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Effect of Different Mulch Materials on Yield and Nutrition Profile of Common *Capsicum* (*Capsicum annuum*) Cultivars in Bangladesh

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Abstract

Capsicum is a nutritious vegetable and its cultivation in farms is getting popular in Bangladesh. Although many efforts have lain to explore better yielding and nutritionally rich cultivars with suitable modern cultivation techniques but still have to find the desired outcome. Thus, it's necessary to conduct further research to identify the high-yielding and nutritious *capsicum* cultivars in Bangladesh. An experiment was conducted from July 2021 to June 2022 at the Bangladesh Institute of Research and Training on Applied Nutrition (BIRTAN) research field with three cultivars of *capsicum*: B_0 = California Wonder, B_1 = BARI Misti Morich-1 and B_2 = BARI Misti Morich-2 and three mulching: T_0 = No mulching, T_1 = Water hyacinth, T_2 = Poly Mulching in randomized complete block design with three replications to identify better quality *capsicum* cultivar and suitable mulching material. Among cultivars the BARI Misti Morich-2 (B_2) showed increased agronomic parameters like number of branches and effective branches per plant, leaves length and width, consequently yield and yield contributing traits were also enhanced like fruits per plant, fruit length, fruit diameter and yield per plant (25.97%, 4.54%, 3.64% and 21.43%, respectively). Poly Mulching (T_2) increased agronomic

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traits, yield traits and yield (0.61 kg) than BARI Misti Morich-1 (T_1). The combined effect of B_2T_2 increased the number of branches per plant, effective branches per plant, leaves length and breadth by 40%, 90%, 15.57% and 26.22%, respectively, hence resulting in an increased yield of 20%. BARI Misti Morich-2 cultivar showed an increase in Fe, Zn and Vitamin-C content of 26.24% and 23.10%, 8.82% and 5.14%, and 6.03% and 5.74% than B_0 and B_1 cultivars, respectively. Therefore, BARI Misti Morich-2 exhibited the improved agronomic, yield and nutritional traits of *capsicum* under poly mulching among other cultivars in Bangladesh.

Keywords

Capsicum Cultivars, Mulch Materials, Yield, Yield Contributing Traits, Nutritional Quality

1. Introduction

Agriculture is one of the driving forces of the economy in Bangladesh which includes more than half of the working population of the country and contributes around twelve percent in national GDP [1]. In Bangladesh, despite over growing population, declining arable land, climate change and the impact of the COVID-19, agriculture sector is growing by increasing crop productivity, ensuring sustainable food security and creating employment opportunities. Moreover, vegetable farming is getting prominent in Bangladesh than ever before, its production has risen (38.30%) in ten years and the production in 2020-21 is 1.4 million tons in a tiny portion of total cultivable lands [2]. Thus, *Capsicum* as a vegetable may become an economically and nutritionally high value vegetable in Bangladesh like other countries worldwide.

Capsicum is the most important summer crop of temperate regions while efforts are being made to grow sweet pepper in Bangladesh [3]. The genus *Capsicum* includes over 30 species, five of which (*C. annuum*, *C. frutescens*, *C. chinense*, *C. baccatum*, and *C. pubescens*) are domesticated and mainly grown for consumption [4]. However, California Wonder is the most popular variety in Bangladesh while Bangladesh Agricultural Research Institute (BARI) released two variety of *capsicum*. These *capsicum* varieties seeds are locally available and more sustainable to the specific soil and climate of Bangladesh. The bell shaped two varieties are namely BARI Misti Morich-1 and BARI Misti Morich-2. Both are green in color at mature stage but red in ripening for BARI Misti Morich-1, while yellow for BARI Misti Morich-2. All these cultivars are very mild in pungency and even none. *Capsicum* is rich in vitamins, minerals and antioxidants. There are plenty of studies on the nutrient status of *capsicum* worldwide but hardly any study in existing *capsicum* cultivars in Bangladesh. Unrevealing the nutrient status would increase the acceptability of this crop to people and can be supplemented in the existing dietary pattern.

