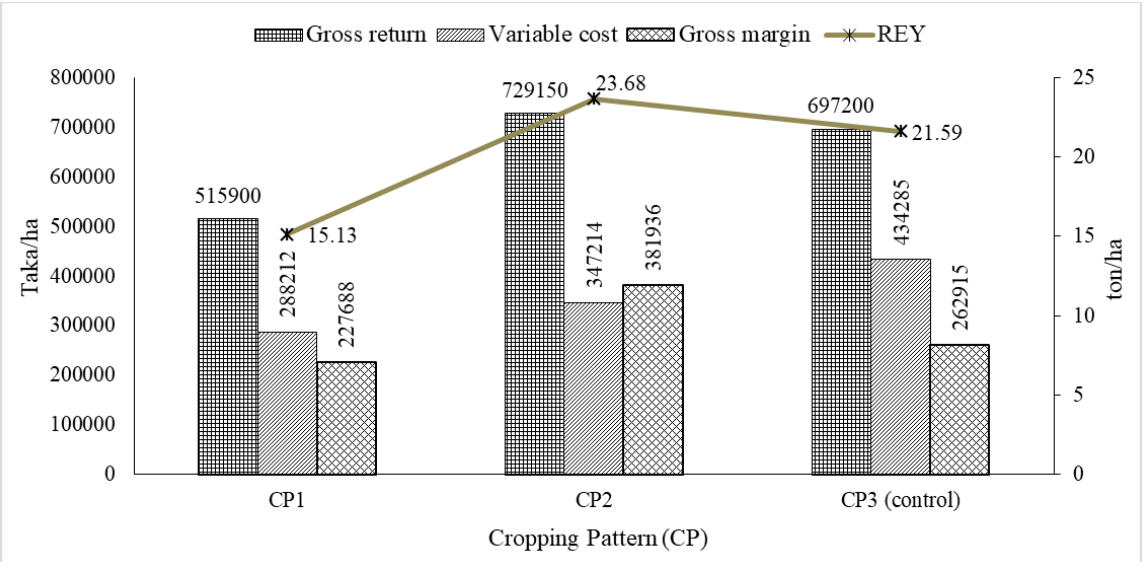

Fig. 3 Rice equivalent yield, cost and return of the three cropping patterns during 2020-21 at Santhia.
[Average Price (Tk/Kg): Rice 30, Mustard 50, Lentil 90 and Sesame 65. Jute 83, Wheat 28, Stem Amaranth 10]

CONCLUSION AND RECOMMENDATIONS

Four crops depended cropping pattern is undoubtedly most intensive cultivation; as turn around time remains very less. But, if short duration variety or cultivar is included it's not impossible to implement. Therefore, production cost and sales price should be closely taken into consideration else four crops cultivation may not be economically feasible. Increasing wages and unavailability of labor, unpredicted weather factors, occurrence of disease pests are major challenges for fruitful application of this pattern. To preserve soil health and gain more economic profit, incorporation of a pulse or oil seed crop is imperative as these crop requires less cultivation cost but gives more profit. As this study covered a single area with limited cropping patterns; further trials with other crop or crop varieties are needed to justify the outcomes of these findings.

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Conflict of interest

The authors declare no conflict of interest exists.

Author Contributions

Sushan Chowhan planned, designed, analyzed data and wrote the draft part of the article. Majharul Islam and Md. Moshiur Rahman recorded, managed and compiled the field experimental data. Md. Shohel Rana, Md. Aktarul Islam and Syful Islam collected weather data, relevant literature, prepared the table, figures and managed the references. All authors read and permitted the final edition of the manuscript.

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