Published with Open Access at Journal BiNET
Vol. 29, Issue 01: 2407-2415
Journal of Bioscience and Agriculture Research

Journal Home: www.journalbinet.com/jbar-journal.html

Influence of humic acid on morpho-physiology and yield of rice

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Article received: 30.01.2022; Revised: 08.05.2022; First published online: 30 May 2022

ABSTRACT

A pot experiment was conducted to investigate the influence of soil organic amendments-cow dung and humic acid on morphology and yield of rice under drought stress at the net-house, Agricultural Botany Department at Sher-e-Bangla Agricultural University, during the period from July 2018 to November 2018. This single factorial experiment pots where arranged in a randomized complete block design with four replications. Four different levels of soil organic amendments viz. SM_1 = Soil + inorganic fertilizer (control), SM_2 = Soil + cow dung + inorganic fertilizer, SM_3 = Soil + inorganic fertilizer + humic acid and SM_4 = Soil + inorganic fertilizer + cow dung + humic acid. The results showed that morphological characters and yield of rice significantly increased with addition of cow dung and humic acid into the soil. In terms of morpho-physiology, the highest plant height 112.90 cm and number of tillers plant^{-1} 11.25 were achieved from the treatment SM_4 (Soil + inorganic fertilizer + cow dung + humic acid). In terms of the variables that contribute to the yield, the highest days to 1st flowering (72.75) and days to 1st maturity (122.05 days) were found from control treatment SM_4 (Soil + inorganic fertilizer + humic acid + cow dung). Similarly, the highest panicle length (24.94 cm), number of filled grain panicle^{-1} (221.40), number of unfilled grain panicle^{-1} (42.25), root length (17.93 cm), number of grains panicle^{-1} (247.40), grain weight hill^{-1} (25.17 g), straw weight hill^{-1} (33.26 g) and harvest index (42.93%) were achieved from SM_4 (Soil + inorganic fertilizer + cow dung + humic acid) . The highest soil moisture content (17.23 and 16.17% at 55 and 70 DAT, respectively) was also achieved from SM_4 (Soil + inorganic fertilizer + cow dung + humic acid). This experimental results highlighted that together use of cow dung and humic acid increased the grain weight plants^{-1} more than 150% compared to controlled condition. Finally, it concluded that application of cow dung and humic acid as soil organic amendments increases the yield of aman rice.

Key Words: *Growth performance, Cow dung, Soil moisture, Root length and Production*

Cite Article: Barai, S., Islam, M. M., Parvin, S., Nizam, R. and Bithy, P. A. (2022). Influence of humic acid on morpho-physiology and yield of rice. Journal of Bioscience and Agriculture Research, 29(01), 2407-2415.
Crossref: https://doi.org/10.18801/jbar.290122.292

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I. Introduction

Rice (*Oryza sativa* L.) is Bangladesh's staple food, with over 95 percent of the population relying on it for their daily diets and accounting for over 85 percent of the country's agricultural workforce. Transplant aman rice types are commonly grown in the rainfed ecosystem, which accounts for 48.97 percent of total rice land and 38.14 percent of total rice production in the country (BRRI, 2018). During the aman season, modern T. aman variants cover roughly 67 percent of rice land (BBS, 2019). The agricultural industry accounts for around 13.31 percent of the country's GDP and employs more than 49 percent of the overall workforce (BBS, 2019). Aman rice is one of Bangladesh's most important rice crops. It is the country's second largest rice crop in terms of volume produced, with boro rice taking first place. It's worth noting that aman rice covers the most land as a single crop, whereas boro rice comes in second. Total *Aman* production in 2019 has been estimated 1.53 crore (15.34 million) metric tons compared to 1.4 crore metric tons in 2018 and 1.36 crore metric tons in 2017. It covers 58.76 lakh hectares of land area during *Aman* season in 2019 (BBS, 2019). It has been stated that application of soil organic amendments-humic acid and cow dung can also be an alternative to management of drought in rice.

