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Influence of Organic Fertilizer Application on Soil Nutrients and Yield of Cotton

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Abstract:- The study was conducted to evaluate the performance of organic fertilizers on cotton yield and soil nutrients at Cotton Research Farm of Cotton Development Board located at Jagodishpur, Chawgacha, Jashore during the crop growing season of 2021 and 2022 using the seeds of genotype CB Hybrid-1 planted in a spacing of 90 × 35 cm. The experiment was laid out in a RCBD design with three replications. The experimental treatments were consisted of different doses of cow dung and processed organic fertilizers of three different sources (a, b and c). The treatments were: T_1 = control (zero fertilizer), T_2 = 10.526 t ha^{-1} of cow dung, T_3 = 3.571 t ha^{-1} of processed organic fertilizer (a), T_4 = 4.225 t ha^{-1} of processed organic fertilizer (b), T_5 = 5.0 t ha^{-1} of processed organic fertilizer (c), T_6 = ½ cow dung + ½ recommended fertilizer dose (RFD) of N, P, K, S, B, Zn and Mg, T_7 = ½ (a) + ½ RFD of N, P, K, S, B, Zn and Mg, T_8 = ½ (b) + ½ RFD of N, P, K, S, B, Zn and Mg and T_9 = ½ (c) + ½ RFD of N, P, K, S, B, Zn and Mg. The trend of nutrients was smaller but increase was observed. The highest increase of total OM, total N, P, K, S, Zn and B were 7.89%, 10.0%, 8.27%, 9.09%, 9.0%, 8.81%, 8.33% respectively and those were recorded in T_5, T_2, T_6, T_3, T_7, T_7 and T_5 treatments respectively in the end of second year. The results indicated that the half amount of organic fertilizer (b) along with ½ RFD (T_8) produced the maximum seed cotton (2.49 t/ha) in 2021. But sole organic fertilizer at the rate of 4.225 t ha^{-1} (source- b) produced maximum seed cotton (2.51 t/ha) in 2022. Amendment of sole cow dung gave maximum BCR of 2.34 and 2.69 in 2021 and 2022 respectively. The treatments T_3, T_6, T_7 and T_8 might be the optimum treatment on the basis of BCR. Application of organic fertilizer with inorganic offers higher yield of seed cotton and economic returns with an increase of soil nutrients.

Keywords:- *Amendment, Fertilizer, Increase, Nutrient, Organic.*

I. INTRODUCTION

Application of **o**rganic and inorganic fertilizers increase the accumulation of C, N, and P in the soil and improve the soil's ability to supply nutrients to crops (Ma *et al*., 2009). Fertilizers are used to increase soil fertility and it contribute a lot in food production and food security (Choudhary *et al*., 2021 and Wang *et al*., 2021). However, there are problems with high frequency of chemical fertilizer application and less use of organic fertilizers (Chen *et al*., 2017). Organic fertilizer is the source of soil organic carbon and soil organic carbon is an important indicator of soil health, particularly impacts on soil fertility for crops, because it has several benefits: improving soil structure through soil particle aggregation enabling better root access, increased water infiltration and retention, increased nutrient bioavailability due to soil organic matter decomposition and more exchange sites for mineral nutrients increasing the soil's cation exchange capacity. Many studies have shown that applying organic fertilizers to the soil surface can provide a rich food source for microorganisms and significantly increase microbial community composition and diversity compared to no application (Chang *et al*., 2007; Diacono and Montemurro, 2010).

Mineral fertilizers, particularly nitrogen, phosphorus and potassium (NPK), are widely used in intensive arable farming, but at present organic fertilizers are not common in Bangladesh. Furthermore, crop straw is removed from agricultural farms and cow dung is burned as homestead fuel. Chemical fertilizers are widely used in agricultural production practices. The use of large amounts of chemical fertilizers has a series of harmful ecological and environmental impacts, such as soil acidification, soil compaction, and soil fertility degradation, which severely restrict the sustainable development of green agriculture (Chen *et al*., 2017 and Gosal *et al*., 2018).

