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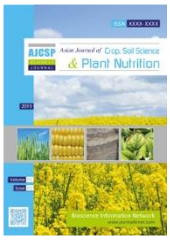

Effect of different types of mulch on watermelon yield and profitability in the saline soil of coastal Bangladesh

Md. Monir Hossain[1], Abul Hasnat Md. Amir Faisal[2], Md. Imrul Kaysar[3], Manobendra Nath Sarkar[4], Md. Nasirul Farid[4] and Faisal Ahmed[5]

[1]Planning & Evaluation Wing, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh
[2]On-Farm Research Division, Bangladesh Agricultural Research Institute, Noakhali, Bangladesh
[3]Pulse Research Centre, Bangladesh Agricultural Research Institute, Ishwardi, Pabna, Bangladesh
[4]Regional Agricultural Research Institute, Bangladesh Agricultural Research Institute, Rangpur, Bangladesh
[5]Citrus Research Station, Bangladesh Agricultural Research Institute, Jaintapur, Sylhet, Bangladesh

✉ Article correspondence: munnabau1991@gmail.com (Hossain, MM)
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ABSTRACT

Soil salinity and irrigation water quality are the primary limitations for agricultural productivity in the Subarnachar upazila of Noakhali district. Nevertheless, farmers are growing watermelons in pit systems with two additional irrigations, resulting in below-average yields compared to other regions of Bangladesh. An investigation was conducted in Char Bata, Subarnachar, and Noakhali under farmer's field conditions (AEZ 18f) during the Rabi season of 2017-18 in order to determine the impact of several mulch items on the yield and growth parameter of watermelon. This study examined the effects of five different interventions on moisture retention and salinity reduction: T_1 (no mulch), T_2 (water hyacinth at 10 t ha^{-1}), T_3 (rice straw at 5 t ha^{-1}), T_4 (rice husk at 2 t ha^{-1}), and T_5 (black polythene mulch). The watermelon stem was surrounded with mulch for a distance of 50 cm. In contrast to alternative mulching materials, black polythene mulch exhibited the maximum gross margin of TK. 4,21,880 ha^{-1}, which can be attributed to yield discrepancies despite its higher total variable cost of TK. 1,55,320 ha^{-1}. Watermelon yield was highest, 38.48 t ha^{-1}, when grown with black polythene mulch and the lowest yield was 29.79 t ha^{-1} when grown without any mulch on bare ground. Additional research is needed in different agroecological regions of Bangladesh to assess the advantages of using mulching materials to preserve soil moisture and reduce soil salinity.

Key Words: *Salinity, Watermelon, Soil Moisture, Yield and Profit*

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I. Introduction

Watermelon, scientifically known as *Citrullus lanatus*, is a significant cucurbitaceous crop cultivated widely in Bangladesh and many tropical and subtropical regions globally. Watermelon has become a profitable cash crop in the coastal salty region of Noakhali. In the 2017-18 agricultural season, it utilized 4354 hectares of land in the Subarnachar upazila (DAE, Subarnachar). The primary limitations for crop productivity in the Subarnachar upazila are soil salinity and irrigation water quality. Meanwhile, farmers are growing watermelons using a pit method and two additional irrigations, resulting in a yield lower than the national average in Bangladesh. In addition, farmers often lack sufficient water to irrigate their lands. Salinity had a detrimental impact, causing mature and immature plants to perish and reducing their production. Soil moisture and salinity have an inverse relationship. Soil salinity reduces with increasing soil moisture levels. Escaping or limiting salinity is crucial for watermelon development in moderately salty areas with an electrical conductivity of 4 to 8 dS m^{-1}. Therefore, certain cultural approaches, like mulching, can be utilized in watermelon cultivation. Mulches enhance soil physical properties by reducing bulk density, increasing infiltration rate, sustaining optimal plant growth circumstances, and moderating temperature (Ahmed et al., 2009).