Humic compounds have been used as fertilizer and soil conditioners in agriculture on a small basis. Ihsanullah and Bakhashawin (2013), El-Razek et al. (2012) and Fong et al. (2007) had previously demonstrated significant effects of these humic compounds on soil structure and plant growth. In the right concentration, HA can help plants and roots develop faster (Ahmed et al., 2013). Positive ions are attracted to humic compounds (humic, fulvic acid), forming chelates with micronutrients and releasing them slowly when needed by plants. Humic compounds operate as chelating agents, preventing precipitation, fixing, leaching and oxidation of micronutrients in soil (Kadam et al., 2010). Although humic acid is technically not a fertilizer, many people believe it is an effective substance to use in conjunction with synthetic or organic fertilizers. Humic acid is a water-soluble organic acid found naturally in soil organic matter. It has been discovered that humic acid substances have a variety of beneficial effects on soil structure and soil microbial populations, as well as increase modify mechanisms involved in plant growth stimulation, cell permeability, and nutrient uptake, and yield increase. Humic compounds may increase mineral absorption by stimulating microbial activity (Mayhew, 2004) and also have a significant impact on plant root growth (Pettit, 2004)). Since humic and fulvic acids have been administered to the soil, root initiation and growth have improved. According to Daur and Bakhashwain (2013), there were noticeable differences in humic acid levels for each of the parameters. Increasing the rate of humic acid boosted growth characteristics, yield characteristics and the percentage of protein (Aisha et al., 2014). Plants that received higher levels of humic acid (14.40 l/ha.) with cow dung had the highest mean values of growth characters, roots characters, and protein percentage. The major goal of this study was to use cow dung and humic acid as soil organic amendments to improve the morphological characteristics and yield potential of rice.

II. Materials and Methods

Experimental site

This study was conducted in the research field of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh during the period from July 2018 to November 2018.

Soil Characteristics

The soil in the study field is from the Modhupur Tract, which is part of AEZ No. 28 (Anonymous, 1988).

The research venue's climate

The study location is located in the subtropical monsoon climatic zone, which is classified by excessive rain from April to September (Kharif period) and little rain the rest of the year (Rabi period).

Planting materials

The variety BRRI dhan-49 was used. The seeds of rice were grown at the research field in Sher-e-Bangla Agricultural University.

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Treatments of the experiment

Different levels of soil organic amendments – humic acid and cow dung

1. SM_1 = Soil + inorganic fertilizer (control)
2. SM_2 = Soil + cow dung + inorganic fertilizer
3. SM_3 = Soil + inorganic fertilizer + humic acid
4. SM_4 = Soil + inorganic fertilizer + cow dung + humic acid

The research's structure & arrangement

Randomized Complete Block Design (RCBD) was used to plan this research with four grades of soil organic amendments-humic acid and cow dung. Four replications were maintained in this experiment. Every pot has a width of 35 cm (14 inches) as well as a height of 30 cm (12 inches). Pots were put on separate clay plates beneath the net house, which was composed of bamboo with a net.

Preparing of the pot

Equivalent amounts of soil (about 12 kg) were created in equal-sized plastic pots using dirt acquired from the SAU Soil Science Field Laboratory.

Preparing the nursery and planting seeds

The seedbed was prepared as per BRRI recommendations, adding fertilizers as needed. We sowed seeds in the seed bed to transplant seedlings into pots.

Remove seedlings from the soil

Before removing the seedlings, the nursery bed was soaked with water. The roots of the seedlings were not damaged in the process of their removal.

Seedlings are transplanted into the appropriate pots

Seedlings that were 30 days old were transferred into pots.