In *capsicum* farming, mulching is one of the important agronomic practices in conserving the soil moisture and modifying the soil physical environment. The mulching increases vegetables fruit number, average fruit weight, fruit length, fruit diameter and plastic mulches positively effect on improved fruit yield [5]. However, different mulching materials generate different soil temperatures and soil moistures, hence mulching produces *Capsicum annuum* fruits with higher vitamin-C, chlorophyll-a, chlorophyll-b, total chlorophyll contents, fruits per plant and yield [6]. The fruit number, average fruit weight, fruit length, fruit diameter and fruit yield in vegetables including *capsicum* is strongly related to soil moisture content [7]. The optimum soil and canopy environment, relative water content, leaf water potential, leaf weight, root length density and dry biomass are favorable for higher yield with enhanced water efficiency under organic mulching [8]. Thus, mulching seems to be a viable tool to produce *capsicum* under the tropical conditions like in Bangladesh. Water hyacinth and poly mulching materials are common and economically viable for the local farmers in Bangladesh. Moreover, water hyacinth improves soil quality and poly mulching may reuse to develop sustainable cultivation system in terms of Bangladesh.

Therefore, this present research study was framed to evaluate the nutrient enrich *capsicum* cultivar and its responses in agronomic traits, yield contributing parameters and yield with different mulch materials on available *capsicum* cultivars in Bangladesh.

2. Methods

2.1. Experimental Site

The experiment was conducted at the field crop research division of the Bangladesh Institute of Research and Training on Applied Nutrition (BIRTAN) head office in Araihazar, Narayangonj from July 2021 to June 2022. It is situated middle Meghna River floodplain of AEZ-16 in Bangladesh. The land type was medium-low and sandy loam soil having a pH of around 7.0. The research area was located between 23˚40' and 23˚53' north latitudes and between 90˚35' and 90˚45' east longitudes. The site was situated in the sub-tropical climatic zone with scanty rainfall during the time. The average maximum and minimum temperatures were 28.3˚C and 18.4˚C, respectively and the average relative humidity varied from 54.20% to 74.60%.

2.2. Treatments and Materials

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were 12 plots with the unit plot size of 4.0 m × 2.0 m and plant-to-plant and row-to-row space was 60 cm × 70 cm, respectively.

1) Common *capsicum* cultivars (California Wonder, BARI Misti Morich-1 and BARI Misti Morich-2).

2) Mulching materials (No mulching, water hyacinth and poly mulching etc.).

3) Net-shed was used to prevent extreme sun light.

2.3. Land Preparation and Fertilization

The soil for *capsicum* cultivation was loosen to a fine tilth and then beds were formed. The beds were drench with 4% formaldehyde (4 liters per m^2 of the bed) and covered with polythene sheet for 3 - 5 days. Afterward, the polythene was removed; the beds were rake repeatedly every day to remove the trapped formaldehyde fumes completely prior to planting.

2.4. Selection of Planting Materials

- The planting materials were healthy, resistant to diseases and pests.
- Age of the seedlings was 35 to 40 days old.
- Height of the seedlings was 16 - 20 cm.
- The plant was possessing good rooting system.
- The seedlings were at least 4 - 6 leaves on the stem at the time of plantation.

2.5. Planting, Intercultural Operation and Harvesting

The optimum spacing for *capsicum* was 60 cm × 70 cm. Planting preferably be done in raised bed and in pit size of 15 cm × 20 cm. Before planting, the seedlings were dipped for 15 minutes in *Trichoderma* + *Pseudomonas* culture @ 10% to manage wilt problem. Two rows of *capsicum* seedlings were planted in a zigzag method on the bed.

2.6. Harvesting and Yield of *Capsicum*

Harvesting of *capsicum* fruits started from 60 days of planting in case of green color *capsicum*, 80 to 90 days in case of yellow and red fruited hybrids. Harvesting continues up to 170 to180 days at 10 days interval in green and up to 200 to 250 days in red and yellow. Fruits those were mature green, yellow when it is 75% yellow and red when it is 100% red harvested and kept in a cool place.

3. Nutritional Analysis

3.1. Determination of Mineral Composition

The sample were dried at 70 ˚C in an oven for 24 h. Dried sample were grounded finely in a mill. The final dried and milled powder was analyzed for macronutrients (Potassium, Calcium and Magnesium) and microelements (Iron, Manganese and Zinc), Carbohydrate (g/kg) and dietary fiber (g/100 g). The nitric-perchloric acid digestion method was followed to determine Potassium, Calcium, Magnesium, Iron and Zinc from powdered leaves.

3.2. Estimation of Carotenoid Contents

The sample was extracted in 80% acetone to estimate the total carotenoid contents. A spectrophotometer was used to read the absorbance at 470 nm for total

carotenoids. Data were expressed as mg carotenoids per 100 g FW.