Mulches applied to the soil's surface managed weed growth, reduced soil water loss due to evaporation, and prevented salt buildup, according to an experiment with corn done by Bu et al. (2002). Applying surface mulch significantly reduced water loss through evaporation and increased soil salinity levels in desalinized plots growing winter wheat, according to Yang et al. (2007). Black plastic, water hyacinths, straws, sawdust, and rice husks are all available to the local farmers. However, mulch is not used when growing watermelons. Mulch comes in two varieties: organic and inorganic. Compost, grass clippings, leaves, rice straw and other organic materials decompose to improve soil nutrient quality, organic matter percent and water holding capacity.

It can also serve as a perfect environment for earthworms and helpful soil microbes (Dickerson, 2000). Growers can benefit from using inorganic mulches like plastic films and polyethylene. Their benefits include increasing agricultural output, promoting early maturity of high-quality goods, and managing insects and weeds (Lament, 1993). Mulching is an excellent agricultural technique with several advantages. Parmar et al. (2013) reported that mulches aid in preserving soil moisture, warmth and fertility while also managing weeds and shielding plants by protecting from the contact of direct soil salinity. Mulching material decreases soil water loss. Consequently, soil moisture is evenly sustained, leading to a decrease in the need for irrigation. Mulches obstruct the passage of light into the soil. Weeds cannot flourish in mulch environments. Surplus water is drained from the impermeable mulch. Faisal et al. (2011) reported that balanced fertilization and irrigation with mulching can minimize yield loss by improving nutrient availability. Mulch improves the efficiency and effectiveness of fertilizer application by retaining it rather than letting it leach out. Soil remains loose, crumbly, and aerated when covered with plastic mulch. Encouraging increased microbial activity, roots acquire sufficient oxygen. The study aimed to assess the impact of various mulches on watermelon yield in the coastal saline zones of the Noakhali region inside AEZ 18f.

II. Materials and Methods

A research investigation was carried out in the agricultural field of Char Bata, Subarnachar upazila, Noakhali, throughout the Rabi season of 2017-2018, focusing on a watermelon crop of the cucurbitaceous variety Glory. Longitude: 91°7'58"E and latitude: 22°36'24"N represented the experimental site. The climate at the site of the experiment was tropical monsoon, marked by elevated levels of humidity and high temperatures (Table 01). The soil consisted of silty clay loam, which belonged to the Hatiya series of the Young Meghna Estuarine Flood Plain (AEZ 18f).

Table 01. Average climatic condition of the site during the experimental period

Month	Temperature (°C)		Total rainfall (mm)	Relative humidity (%)
	Lowest	Highest		
December 2017	17	26	77	85
January 2018	13	24	0	80
February 2018	15	34	2	77
March, 2018	16	34	4	75
April 2018	20	35	78	78

T_1 (no mulch), T_2 (10 t ha^{-1}) water hyacinth, T_3 (5 t ha^{-1}) rice straw, T_4 (2 t ha^{-1}) rice husk, and T_5 (625 sq. m ha^{-1}) black polythene mulch comprised the experimental design. A Randomized Complete Block

(RCB) with three replications comprised the design. A mulch with a width of 20 centimeters was applied around the trunk of the cantaloupe plants. Each unit allocation was 5m by 8m in size. On January 14, 2018, 25-day-old seedlings were sown in polybags that had previously been utilized to cultivate the seedlings, with a spacing of 2 meters by 2 meters. Fertilizers were applied according to 63-35-75-9-4-2 kg ha^{-1} of N-P-K-S-Zn-B to the land in conjunction with 1 ton ha^{-1} of cattle manure.

Fifty percent of the cattle manure, one-third of the P and K, and the entire dose of S were applied during the final land preparation. The pit preparation process entailed utilizing one-third of the potassium, two-thirds of the nitrogen, and one-half of the bovine dung. Following twelve to fifteen days from the date of transplantation, supplementary irrigation was conducted, during which one-third of the nitrogen, half of the potassium, and the entire dosage of zinc were administered in a ring system. On the seedlings at 20 DAP, an assortment of mulch materials was applied. The remaining N, K, and complete doses of B were administered with the second supplemental irrigation before the onset of blossoming (40 DAS). The litter materials were extracted two days prior to the administration of fertilizer and reintroduced following the reintroduction period.