Fertilizer application

Exploratory pot was fertilized as per treatment. Full doses of fertilizers *viz*. one third of urea, TSP, MOP, and cow dung were used as basal dose. Remain urea was applied as top dressed at two times. The following fertilizer doses was used for pot preparation Urea = 1.25 g pot^{-1} (200 kg ha^{-1}), TSP = 0.22 g pot^{-1} (35 kg ha^{-1}), MOP = 0.56 g pot^{-1} (90 kg ha^{-1}), $ZnSO_4$ = 0.03 g pot^{-1} (5 kg ha^{-1}), Gypsum = 0.25 g pot^{-1} (40 kg ha^{-1}), Cow dung = 62.5 g pot^{-1} (10 t ha^{-1}) and Humic acid = 0.025 g pot^{-1} (6 kg ha^{-1})

Exogenous application of humic acid

Humic acid was applied during pot preparation as basal mixing with cow dung, TSP, MOP when these were mixing with soil.

Intercultural operations

Weeding: Grass was manually eliminated as needed.

Irrigation: watering per BRRI advice.

Crop protection measures: Insects, particularly grasshoppers, stem borers, rice ear cutting caterpillars, thrips, and rice bugs, were controlled by spraying Curatter 5G and Sumithion. Tilt was used to control a brown spot on rice.

General observation of the experimental pots

Observations were regularly made. All the stages of plants and plant's response as per treatments were observed carefully.

Harvesting

The rice plant was collected based on its maturity, and collecting was done by hand from every pot. On November 24, 2018, the BRRI dhan 49 was harvested. Each plot's collected crop was packed individually, neatly labelled, and delivered to the threshing floor. Harvesting, threshing, and washing rice seeds were all done with great care. The fresh weight of grain and straw was recorded pot by pot. After cleaning the grains, the weight was adjusted to a moisture level of 12%. The straw was sun dried, and the grain and straw pot^{-1} yields were reported.

Collection of data

Following data were collected: Plant height, Number of tillers hill^{-1}, Days to 1st flowering, Days to 1st maturity, Panicle length, Number of filled grains panicle^{-1}, Number of unfilled grains panicle^{-1}, Number of grains panicle^{-1}, Grain weight hill^{-1} (g), Straw weight hill^{-1} (g), Root length at harvest (cm), Harvest index (%). Harvest index was recorded by the following formula

$$\text{Harvest index} = \frac{\text{Grain yield hill}^{-1}}{\text{Grain yield hill}^{-1} + \text{Straw yield hill}^{-1}} \times 100$$

Data Evaluation

The treatment of different characteristics was statistically assessed to see if there was a significant difference in results. Mean values for all characters were determined and variance analysis was carried out. The Duncan's Multiple Range Test (DMRT) was used to determine the significance of the difference between the treatment averages at a 5% level of probability ($P<0.05$) (Gomez and Gomez, 1984).

III. Results and Discussion

Growth parameters

Plant height: Application varying amounts of soil organic amendments shown a considerable variation at the height of the rice plant at different ages of the plants (Figure 01).The highest plant height (74.56, 86.96, 93.21 and 112.90 cm at 40, 55, 70DAT and at the time of harvest, gradually) was achieved by SM_4 (Soil + inorganic fertilizer + cow dung + humic acid) situations which was statistically significant in comparison to other treatments at different ages of plants followed by SM_3 (Soil + inorganic fertilizer + humic acid). The lowest plant height (69.53, 79.16, 85.88 and 99.90 cm at 40, 55, 70 DAT and at the time of harvest, accordingly) was discovered from control situations SM_1 (Soil + inorganic fertilizer) without soil organic amendments. Under the present study, it was found that soil organic amendments-humic acid and cow dung had significant influence on growth parameters of rice. Results showed that application of humic acid gave higher plant height compared to the situations without humic acid. Arancon et al. (2006) reported that humic compounds, which stimulate plant germination and growth, and believe that humic acid works as a plant growth hormone, found a similar result. They act in a similar way to growth hormones. Humic acid may aid plant growth by improving cell membrane permeability, facilitating the movement of vital nutrients inside the roots, and promoting respiration (Cacco and Dell Agnolla, 1984; Masciandaro et al., 2002). The outcomes of the study corroborate previous findings and imply that adding humic acid to the soil improves soil health and morphological characteristics, including rice plant height.