3.3. Estimation of Vitamin

Fresh sample were used to measure Vitamin with a spectrophotometer. Data were recorded as mg ascorbic acid per 100 g fresh weight (FW).

4. Data Collection

In field stage the following data were recorded.

1) Plant height (inch), 2) Number of branches per plant,
3) Number of leaves per plant, 4) Days to first flowering,
5) Number of fruits per plant, 6) Length of mature fruits (cm),
7) Diameter of fruits (mm), 8) Seeds per fruits,
9) Weight of one fruit (gm).

In Lab

1) Proximate analysis of macro elements (mg/g FW) K, Ca and Mg,
2) Proximate analysis of micro elements (μg/g FW) Fe and Zn,
3) Proximate analysis of Carotenoids (mg/100 g) and Vitamin-C.

Statistical Analysis

Replicate samples were averaged to obtain replication means. Mean data of triplicate samples were also statistically analyzed by ANOVA using Statistics 10 software and the means were compared by Tukey's HSD test at a 1% level of probability. The results were reported as the average of six replications ± SD.

5. Results and Discussion

5.1. Agronomic Parameters

In this experiment three cultivars of *capsicum* (B_0 = California Wonder, B_1 = BARI Misti Morich-1 and B_2 = BARI Misti Morich-2) and application of different mulching (T_0 = No mulching, T_1 = Water hyacinth, T_2 = Poly Mulching) exhibited significant variations (at the level of $P < 0.05$) in agronomic parameters (Table 1).

Here, among cultivars B_2 cultivar showed a significant increase of number of branches per plant, number of effective branches per plant, leaves length, and leaves breadth; while, highest plant height (24.30 cm) and number of leaves per plant (76.40) were observed in B_0 cultivar. B_1 cultivar continuously showed the lowest values in all the agronomic parameters.

In case of mulching, it was observed that water hyacinth (T1) mulching showed highest plant height and leaves breadth (26.33 cm and 7.60 cm, respectively) and Poly Mulching (T_2) showed highest number of effective branches per plant (3.36) and leaves length (22 cm). No mulching (T_0) showed significantly lower values in all agronomic traits except for highest number of leaves per plant (66.93). These findings also supported the plastic mulch increased the plant height than other mulches [9].

Table 1. The agronomic parameters by the interactions of *capsicum* cultivars and different mulching materials.

Cultivar	Mulching	Treatments	Plant height (inch)	Number of branches/plant	Number of effective branches/plant	Number of leaves/plant	Leaves length (cm)	Leaves breadth (cm)
B_0			24.30 a	3.06 b	2.53 b	76.40 a	20.63 ab	6.28 b
B_1			21.00 b	2.93 b	2.60 b	53.93 b	19.83 b	6.47 b
B_2			21.80 b	4.06 a	3.46 a	56.40 b	21.60 a	7.13 a
$LSD_{0.05}$ (Cultivar)			0.000	0.000	0.008	0.003	0.061	0.012
	T_o		18.86 c	3.33 a	2.40 b	66.93 a	17.26 b	5.30 c
	T_1		26.33 a	3.13 a	2.93 ab	66.53 ab	22.80 a	7.60 a
	T_2		21.90 b	3.60 a	3.26 a	53.26 b	22.00 a	6.98 b
$LSD_{0.05}$ (Mulching)			0.000	0.239	0.031	0.0766	0.000	0.000
		B_0T_0	23.40 bc	3.00 c	2.00 c	82.40 ab	19.90 d	6.10 cd
		B_0T_1	27.40 a	2.80 c	2.80 abc	88.60 a	20.40 cd	6.40 c
		B_0T_2	22.10 cd	3.40 abc	2.80 abc	58.20 c	21.60 bcd	6.34 c
		B_1T_0	16.80 e	3.00 c	2.20 bc	57.20 c	15.50 e	4.60 e
		B_1T_1	25.40 ab	2.60 c	2.40 bc	54.00 c	22.60 bc	7.90 ab
		B_1T_2	20.80 d	3.20 bc	3.20 ab	50.60 c	21.40 bcd	6.92 bc
		B_2T_o	16.40 e	4.00 ab	3.00 abc	61.20 bc	16.40 e	5.20 de
		B_2T_1	26.20 a	4.00 ab	3.60 a	57.00 c	25.40 a	8.50 a
		B_2T_2	22.80 cd	4.20 a	3.80 a	51.00 c	23.00 ab	7.70 ab
$LSD_{0.05}$ (Cultivar × Mulching)			0.001	0.956	0.865	0.490	0.000	0.000

Notes: Cultivars: B_1 = California Wonder, B_1 = BARI Misti Morich-1 and B2 = BARI Misti Morich-2, Mulching: T_0 = No mulching, T_1 = Water hyacinth, T_2 = Poly Mulching. Means followed by the different letter within same cultivar, stage and parameters column indicate significant differences among the treatments at ($P < 0.05$).