Cotton, an important fiber crop, is cultivated widely in tropical and sub-tropical regions, which play an important role in the national economy of Bangladesh. It occupies about 50,000 hectares of the cultivated land of the country. The farmers are generally subsistence small holders with poor knowledge of fertilizer management (FAO, 2015). Now a days, most of the farmers in Bangladesh use high yielding varieties and consequently it requires more fertilizer application. Although farmers are willing to use more N fertilizer for a better crop yield. The lower yield of cotton with association of inorganic fertilizers is one of the challenge for farmers. A very few farmers are using different processed organic fertilizers as the substitute of cow dung or farmyard manure along with inorganic fertilizers in cotton cultivation. Organic fertilizers or manures release nitrogen, potassium, phosphorus and other nutrient elements to the soil. In cotton nitrogen encourages vegetative growth and boll setting by increasing sympodial

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branches and boll weight. But nitrogen can be reduced yield and quality of cotton to have excess nitrogen in late reproductive stage (Luo *et al*., 2018). Therefore, rationally balancing organic and chemical fertilizer input and enhancing crop yields and soil sustainability are the targets that need to be focused urgently in current cotton cultivation practices. The effect of organic fertilizers on cotton yield and soil nutrient has not been studied extensively. The aim of this experiment was to investigate the effects of applying different organic fertilizers on cotton yield and soil nutrient.

II. MATERIALS AND METHODS

The experiment was conducted to evaluate the yield contributing parameters of cotton and soil nutrients as affected by organic fertilizers during 2021 and 2022 at Cotton Research, Training and Seed Multiplication Farm, Jagodishpur, Chowgacha, Jashore. The experimental site was gangetic alluvium soil with sandy loam textured. A description of air temperature and rainfall is presented in Table 1. The monthly mean maximum temperature of 34 ^{0}C was recorded in the month of July and the monthly mean minimum temperature of 16.7 ^{0}C was found in the month of December in the crop growing season 2021. The monthly mean maximum temperature of 35.6 ^{0}C was recorded in the month of August and the monthly mean minimum temperature of 15.0 ^{0}C was found in the month of December in the crop growing season 2022. The crop received total rain fall of 1151 mm in 2021 and 561 mm in 2022. Cow dung and processed organic fertilizers were used in the study. The sources of processed organic fertilizers were a) Soil Tech Agro Organic Fertilizer; b) NAAFCO (Pvt.) Limited and c) Advanced Chemical Industries (Ltd.). The experiment comprised of nine treatments: T_1 = 0.0 kg ha^{-1} organic and inorganic fertilizer (control), T_2 = 10.526 t ha^{-1} cow dung (N = 60 kg ha^{-1}), T_3 = 3.571 t ha^{-1} processed (a) organic fertilizer (N = 60 kg ha^{-1}), T_4 = 4.225 t ha^{-1} processed (b) organic fertilizer (N = 60 kg ha^{-1}), T_5 = 5.0 t ha^{-1} processed (c) organic fertilizer (N = 60 kg ha^{-1}), T_6 = 5.263 t ha^{-1} cow dung + 1/2 RFD of N, P, K, S, B, Zn and Mg, T_7 = 1/2 (a) + 1/2 RFD of N, P, K, S, B, Zn and Mg, T_8 = 1/2 (b) + 1/2 RFD of N, P, K, S, B, Zn and Mg and T_9 = 1/2 (c) + 1/2 RFD of N, P, K, S, B, Zn and Mg. The experiment was laid out in a RCBD design with three replications. RFD is the recommended fertilizer dose at the rate of 60 (reduced), 75, 205 , 25, 2, 3.3 and 1.8 kg N, P, K, S, B, Zn and Mg ha^{-1} respectively in the form of Urea, TSP, MoP, Gypsum, Borax, Zinc sulfate and Magnesium sulfate. The seeds of cotton genotype CB Hybrid-1 were sown maintaining a spacing of 90 cm x 35 cm. All other required cultural operations regarding weeding and plant protection measures were adopted uniformly in all the plots throughout the growing periods. Irrigation was done on first week of November and last week of November. Soil samples were collected initially in 2021 and in the end of seed cotton harvest in 2022 to analyze nutrient status of the soil. Organic carbon in the soil sample was determined by wet oxidation method of Walkley and Black (1965). Total N content of soil was determined following Kjeldahl method as outlined by Jackson (1973). Available P content of soil was extracted from the soil with 0.5M $NaHCO_3$ solution at pH 8.5 (Olsen *et al*., 1954). The P in the extract was then determined by developing blue color measuring the color by spectrophotometer at 660 nm wave length. K was determined from the extract (extraction with 1M ammonium acetate) using a flame photometer (Black, 1965). The S content in the extract (extracting soil sample with 0.15% $CaCl_2$ solution as described by Page *et al*.,1982 and S was determined turbidimeterically, the turbid was measured by a spectrophotometer. The available B content of soil was extracted by hot water and extractable B was determined by azomethene-H method. The absorbance of B was measured at 420 nm on a spectrophotometer and calculated by using a standard curve (Petersen, 1999). Data on total biomass (not presented) and yield contributing parameters were recorded during seed cotton harvest. Data for the studied characters were statistically analyzed. Duncan's multiple range test (DMRT) was used to determine the significant differences at 5% level of significance.