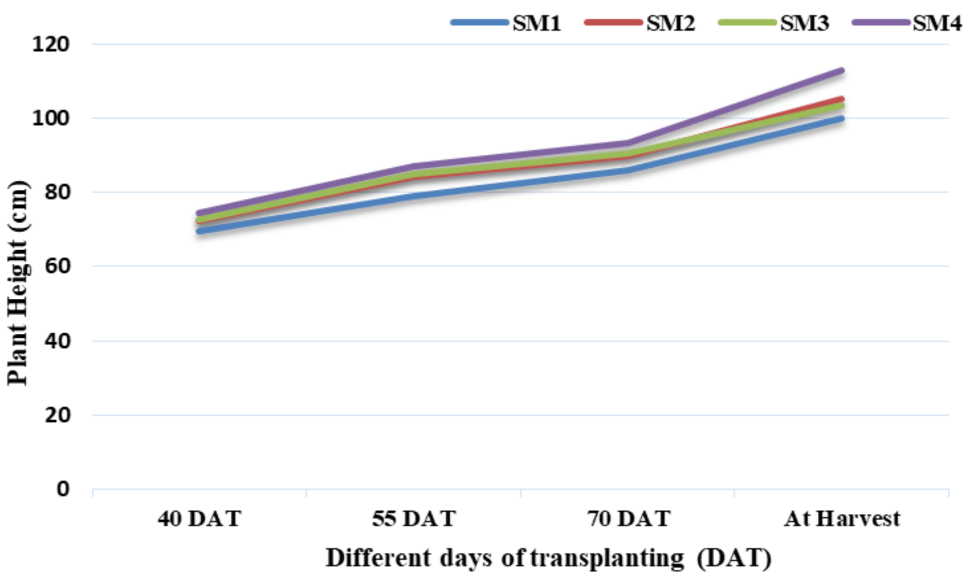

Figure 01. Rice plant height as impacted by soil organic amendments

SM_1 = Soil + inorganic fertilizer (control), SM_2 = Soil + cow dung + inorganic fertilizer, SM_3 = Soil + organic fertilizer + humic acid, SM_4 = Soil + inorganic fertilizer + cow dung + humic acid

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Number of tillers plant^{-1}: The application of varying amounts of soil organic amendments resulted in a considerable difference in the number of tillers plant^{-1} of rice at various plant ages (Figure 02). The SM_4 (Soil + inorganic fertilizer + cow manure + humic acid) condition produced the most tillers plant^{-1} (4.94, 8.94, and 10.38 at 40, 55, and 70 DAT, respectively). At 55 and 70 DAT, the number of tillers plant^{-1} derived from SM3 (Soil + inorganic fertilizer + humic acid) exhibited no significant difference from SM_4 (Soil + inorganic fertilizer + cow dung + humic acid). Again, the control condition SM_1 (Soil + inorganic fertilizer) yielded the fewest tillers plant^{-1} (4.06, 6.38, and 6.88 at 40, 55, and 70 DAT, respectively). The results indicated that soil organic additions had a substantial influence on the number of tillers plant^{-1} and that treatments with soil organic amendments produced more tillers plant-1 than treatments without soil organic amendments. Gomaa et al. (2011) found a similar outcome, reporting that applying 14.40 kg/ha of humic acid considerably boosted growth metrics such as the number of tillers plant^{-1} when compared to an untreated scenario (control).