The interactions of three *capsicum* cultivars and different mulching technics showed significant variations among agronomic parameters. Here, almost all the agronomic parameters were significantly increased with the treatment of B_2T_1 and B_2T_2, except for number of leaves per plant, while B_0T_0 showed the constant decrease of all the agronomic parameters and exhibited the lowest plant height (23.40 inch), number of branches per plant (3.00), number of effective branches per plant (2.00), leaves length (19.90 cm), and leaves breadth (6.10 cm). However, B_2T_1 increased plant height, number of branches per plant, number of effective branches per plant, leaves length, and leaves breadth by 11.96%, 33.33%, 80%, 27.64% and 39.34%, respectively and B_2T_2 increased number of branches per plant, number of effective branches per plant, leaves length, and leaves breadth by 40%, 90%, 15.57% and 26.22%, respectively (Table 1). These findings are in similar with organic and inorganic mulches increased leaf area in radish [10].

5.2. Yield and Yield Contributing Traits

In this experiment, *capsicum* cultivars (B_1 = California Wonder, B_1 = BARI Misti Morich-1 and B2 = BARI Misti Morich-2) and different mulching (T_0 = No mulching, T_1 = Water hyacinth, T_2 = Poly Mulching) showed significant variations at the level of ($P < 0.05$) in yield and yield traits (Table 2).

Here, the *capsicum* cultivars showed significant variations in yield and yield traits. The B_2 cultivar presented highest yield and yield traits except weight per fruit and increased number of fruits per plant (25.97%), length of mature fruit (4.54%), fruit diameter (3.64%), and yield per plant (21.43%) from B_0, while cultivar B_0 also showed the lowest yield per plant (0.56 kg).

Table 2. The yield and yield traits by the interactions of *capsicum* cultivars and different mulching materials.

Cultivar Mulching Treatment	Number of fruits/plant	Length of Mature fruit (cm)	Fruit diameter (cm)	Weight of 1 fruit (gm)	Thickness (cm)	Yield kg/plant
B_0	5.66 a	9.24 b	7.13 b	134.61 a	0.66 a	0.56 c
B_1	5.46 a	8.10 c	6.49 c	112.34 c	0.62 a	0.60 b
B_2	7.13 a	9.66 a	7.39 a	114.37 b	0.64 a	0.68 a
$LSD_{0.05}$ (Cultivar)	0.141	0.000	0.000	0.448	0.000	0.000
T_o	4.06 b	8.85 b	5.90 c	103.45 c	0.75 a	0.64 a
T_1	8.33 a	9.05 ab	6.93 b	111.68 b	0.57 b	0.59 b
T_2	5.86 b	9.09 a	8.17 a	146.19 a	0.59 b	0.61 ab
$LSD_{0.05}$ (Mulching)	0.000	0.239	0.000	0.076	0.000	0.043
B_0T_0	4.80 cd	9.96 b	6.18 d	126.04 c	0.74 ab	0.58 b
B_0T_1	8.00 ab	11.31 a	6.71 c	168.44 a	0.71 ab	0.53 c
B_0T_2	4.20 cd	6.44 f	8.49 a	109.3 d	0.53 d	0.56 bc
B_1T_0	3.00 d	7.40 e	5.46 e	91.26 f	0.71 ab	0.66 a
B_1T_1	7.20 abc	7.30 e	6.53 c	81.14 h	0.48 d	0.58 bc
B_1T_2	6.20 bc	9.61 b	7.47 b	164.62 b	0.68 bc	0.57 bc
B_2T_o	4.40 cd	9.21 c	6.07 d	93.04 e	0.80 a	0.66 a
B_2T_1	9.80 a	8.55 d	7.56 b	85.46 g	0.54 d	0.68 a
B_2T_2	7.20 abc	11.23 a	8.55 a	164.60 b	0.58 cd	0.70 a
$LSD_{0.05}$ (Cultivar × Mulching)	0.394	0.000	0.000	0.000	0.000	0.0432

Notes: Cultivars: B_1 = California Wonder, B_1 = BARI Misti Morich-1 and B2 = BARI Misti Morich-2, Mulching: T_0 = No mulching, T_1 = Water hyacinth, T_2 = Poly Mulching. Means followed by the different letter within same cultivar, stage and parameters column indicate significant differences among the treatments at ($P < 0.05$).