As necessary, various intercultural procedures and plant protection measures were executed to guarantee the development of resilient crops. Soil salinity and moisture measurements were performed at 45 DAS and 60 DAS; prior to harvest, subsequent to the transplantation of seedlings. The salinity was ascertained using an EZODO PCT-407 pH/ORP/Conductivity/TDS/Salt/Temperature Meter. The FSRD office employed a 1:3 extraction method to acquire the precise measurements from five (05) soil samples from each replication, which were classified according to treatment. This method utilized distilled water and soil. The moisture content of the soil at a 15-centimeter depth from each intentionally selected plot was determined using a soil moisture analyzer (Model DM-15). The agricultural harvest was concluded throughout April 9-13, 2018. Five plants were selected at random from each experimental site to determine the following parameters: fruit weight (g), total yield (t ha^{-1}), number of lateral branches, primary vine length (cm), and number of fruits per plant. The means were compared and an analysis of variance was conducted using the R Project for Statistical Computing.

III. Results and Discussion

Effect of mulches on soil moisture and salinity

Mulching significantly affects soil moisture retention and soil salinity levels throughout the growth period of watermelon (Table 02).

Soil moisture (SM)%: Soil moisture percentages were relatively high across all treatments at transplanting, with water hyacinth mulch (T_2) maintaining the highest SM (49%) and rice husk mulch (T_4) the lowest (45%). At 20 DAT, water hyacinth mulch (T_2) and black polythene mulch (T_5) showed superior moisture retention (44%), compared to no mulch (T_1), which showed a decrease to 40%. While 45 DAT, black polythene mulch (T_5) demonstrated the highest moisture retention (41%), while no mulch (T_1) had the lowest (32%). At 60 DAT, both water hyacinth (T_2) and black polythene mulch (T_5) significantly maintained higher soil moisture (39% and 38%, respectively) compared to no mulch (29%). Finally, at harvest, water hyacinth (T_2) and black polythene mulch (T_5) treatments showed the highest soil moisture levels (52% and 51%, respectively), indicating their effectiveness in moisture conservation throughout the growth period.

Soil Salinity (SS) dS m^{-1}: Initial SS levels were low across all treatments, at transplanting with rice straw mulch (T_3), showing the lowest salinity (1.05 dS m^{-1}). At 20 DAT, water hyacinth mulch (T_2) and black polythene mulch (T_5) treatments showed lower increases in salinity (1.48 dS m^{-1} and 1.52 dS m^{-1} respectively) compared to no mulch (2.25 dS m^{-1}). Again, at 45 DAT, black polythene mulch (T_5) and water hyacinth mulch (T_2) exhibited lower salinity levels (2.6 dS m^{-1} and 2.95 dS m^{-1} respectively), with no mulch (T_1) experiencing higher salinity (4.7 dS m^{-1}). Similarly, black polythene mulch (T_5) maintained lower salinity (3.8 dS m^{-1}) compared to no mulch (7.98 dS m^{-1}) at 60 DAT. Finally, at harvest, black polythene mulch (T_5) treatment showed the lowest soil salinity (6.04 dS m^{-1}), significantly lower than no mulch treatment (10.47 dS m^{-1}).

Ahmed et al. (2009) observed that mulching improves soil physical qualities by decreasing bulk density, boosting infiltration rate, and generating optimal conditions for plant growth. Ufoegbune et al.