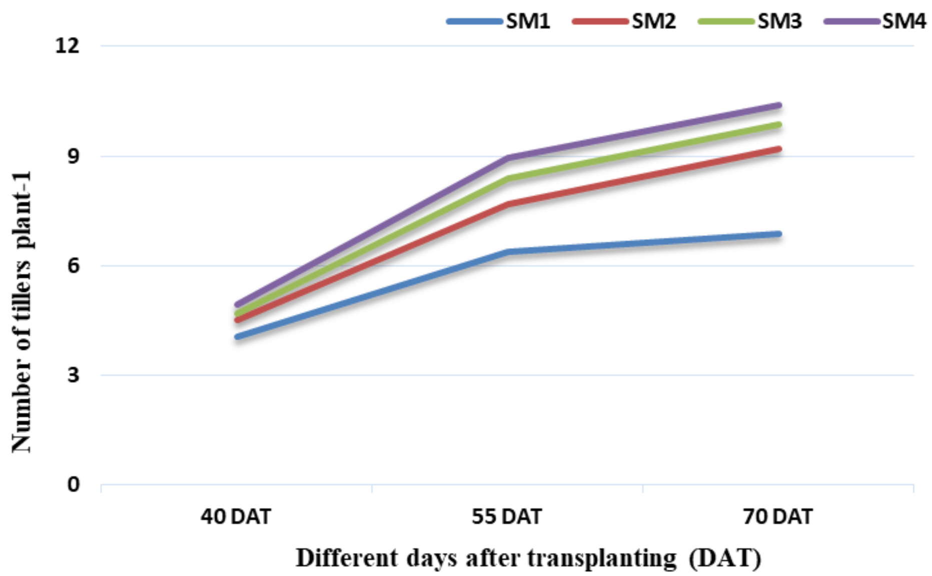

Figure 02. The impact of soil organic amendments on the number of tillers plant^{-1} of rice
SM_1 = Soil + inorganic fertilizer (control), SM_2 = Soil + cow dung + inorganic fertilizer, SM_3 = Soil + inorganic fertilizer + humic acid, SM_4 = Soil + inorganic fertilizer + cow dung + humic acid

Yield contributing parameters

Days to 1st flowering: The days to first blooming of rice varied significantly across amounts of soil organic additions (Table 01). The SM_1 (Soil + inorganic fertilizer) condition had the lowest days to first flowering (70.13), whereas the SM_4 (Soil + inorganic fertilizer + cow dung + humic acid) had the most (72.75).

Days to 1st maturity: The implementation of varying quantities of soil organic amendments resulted in a large difference in rice days to first maturity (Table 01). The SM_1 (Soil + inorganic fertilizer) attained the lowest days to first maturity (120.00 days), which was considerably different from the other situations. The control condition SM_4 (Soil + inorganic fertilizer + cow dung + humic acid) had the longest days to first maturity (122.05 days), followed by SM_2 (Soil + cow dung + inorganic fertilizer) and SM3 (Soil + inorganic fertilizer + humic acid). Similar findings were reported by Fu Jiu et al. (1995) who found that soil organic amendments aided in crop maturity.

Panicle length (cm): Different quantities of humic acid administration resulted in a considerable difference in rice panicle length (Table 01). The maximum panicle length (24.94 cm) was obtained from SM_4 (Soil + inorganic fertilizer + cow dung + humic acid), which was dissimilar from the other conditions, and was followed by SM_2 (Soil + cow dung + inorganic fertilizer). The control condition SM_1 (Soil + inorganic fertilizer) had the shortest panicle length (21.82 cm). Fu Jiu et al. (1995) discovered comparable findings to the current research.

Number of filled grain panicle^{-1}: Addition of varied quantities of soil organic amendments resulted in a considerable change (Table 01). SM_4 (Soil + inorganic fertilizer + cow dung + humic acid)

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produced the most full grain panicle^{-1} (221.40), followed by SM_2 (Soil + cow dung + inorganic fertilizer) and SM_3 (Soil + inorganic fertilizer + humic acid). The lowest number of filled grain panicle^{-1} (160.90) was found from control situation SM_1 (Soil + inorganic fertilizer).

Number of unfilled grain panicle^{-1}: The number of unfilled grain panicle^{-1} of rice exhibited a substantial fluctuation when varied levels of soil organic amendments were applied (Table 01). The most unfilled grain panicle^{-1} (42.25) were obtained from SM_1 (Soil + inorganic fertilizer), which was substantially different from the other conditions, followed by SM_2 (Soil + cow dung + inorganic fertilizer). The control condition SM_4 (Soil + inorganic fertilizer + cow manure + humic acid) had the fewest unfilled grain panicle^{-1} (20.63).