Table 3. Nutritional content of different *capsicum* cultivars.

Treatment	Ca (ppm)	Mg (ppm)	K (ppm)	Fe (ppm)	Zn (ppm)	Vitamin-C (mg/100 g)	β-Caroetene (mg/100 g)
B_0	2.08 a	0.27 a	0.83 a	196.33 b	41.33 c	83.09 b	72.40 b
B1	1.12 c	0.30 a	0.70 b	188.33 c	43.00 b	83.35 b	85.23 a
B2	1.71 b	0.30 a	0.81 a	255.33 a	45.33 a	88.43 a	62.15 c
P value	0.000	0.128	0.001	0.0000	0.000	0.000	0.000

Notes: Cultivars: B_0 = California Wonder, B_1 = BARI Misti Morich-1 and B2 = BARI Misti Morich-2. Means followed by the different letter within same cultivar and parameters column indicate significant differences among the treatments at ($P < 0.05$).

Different mulching also showed significant variation, Poly Mulching (T_2) showed highest length of mature fruit (9.09 cm), Fruit diameter (8.17 cm), weight per fruit (146.19 gm) and significantly higher yield (0.61 kg) than T_1. The lowest number of fruits per plant (4.06), length of mature fruit (8.85 cm), fruit diameter (5.90 cm) and weight per fruit (103.45 gm), while highest thickness (0.75) and yield (0.64) were observed from T_0. In addition, T_1 showed consistent lower yield and yield traits, except number of fruits per plant.

The significant variations ($P < 0.05$) were observed from the interactions of *capsicum* cultivars and different mulching materials. The B_2T_2 treatment showed the highest yield per plant (0.70 kg) and other yield traits like, number of fruits per plant (7.20), length of mature fruit (11.23 cm), fruit diameter (8.55 cm). Moreover, 20% increase in yield was observed in B_2T_2 than B_0T_0 treatment, while the lowest yield was found in B_0T_1. The B_0T_1 treatment showed the lowest number of fruits per plant (3), length of mature fruit (7.20 cm), fruit diameter (5.46 cm) (**Table 2**). From the previous research findings, it is clear that Mulching is favorable for maximum yield with very low input resources [11] [12] [13] [14].

5.3. Nutritional Quality Parameters

In this experiment, the competitive analysis of varieties California Wonder (B_0), BARI Misti Morich-1 (B1) and BARI Misti Morich-2 (B2) showed significant variations among all the tested nutrient parameters with the exception in Mg content. California Wonder (B_0) showed significantly highest Ca (2.0767 ppm) and K (0.830 ppm) content, while lowest Zn (41.333 ppm) content. The B_1 variety presented constant significant decline in Ca, K, Fe, Zn and Vitamin-C than the B_0 and B_2 varieties, while the highest β-Caroetene was found in B_1. There were significant increases in Fe, Zn, and Vitamin-C by the B_2 variety than B_1 variety. Moreover, it was observed that the highest Vitamin-C (88.433 mg/100g) found in B_2 variety. In addition, B_2 variety showed increase in Fe content 26.24% and 23.10%, Zn content 8.82% and 5.14%, and Vitamin-C content 6.03% and 5.74% than B_0 and B_1 (**Table 3**).

6. Conclusion

The research concluded that the *capsicum* cultivar BARI Misti Morich-2 im-

proved the agronomical parameters, yield traits and yield than other cultivars. BARI Misti Morich-2 also increased Fe, Zn and Vitamin-C content in the fruit. In addition, although BARI Misti Morich-1 cultivar constantly declined in Ca, K, Fe, Zn and Vitamin-C, it had highest β-Carotene, and California wonder had the highest Ca and K content. Thus, among the cultivars BARI Misti Morich-2 was the most performing cultivar which may improve in future with desirable traits from other cultivars. The use of mulching materials also improved the agronomic parameters, yield traits and yield of *capsicum* cultivars. BARI Misti Morich-2 with Water hyacinth and Poly mulching increased the number of branches, number of effective branches, leaves length, and leaves breadth, which increased the yield. The highest yield was observed from the poly mulching in BARI Misti Morich-2. These results and findings of this experiment will initiate new measures to attain more yielding and nutrient enriches cultivar and updated technics of *capsicum* cultivation in Bangladesh.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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