Table 1: Air temperature and rainfall data during crop growing season 2021 and 2022

Month	Minimum mean temperature (^{0}C)		Maximum mean temperature (^{0}C)		Rainfall (mm)	
	2021	2022	2021	2022	2021	2022
July	26.8	26.6	34.0	35.0	269	74
August	27.0	26.8	33.6	35.6	247	215
September	26.3	26.8	32.6	34.2	287	162
October	26.0	27.4	33.4	33.7	151	110
November	17.7	17.4	29.6	30.2	38	-
December	16.7	15.0	25.6	26.4	159	-

Source: Bangladesh Metrological Department

III. RESULTS AND DISCUSSIONS

The effect of different organic fertilizers on soil nutrient was determined. The nutrient status of the experimental plots in the baseline year 2021 (initial) and in the end of crop growing season 2022 are presented in Table 2. The nutrient elements of the studied plots were found similar in the baseline year 2021 and in 2022. In the control treatment (T_1) organic matter (OM) was not changed. OM was increased highest of 7.89 % in T_5 treatment over the baseline year. The initial total N was recorded highest of 0.071% in T_7 treatment and the highest increase of total N of 10% was recorded in T_2 treatment in the end of second year. The trend of available P was found increased with the highest increase of 8.27% over the baseline year in T_6 treatment and the highest average of P was 11.42 µg/g soil

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in T_9 treatment. K was determined highest of 2.29 m.e./100g soil in T_6 treatment in the baseline year and in 2022. K was decreased in the control treatment in 2022 and the increase was determined highest of 9.09% over the baseline year in T_3. The available S was observed highest of 17.55 µg/g soil in T_6 and T_9 treatment in the baseline year and the highest increase of 9% was observed in T_7 treatment in the end of second year. The available Zn of 2.45 µg/g soil was similar in the baseline year and in 2022 in control treatment and it was increased highest of 8.81% in T_7. The available B was decreased in T_1 and T_7 treatment and the highest increase of 8.33% was found in T_5 over the base line year. Similar benefit of using manures in the soil are reported by Cathy *et al.,* 2019.

Performance of yield traits of cotton: Yield contributing characters of cotton have been evaluated in this experiment during 2021 and 2022. Mean squares of yield traits of cotton under different organic fertilizers are presented in Table 3. The parameters viz. number of bolls palnt^{-1} and yield were highly significant, but single boll weight found insignificant among treatments in 2021. The results also shows that the number of bolls palnt^{-1}, single boll weight and yield were highly significant among treatments in 2022.