(2014) found that augmenting moisture for watermelons in the dry season results in a faster growth rate. Moreover, the prolonged retention and accessibility of moisture enhance nutrient absorption for optimal plant growth and development, resulting in increased plant growth compared to conditions without mulch. Except for mulching with rice husk (9.45 dSm^{-1}), soil salinity was low in all organic mulch materials treatments, notwithstanding growth characteristics. The soil salinity remained consistently low in the inorganic mulch layer (Black polythene), ranging from 1.09 to 6.04 from transplanting to just before harvesting. Bu et al. (2022) showed that surface-applied mulches effectively prevented soil water loss due to evaporation, prevented salt accumulation on the surface, and controlled the growth of weeds. This can profoundly impact watermelon growth, yield, and quality, underlining the importance of selecting appropriate mulch materials for sustainable watermelon cultivation.

Table 02. Soil moisture and salinity level at the growth period of watermelon under different mulch

Treatments	Transplanting		20 DAT		45 DAT		60 DAT		Harvest	
	SM (%)	SS ($dS\ m^{-1}$)	SM (%)	SS ($dS\ m^{-1}$)	SM (%)	SS ($dS\ m^{-1}$)	SM (%)	SS ($dS\ m^{-1}$)	SM (%)	SS ($dS\ m^{-1}$)
T_1 = No Mulch	47	1.2	40	2.25	32	4.7	29	7.98	42	10.47
T_2 = Water hyacinth @10 t ha^{-1}	49	1.12	44	1.48	39	2.95	39	4.1	52	7.2
T_3 = Rice straw @ 5 t ha^{-1}	47	1.05	43	1.62	38	3.1	33	5.38	38	7.5
T_4 = Rice husk@ 2 t ha^{-1}	45	1.15	40.33	1.3	35	4.25	30.33	7.17	44	9.45
T_5 = Black polythene mulch @ 625 sq. m ha^{-1}	46	1.09	44	1.52	41	2.6	38	3.8	51	6.04
LSD	3.17	0.97	3.17	0.97	3.17	0.97	3.17	0.97	3.17	0.97
CV	4.7	14.77	4.7	14.77	4.7	14.77	4.7	14.77	4.7	14.77
Level of significance	***	***	***	***	***	***	***	***	***	***

'***' 0.001 '**' 0.01 '*' 0.05 SS= Soil Salinity ($dS\ m^{-1}$), SM= Soil Moisture (%)

Yield contributing characters of watermelon

The research discovered that several mulch items substantially influenced the growth and development characteristics of watermelon (Table 03).

Lateral branch (LB) number: The black polythene mulch treatment (T_5) resulted in the highest number of lateral branches (9.8), indicating a potential for a more extensive plant canopy, which can contribute to higher photosynthetic activity and potentially higher fruit yield. The no mulch treatment (T_1) showed the lowest lateral branches (6.2).

Main vine length (MVL): Again, the black polythene mulch (T_5) led to the longest main vine length (126.8 cm), which may suggest better plant growth conditions under this treatment. The shortest main vine length was observed in the no mulch treatment (T_1) at 96.5 cm.

Fruits per plant (FPP): Black polythene mulch (T_5) also led to the highest number of fruits per plant (4.36), while the no mulch treatment (T_1) had the lowest (3.77). This indicates that mulch treatments, especially black polythene, can enhance fruiting.

Individual fruit weight (IFW): Similar to the other parameters, black polythene mulch (T_5) showed the highest individual fruit weight (3.55 Kg), suggesting that it not only increases the number of fruits but also contributes to larger fruit size. The lowest was observed in the no mulch treatment (T_1) with 3.19 Kg.

Fruit yield (FY): Corresponding with the previous findings, the black polythene mulch (T_5) achieved the highest fruit yield (38.48 t ha^{-1}), significantly outperforming the no mulch control (T_1), which had the lowest yield (29.79 t ha^{-1}).