Root length at harvest (cm): The application of various quantities of soil organic amendments resulted in a considerable variance in rice root length (Table 01). The highest root length (13.79 cm) was obtained from SM_1 (Soil + inorganic fertilizer), which was dissimilar from the other conditions, followed by SM_2 (Soil + cow dung + inorganic fertilizer), and the lowest root length (11.33 cm) was obtained from SM_4 (Soil + inorganic fertilizer + cow dung + humic acid). Nandakumar et al. (2004) found similar results, which corroborated the latest research. Organic acids have the ability to change mineral weathering conditions by altering soil complexing capability, pH, and mineral element amounts Cocco et al. (2013). They can alter the macrostructure of the HS (Humic Substance) promoting the release of small fractions Canellas et al. (2010), Nardi et al. (2002) (Figure 03). These fractions can target the cell receptors at the surface of the root or enter the root cells and induce biological activity.

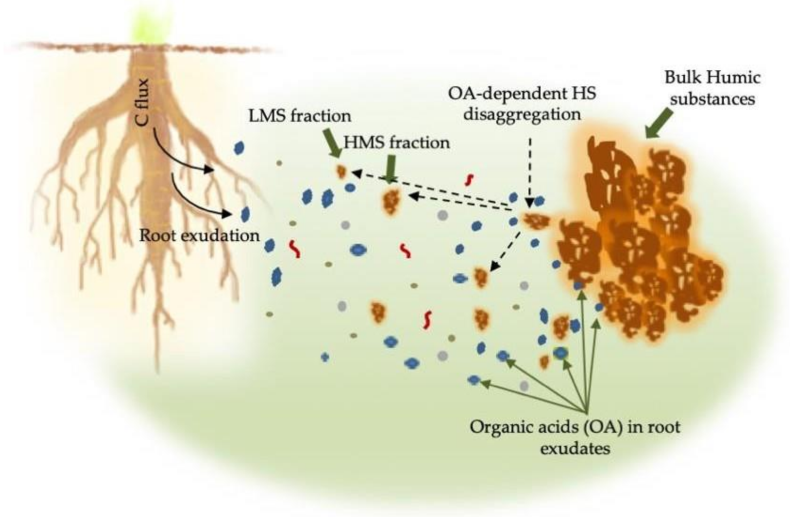

Figure 03. Root exudates contain substances, including low molecular weight organic acids (OA) that may influence the solubility of soil HS (bulk HS) by inducing their disaggregation to produce LMS and HMS fractions (Nardi et al, 2021).

Table 01. Parameters that influence yield of rice by soil organic amendments

Treatment	Yield contributing parameters					
	Days to 1st flowering	Days to 1st maturity	Panicle length (cm)	Number of filled grain panicle^{-1}	Number of unfilled grain panicle^{-1}	Root length at harvest (cm)
SM_1	70.13 d	120.00 a	21.82 c	160.90 c	42.25 a	13.33 d
SM_2	71.13 c	121.07 b	22.44 b	178.40 b	34.63 b	12.93 b
SM_3	71.94 b	121.30 b	22.83 b	181.53 b	28.33 c	12.52 c
SM_4	72.75 a	122.05 c	24.94 a	221.40 a	20.63 d	11.33 a
$LSD_{0.05}$	0.75	0.65	1.18	5.84	1.76	0.72
CV(%)	5.71	5.72	8.09	10.84	6.29	9.17

SM_1 = Soil + inorganic fertilizer (control), SM_2 = Soil + cow dung + inorganic fertilizer, SM_3 = Soil + inorganic fertilizer + humic acid, SM_4 = Soil + inorganic fertilizer + cow dung + humic acid

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Yield parameters

Number of grains panicle^{-1}: Application of different levels of soil organic amendments showed significant variation on number of grains panicle^{-1} of rice (Figure 04). The highest number of grains panicle^{-1} (247.40) was achieved from SM_4 (Soil + inorganic fertilizer + cow dung + humic acid) which was noticeably distinguishable from other situations whereas the number of lowest grains panicle^{-1} (192.30) was observed in situation SM_1 (Soil + inorganic fertilizer). The recent study's findings were comparable to the results of Fu Jiu et al. (1995) who found that humic acid has contribution to increase number of grains panicle^{-1}.