Table 2: Effect of different organic and inorganic fertilizers on soil nutrient

Nutrient	Season	Amount of soil nutrient elements under different treatments								
		T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
OM (%)	initial	0.64	0.54	0.64	0.53	0.38	0.88	1.02	1.16	0.56
	2022	0.64	0.58	0.68	0.55	0.41	0.9	1.06	1.15	0.59
	increase (%)	0.00%	7.41%	6.25%	3.77%	7.89%	2.27%	3.92%	-0.86%	5.36%
	average	0.64	0.56	0.66	0.54	0.395	0.89	1.04	1.155	0.575
Total N (%)	initial	0.037	0.03	0.037	0.035	0.022	0.052	0.071	0.052	0.057
	2022	0.03	0.033	0.039	0.038	0.021	0.054	0.073	0.054	0.057
	increase (%)	-18.92%	10.00%	5.41%	8.57%	-4.55%	3.85%	2.82%	3.85%	0.00%
	average	0.0335	0.0315	0.038	0.0365	0.0215	0.053	0.072	0.053	0.057
P (µg/g)	initial	7.63	7.63	7.29	8.45	10.34	10.16	8.86	7.55	11.32
	2022	7.29	8.01	7.61	8.69	10.75	11	9.01	7.86	11.52
	increase (%)	-4.46%	4.98%	4.39%	2.84%	3.97%	8.27%	1.69%	4.11%	1.77%
	average	7.46	7.82	7.45	8.57	10.545	10.58	8.935	7.705	11.42
K (m.e./100g)	initial	0.27	0.22	0.22	0.24	0.27	0.29	0.24	0.23	0.26
	2022	0.25	0.23	0.24	0.24	0.28	0.29	0.26	0.24	0.28
	increase (%)	-7.41%	4.55%	9.09%	0.00%	3.70%	0.00%	8.33%	4.35%	7.69%
	average	0.26	0.225	0.23	0.24	0.275	0.29	0.25	0.235	0.27
S (µg/g)	initial	16	15.95	15	15.95	14.15	17.55	17	15.5	17.55
	2022	15.7	16	16	17.05	15.35	19	18.53	16.31	18.95
	increase (%)	-1.88%	0.31%	6.67%	6.90%	8.48%	8.26%	9.00%	5.23%	7.98%
	average	15.85	15.975	15.5	16.5	14.75	18.275	17.765	15.905	18.25
Zn (µg/g)	initial	2.45	2.88	2.89	2.23	3.45	3.45	2.27	2.65	3.21
	2022	2.45	2.91	2.95	2.35	3.51	3.51	2.47	2.88	3.39
	increase (%)	0.00%	1.04%	2.08%	5.38%	1.74%	1.74%	8.81%	8.68%	5.61%
	average	2.45	2.895	2.92	2.29	3.48	3.48	2.3	2.765	3.3
B (µg/g)	initial	0.94	0.86	0.87	0.93	0.72	1.28	1.25	0.95	0.89
	2022	0.91	0.91	0.9	0.98	0.78	1.32	1.22	1.02	0.93
	increase (%)	-3.19%	5.81%	3.45%	5.38%	8.33%	3.13%	-2.40%	7.37%	4.49%
	average	0.925	0.885	0.885	0.955	0.75	1.3	1.235	0.985	0.91