These results highlight the effectiveness of mulch treatments, especially black polythene mulch, in improving yield-contributing factors for watermelon cultivation. The use of mulch can significantly impact plant growth characteristics and fruit yield, with the type of mulch being a critical factor in the extent of these benefits. The results were consistent with the findings of Arancibia and Motsenbocker

(2008), suggesting that moisture in the root zone may prevent evaporative loss, acting as a barrier to the capillary flow of saline. Yang et al. (2007) reported that the utilization of surface mulch resulted in a significant decrease in the amount of water that evaporated and the salinity of the soil in desalinized plots that were farmed with winter wheat.

Table 03: Yield contributing characters of watermelon influenced by various mulch

Treatments	LB (no.)	MVL (cm)	FPP (no.)	IFW (Kg)	FY (t ha^{-1})
T_1 = No Mulch	6.2	96.5	3.77	3.19	29.79
T_2 = Water hyacinth @10 t ha^{-1}	8.9	112.9	4.03	3.42	34.31
T_3 = Rice straw @ 5 t ha^{-1}	7.1	104.7	3.83	3.08	30.22
T_4 = Rice husk@ 2 t ha^{-1}	6.6	100.8	3.90	3.16	30.24
T_5 = Black polythene mulch @ 625 sq. m ha^{-1}	9.8	126.8	4.36	3.55	38.48
LSD (0.05)	2.84	17.49	NS	0.46	3.73
CV (%)	19.50	8.57	9.06	7.41	6.07

LB= Lateral branch, MVL=Main vine length, FPP=Fruits per plant, IFW=Individual fruit weight, FY= Fruit yield

Cost and profitability assessment

The economic analysis clearly shows that while the initial investment in mulching, especially with black polythene, is higher, the yield and financial gain returns are significantly greater (Table 04). The highest watermelon yield was 38.48 tons per hectare in T_5, leading to a gross return of TK. 5,77,200 per hectare and a gross margin of TK. 4,21,880 per hectare. Black polythene mulch had the best gross margin among various mulching materials, although it had the highest overall variable cost because of variances in output. The no mulch treatment had the lowest gross margin of TK. 3,10,480 ha^{-1} due to high total variable cost. Rice straw was utilized as feed during the dry season, causing an increase in price. The cost and return structure indicate that watermelon farming is profitable.

Table 04. Cost and benefit of watermelon influenced by various types of mulch

Treatment	Yield (t ha^{-1})	GR	TVC	GM
T_1 = No Mulch	29.79	4,46,850	1,16,970	3,29,880
T_2 = Water hyacinth @10 t ha^{-1}	34.31	5,14,650	1,37,820	3,76,830
T_3 = Rice Straw @ 5 t ha^{-1}	30.22	4,53,300	1,42,820	3,10,480
T_4 = Rice husk@ 2 t ha^{-1}	30.24	4,53,600	1,27,820	3,25,780
T_5 = Black polythene mulch @ 625 sq. m ha^{-1}	38.48	5,77,200	1,55,320	4,21,880

GR= Gross Return (TK.ha^{-1}), TVC= Total Variable Cost (TK.ha^{-1}), GM= Gross Margin (TK.ha^{-1}); Price per kilogram for input and output: (Tk/kg); Watermelon seed= 23000, Urea = 16, TSP = 22, MoP = 15, Gypsum = 12, Zinc Sulphate = 140, Boron = TK.120, Cowdung = 2, Water hyacinth = 2, Rice straw = 5, Rice husk =5, Black Polythene = TK.140; The price of watermelon per kilogram is TK.15

IV. Conclusion

The application of mulch in watermelon cultivation offers multiple agronomic and economic benefits, including improved yield, enhanced soil moisture retention, reduced soil salinity stress, and increased profitability. Among the tested mulches, black polythene mulch stands out as the most effective in maximizing watermelon yield and ensuring the highest economic return despite its higher cost. However, the selection of mulch type should also consider sustainability aspects, availability of materials, and specific local conditions. This comprehensive analysis underscores the importance of integrating mulch use into watermelon cultivation practices to achieve optimal growth conditions, higher productivity, and better returns on investment while also contributing to the sustainability of farming systems.

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