Grain weight hill^{-1} (g): Application of different levels of soil organic amendments showed significant variation on grain weight hill^{-1} of rice (Figure 04). The highest grain weight hill^{-1} (25.17 g) was achieved from SM_4 (Soil + inorganic fertilizer + cow dung + humic acid) treatment that was distinct from others situations after that SM_2 (Soil + cow dung + inorganic fertilizer) and SM_3 (Soil + inorganic fertilizer + humic acid). The grain with the smallest load hill^{-1} (16.75 g) was found from control situation SM_1 (Soil + inorganic fertilizer). Indistinguishable outcome was reported by Gomaa et al. (2011) who reported that application of 14.40 kg/ha of humic acid significantly increased grain yield, and its components compared to untreated treatment (control). Humic acid, as well as cow dung, an important component of organic fertilisers and humic substances, can be used to enhance plant growth by increasing water content, photosynthesis, antioxidant metabolism, and enzyme activity in the leaves, thereby increasing tolerance and contributing to increased yield and yield components of crops (Fu Jiu et al., 1995). Indistinguishable outcome was also reported by Gomaa et al. (2011).

Straw weight hill^{-1} (g): Application of different levels of soil organic amendments showed significant variation on straw weight hill^{-1} of rice (Figure 04). The highest straw weight hill^{-1} (33.26 g) was achieved from SM_4 (Soil + inorganic fertilizer + cow dung + humic acid) that was distinct from others situations after that SM_3 (Soil + inorganic fertilizer + humic acid). The lowest straw weight hill^{-1} (23.07 g) was found from control situation SM_1 (Soil + inorganic fertilizer). Fu Jiu et al. (1995) indistinguishable outcome was discovered in the current investigation, who reported that increased Stover yield was found with humic acid under drought stress.

Harvest index (%): Application of different levels of soil organic amendments exhibited considerable variation on the basis of the harvesting index (Figure 04). The most satisfactory harvest index (42.93%) was achieved from SM_4 (Soil + inorganic fertilizer + cow dung + humic acid) situation which was statistically identical with SM_2 (Soil + cow dung + fertilizer) in contrast to the minimum harvest index (40.66%) was discovered control situation SM_1 (Soil + inorganic fertilizer).

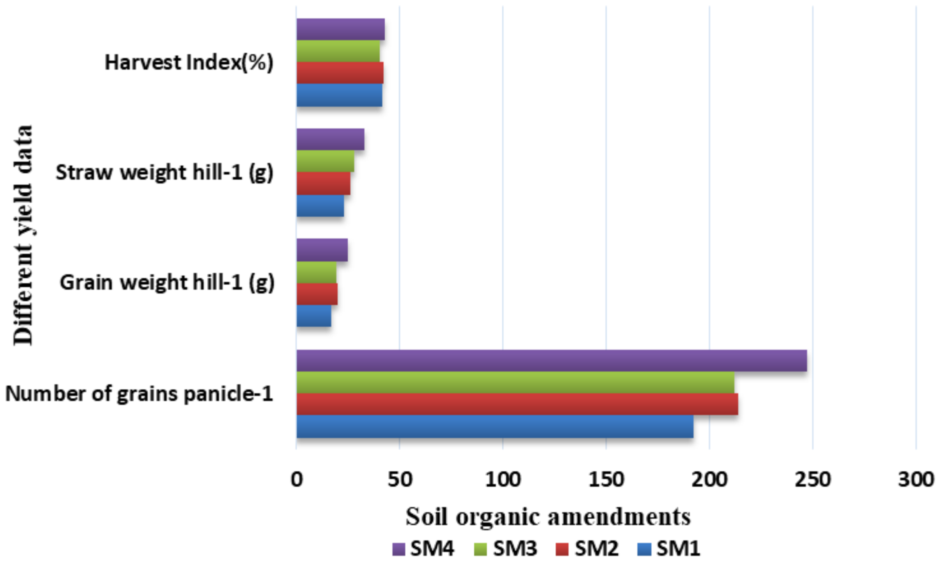

Figure 04. Yield parameters of rice as influenced by soil organic amendments

SM_1 = Soil + inorganic fertilizer (control), SM_2 = Soil + cow dung + inorganic fertilizer, SM_3 = Soil + inorganic fertilizer + humic acid, SM_4 = Soil + inorganic fertilizer + cow dung + humic acid