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Results in Fig. 1 and Fig. 2 showed that the number of bolls plant^{-1} was increased over control treatments due to application of fertilizers in 2021 and 2022. The T_8 treatment produced the highest number of bolls plant^{-1} (20.8) which was statistically similar with those observed in treatments T_4, T_6, T_7 and T_9 in 2021. But in 2022, the highest number of bolls plant^{-1} of 23.5 was observed in the treatment T_4 which was statistically different from all other treatments. The second highest bolls were produced in T_9 which was statistically similar with those treatments observed in T_6, T_7 and T_8. The average boll of 2021 and 2022 was found highest in T_4 (22.1) treatment (amendment by processed organic fertilizer, b). While the highest number of boll per plant was recorded from 70% inorganic N with 30% N from poultry manure by Islam *et al.* (2014) and from amendment of FYM @ 5t/ha with RFD by Sathya *et al.* (2022) which was consistent with our results. Data presented in Fig. 1 also indicated that the highest boll weight of 4.76 g was found in the treatment T_6 followed by T_7. On the other hand, the lowest boll weight of 4.19 g was in the treatment T_1 in 2021. But the T_3 treatment produced the highest weight (4.98) of a single boll in 2022.

Table 3: Mean square values of different agronomic and yield parameters of cotton under different organic fertilizer treatment at Jagodishpur during 20221 and 2022

Year	Source	df	No. of bolls plant^{-1}	Single boll weight	Yield
2021	Replication	2	45.704	0.143	269520
	Treatment	8	43.021**	0.057NS	822430**
	Error	16	8.802	0.042	89893
2022	Replication	2	1.400	0.038	23374
	Treatment	8	64.746**	0.120**	844562**
	Error	16	1.012	0.024	92066

** = significant at $p \leq 0.01$; * = significant at $p \leq 0.05$, NS = Not significant at $p \leq 0.05$

Cotton yield is a complex character which depends on several individual traits such as no. of bolls plant^{-1}, single boll weight, plant height etc. The higher boll weight and boll numbers are considered to be the indication of higher seed cotton yield. In our experiment seed cotton yield was significantly ($p < 0.01$) varied among treatments and it ranged from 1.04 to 2.49 t ha^{-1} in 2021 and 1.0 to 2.51 t ha^{-1} in 2022. The highest yield of 2.49 was observed in the treatment T_8 in 2021 (Fig. 1) and 2.51 t ha^{-1} in T_4 in the crop growing season 2022 (Fig. 2). The treatments may be ranked in order of $T_8 > T_4 > T_3 = T_7 > T_9 > T_5 > T_6 > T_2 > T_1$ in terms of seed cotton yield and T_8 yielded 39% higher over control treatment in 2021. The results of 2022 indicated that after amendment of soil, seed cotton yield was increased in most of the treatments. The highest yield increased of 15.23% was recorded in T_2 treatment and the second highest increased of 12.62% in T_5 treatment over the yield of 2021 at the end of 2022 and the yield was decreased (3.85%) in the control treatment (Fig. 3). The treatments were ranked in the order of $T_4 > T_8 > T_5 > T_9 > T_2 > T_7 > T_3 > T_6 > T_1$ based on seed cotton yield in 2022.

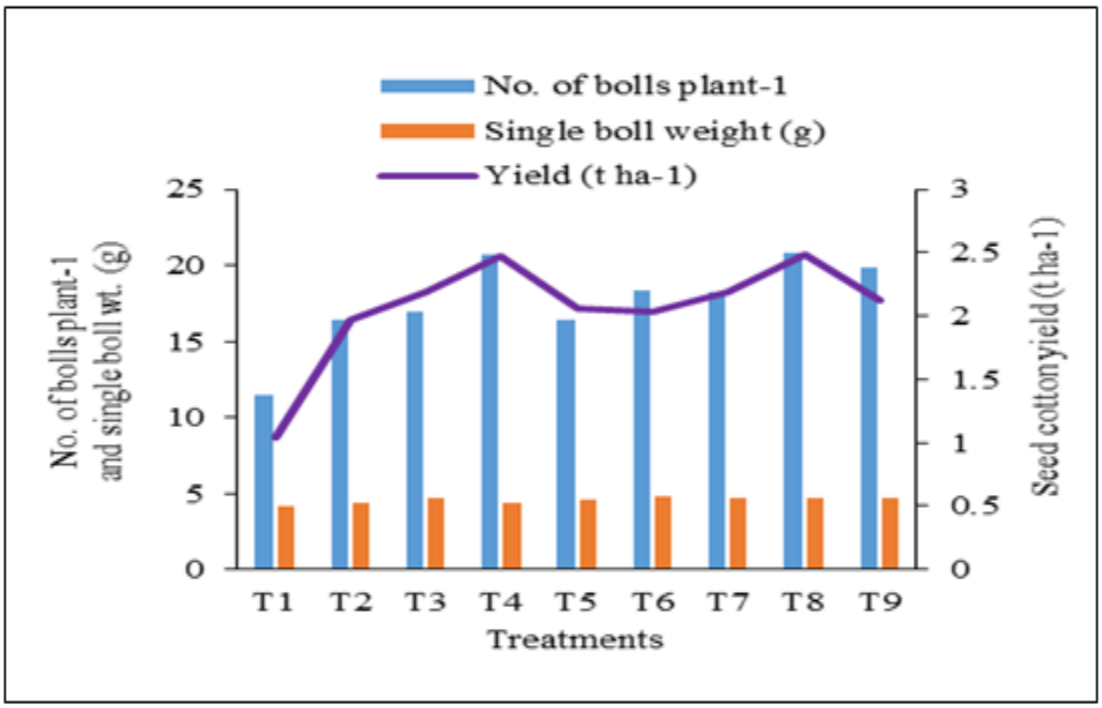

Fig. 1: Effect of organic fertilizers yield attributes of cotton in 2021

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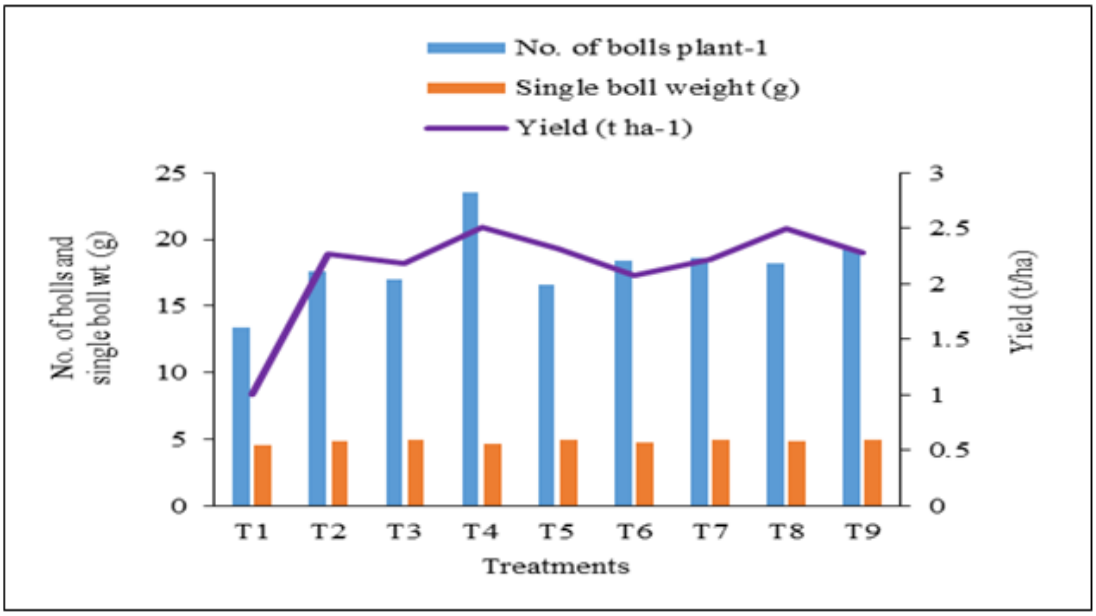