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Soil moisture content

The use of various amounts of soil organic amendments demonstrated a substantial difference in soil moisture content of rice (Figure 05). The highest soil moisture content (17.23 and 16.17% at 55 and 70 DAT, respectively) was achieved from SM_4 (Soil + inorganic fertilizer + cow dung + humic acid) application was clearly distinct from other circumstances that observed SM_2 (Soil + cow dung + inorganic fertilizer) and SM_3 (Soil + inorganic fertilizer + humic acid). The lowest soil moisture content (15.90 and 15.43 at 55 and 70 DAT, respectively) was found from control situation SM_1 (Soil + inorganic fertilizer). Gomaa et al. (2011) reported that current investigation produced same results who found significant outcome of soil organic amendments against drought stress which contributed to higher yield.

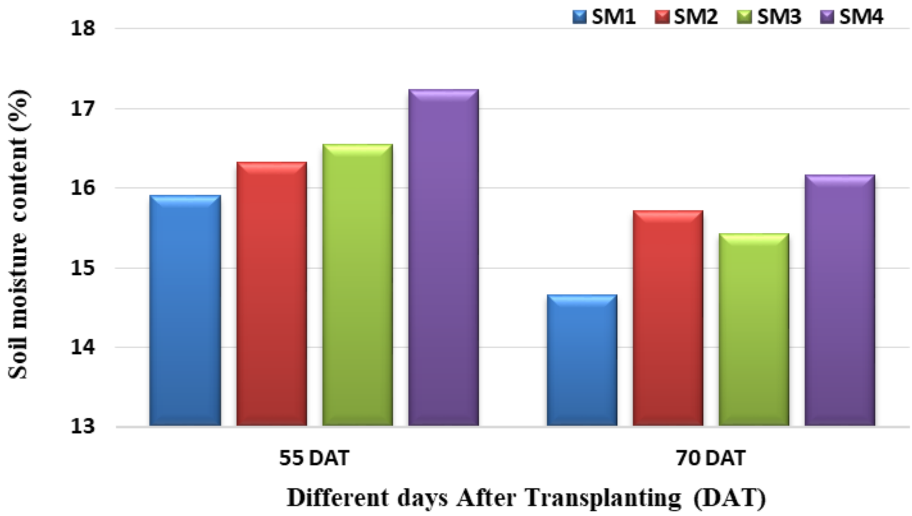

Figure 05. Soil moisture of rice field as influenced by soil organic amendments

SM_1 = Soil + inorganic fertilizer (control), SM_2 = Soil + cow dung + inorganic fertilizer, SM_3 = Soil + inorganic fertilizer + humic acid, SM_4 = Soil + inorganic fertilizer + cow dung + humic acid

IV. Conclusion

According to the above findings, soil organic amendments such as humic acid and cow dung resulted in a significant increase in rice growth and yield. SM4 (Soil + inorganic fertiliser + cow manure + humic acid) exhibited the fastest rice expansion and yield. Humic acids are essential for transferring nutrients from the soil to the plant because they can retain ionised nutrients and prevent them from leaking away. Cow dung manure for plants is a high-quality organic matter fertiliser that helps to promote aeration and break up compacted soils.

Acknowledgement

I thank those authors who helped me with my research. All authors worked together on this project. Designed by Mohammad Mahbub Islam. Parvin Akter Bithy wrote the original draught of the manuscript, while Samar Barai completed the statistical analysis. Suraiya Parvin and Rezowana Nizam managed the study's analyses. Author Samar Barai did the research. This manuscript was approved by all authors.

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