Fig. 2: Effect of organic fertilizers on yield attributes of cotton in 2022

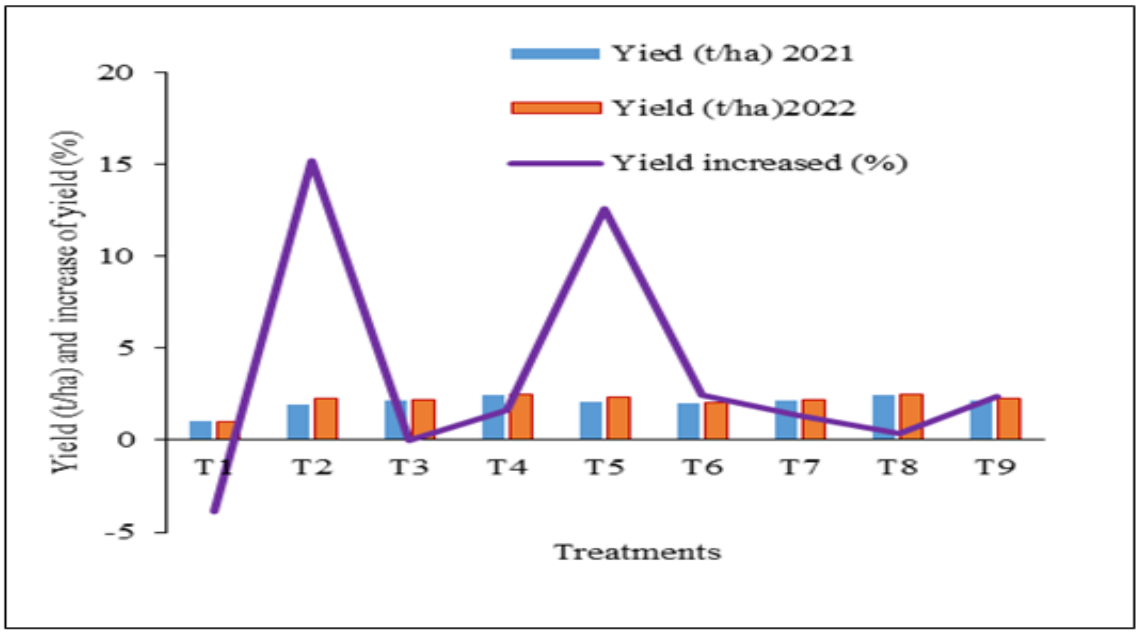

Fig. 3: Change in yield (%) as influenced by organic fertilizers in 22022

In previous results by Sathya *et al.* (2022), Tagaev *et al*. (2022) and Niu *et al.* (2021) were consistent with our results that application of organic fertilizers with inorganic fertilizers increased seed cotton yield. Application of optimum N improves various physiological and metabolic processes such as photosynthesis, carbon, and nitrogen metabolism, which is an important factor of high yield and high quality of cotton. Boquet and Breitenbeck (2000) also concluded that the application of N fertilizer is one of the important means to increase cotton yield. Many studies have confirmed that a reasonable supply of N nutrition can increase the dry matter and growth rate of cotton at all stages (Xue *et al*., 2006). In our study N was applied @ 60 kg/ha (from sole organic fertilizer) and yield was found increased over control.

IV. ECONOMICS

The maximum gross return of cotton production was from T_4 treatment (Tk. 238450/-) followed by from T_1 (Tk.95000/-) in 2022 (Table 4). In 2021, the maximum gross return obtained from T_8 (236550/-) and the lowest from T_1 (Tk.98800/-). The gross margin was obtained highest from T_2 (Tk. 135723/-) followed by T_8 (Tk. 128975/-) and the lowest from T_1 (Tk. 36125/-) in 2022. The gross margin also fond maximum from T_8 (128025/-) in 2021. The maximum benefit cost ratio was found in T_2 (2.69) season 2021, the BCR was highest in T_2 (2.34) and lowest was in T_5 treatment (1.46). The treatments T_3, T_6, T_7 and T_8 also shows the optimum BCR (> 2.0).

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V. CONCLUSION

Application of organic fertilizers in different doses and application with chemical fertilizers had a contribution to increase soil nutrients and seed cotton yield. The trend of nutrients were similar but an increase was observed. In the end of second year, the highest increase of total OM, total N, P, K, S, Zn and B were 7.89%, 10.0%, 8.27%, 9.09%, 9.0%, 8.81%, 8.33% recorded respectively and those increases of elements observed in T_5, T_2, T_6, T_3, T_7, T_7 and T_5 treatments respectively. The half amount

Table 4: Benefit cost analysis of cotton production with the application of organic fertilizer in 2021 and 2002.

Treatment	Season	yield (t/ha)	Gross return (Tk. ha^{-1})	Cost of treatment (Tk./ha)	Total cost of cultivation (Tk. /ha)	Gross margin (Tk./ha)	Benefit-cost ratio (BCR)
T_1	2021	1.04	98800	0	58875	39925	1.68
	2022	1	95000			36125	1.61
T_2	2021	1.97	187150	21052	79927	107163	2.34
	2022	2.27	215650			135723	2.69
T_3	2021	2.19	208050	44638	103513	104537	2.01
	2022	2.19	208050			104537	2.01
T_4	2021	2.47	234650	67600	126475	108175	1.86
	2022	2.51	238450			111975	1.89
T_5	2021	2.06	195700	75000	133875	61825	1.46
	2022	2.32	220400			86525	1.65
T_6	2021	2.03	192850	26376	85251	107599	2.26
	2022	2.08	197600			112349	2.32
T_7	2021	2.19	208050	38169	97044	111006	2.14
	2022	2.22	210900			113865	2.17
T_8	2021	2.49	236550	49650	108525	128025	2.18
	2022	2.5	237500			128975	2.19
T_9	2021	2.13	202350	53350	112225	90125	1.8
	2022	2.28	216600			104375	1.93

T_1 = Control, T_2 = 10.526 t ha^{-1} cow dung, T_3 = 3.571 t ha^{-1} processed (a) organic fertilizer, T_4 = 4.225 t ha^{-1} processed (b) organic fertilizer, T_5 = 5.0 t ha^{-1} processed (c) organic fertilizer, T_6 = 5.263 t ha^{-1} cow dung + 1/2 RFD of N, P, K, S, B, Zn and Mg, T_7 = 1/2 (a) + 1/2 RFD of N, P, K, S, B, Zn and Mg, T_8 = 1/2 (b) + 1/2 RFD of N, P, K, S, B, Zn and Mg, T_9 = 1/2 (c) + 1/2 RFD of N, P, K, S, B, Zn and Mg Cost: Cow dung: 2000 Tk/t; Organic fertilizer (a): 12500 Tk./t; (b): 16000 Tk/t; (c): 15000 Tk/t Urea: 18000 Tk/t; TSP: 24000 Tk/t; MoP: 1800 Tk/t; Gypsum: 35000 Tk/t, Zinc sulfate: 220000 Tk/t; Magnesium sulfate: 50000 Tk/t; Borax: 300000 Tk/t; Basic cost of cultivation: 58875 Tk/ha. Price of seed cotton: 95 Tk /kg of organic fertilizer (b) along with ½ RFD (T_8) produced the maximum seed cotton (2.49 t/ha) in 2021. But sole organic fertilizer 'b' produced maximum seed cotton (2.51 t/ha) in 2022. Amendment of sole cow dung gave maximum BCR of 2.34 and 2.69 in 2021 and 2022 respectively. But the treatments T_3, T_6, T_7 and T_8 might be the optimum treatment on the basis of BCR as their BCR is more than 2.0. From our results it can be concluded that application of organic fertilizer with inorganic offers higher yield of seed cotton and economic returns with small increases of soil nutrients..

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