The Effects of Mulches on Tomato (*Lycopersicon esculentum* L.) in Respect of Yield Attribute in Ecosystem of Coastal Bengal

ABSTRACT

Mulching has become an important practice in modern field production. The use of mulches in vegetable production is undergoing a radical change away from high input, nonrenewable resources, such as plastic, to the use of high-residue organic mulches from cover crop. The purpose of this present study was to compare the growth and yield of tomato when grown under different organic and inorganic mulches. The experiment was conducted with four treatments in two consecutive years (2016-2017 and 2017-2018) at instructional farm of Sasya Shyamala Krishi Vigyan Kendra, Arapanch and different blocks of South 24 Parganas district. Among the treatments, maximum yield 60.3 t/ha and 58.7 t/ha were recorded under poly mulches in the consecutive years.

Keywords**:** *Mulching, Tomato, Growth, Yield, Coastal Belt*

1. INTRODUCTION

Tomato is the second most consumed vegetable in the world after potato [1]. Tomato fruit constitute rich source of essential amino acids, minerals, and vitamins [2]. The fruit is also rich in lycopene which is known to reduce the risk of cancer [3]. About 68% of the global tomatoproduction is consumed fresh while theremaining 32% are processed [4]. Tomato is a regular part of the diet of the average Indian household. It is mostly used for fresh vegetable, salad and processing products like puree, ketchup, sauce etc. It is an important crop grown almost throughout the year but generally it cultivated abundantly in coastal Bengal during two consecutive rabi seasons, when the rainfall is scare and soil moisture is exhausted by evapo-transpiration. It was reported that water directly affects the tomato yield, as it contains 94% water [5]. For successful crop production about 285 mm water is required during plant establishment, flowering, fruit setting and fruit development stage [6]. But irrigation facilities in all the regions are not available. Sometimes, many of the farmers can't able to provide irrigation due to unavailability of irrigation facilities or even can't afford the expenses of irrigation. Under this situation mulching could be a good substitute means for irrigation to make soil moisture available. Mulching has been reported to be increased yield by creating favorable soil temperature and moisture regimes [7]. Mulching is an effective method of manipulating crop growing environment to increase yield and improve product quality by controlling weed growth, ameliorating soil temperature, conserving soil moisture, reducing soil erosion, improving soil structure and enhancing organic matter content [8, 9]. The weed control efficiency of different types of mulch in cayenne pepper production ranged from 27% to 97% [10]. Since, the land holdings are very small in this region; therefore, there is a need of conservation farming and sustainable agriculture to improve the environment. There are several organic and inorganic mulches, but due to the property of reflectance of plastic mulches, they are used more or much beneficial to minimize the incidence of viral diseases and deter the approach to some species of insect pests. The potential of mulches to improve soil structure, increase organic matter, and establish patterns of nutrient cycling more similar to natural ecosystems has been recognized. Polyethylene mulches have induced large increases in growth and yields for tomato [11]. Use of mulches for crop offers great scope to plant growth by improving water infiltration, retention, and reducing runoff. It reduces and controls soil erosion by providing a cover on the soil surface [12]. Therefore, the study reported in this paper sought out to compare the impact of different types of mulches (organic and inorganic) on the performance of tomato production.

2. MATERIALS AND METHODS

The experiment was laid out at the instructional farm of Sasya Shyamala Krishi Vigyan Kendra, Ramkrishna Mission Vivekananda University, Arapanch and also in different villages of Baruipur, Falta, Bhangore-I and Bishnupur-II blocks of South 24 Parganas district during rabi season from 2016-2017 to 2017-2018. ~~The main objective of the study was the evaluation of the efficiency of different types of mulches (organic and inorganic) on the performance of tomato (var. Rocky) yield along with respect to C:B ratio.~~ The treatments were considered as four levels of different mulch materials~~:, *viz.*,~~ T_1: Farmers' practice (no mulch), T_2: Mulching with Jute felt, T_3: Poly mulch and T_4: Straw mulch. Different irrigation strategy was taken as per different treatments. The experiment was laid out in a randomized block design (RBD) with five replications. Thirty days old tomato var. Rocky were transplanted at the spacing of 60 cm × 40 cm in the month of November. Farm yard manure (FYM) enriched with *Trichoderma viride at* ~~@~~ 250 kg/ha. After 15 days of transplanting stalking was done to provide better support from lodging and irrigation was done after application of fertilizer. Neem seed karnel extract (NSKE) 10,000 ppm ~~@~~ 3ml/l has been sprayed twice to protect the biotic stress. Other intercultural operations like weeding, irrigation and plant protection measures were taken as deemed needed as per as crops and field conditions.

Data were collected from randomly selected plants for each plot and the recorded data were analyzed statistically by the technique of "Analysis of variance" and significance was tested by variance ratio *i.e.,* value at 5% level of significance [13]. Economic analysis of each and every treatment also worked out.

3. RESULTS AND DISCUSSION

3.1 Number of effective branches per plant

From the study it was revealed that the mulching of the soil significantly increased the number of effective branches per tomato plant in comparison to the plants having farmer's practices (without any treatment). It can be concluded from the observations of consecutive two years data, the number of branches per plant of tomato under farmer's practices (T_1) and jute felt mulching techniques (T_2) had not shown any remarkable variations, but straw mulching technique (T_3) significantly increased the branches/plant as compared to T_1 and T_2. The maximum number of branches per plant was recorded under poly mulching and need based irrigation (T_3). In the year 2017-2018, it was reflected that poly mulching with black polythene resulted maximum number of effective branches per plant (12 per plant) followed by straw mulched plot (10 per plant). Other results of different treatments also depicted in the Table 2. The same result was found in the first year also that the maximum number of branches per plant was obtained in the poly mulched tomato plot (Table 1). So it can be concluded that the poly mulching was provided highest number of branches per plant [14]. Mulching process is effective in reducing evaporation, conserving soil moisture, increase the infiltration rate of rain or irrigation water, modify the hydrothermal regime of soil [15], improve soil physical conditions by enhancing biological activity of soil fauna and thus increased soil fertility [16]. Among different mulching treatments, polythene mulching technique was found to increase the crop growth as indicated by effective branches per plant that might be consequence of the reduced leaching of nutrients, weed problems and evaporation of soil water and increased water use efficiency by the plant [17, 18, 19, 20].

Table 1. Comparative performance of different technologies on yield attributing characters and economic status (2016-2017)

Treatment	Yield component			No. of irrigation required	Yield (t/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	C:B ratio
	No. of effective branches /plant	No. of fruits / plant	Test wt. (10 fruit wt.)						
T_1 : Farmers' practice Flood irrigation without mulching and need based irrigation	7^{c}	52^{c}	641.6^{c}	8^{a}	38.7^{c}	156200	246870	90670	1.58
T_2: Technology option-1 - mulching with Jute felt and need based irrigation	10^{b}	55^{bc}	670.5^{b}_{c}	7^{b}	52.42^{b}	214500	372120	157620	1.73
T_3: Technology option-II - Poly mulching and need based irrigation	12^{a}	64^{a}	778.5^{a}	6^{c}	60.3^{1a}	220200	432110	211910	1.96
T_4: Technology option-III- Straw mulching and need based irrigation	8^{c}	58^{b}	699.9^{b}	7^{b}	50.78^{b}	179400	306740	127340	1.7

Values are means ± SEm, n = 5 per treatment group.
Means in a row without a common superscript letter differ (P = .05) as analyzed by one-way ANOVA and the DUNCAN test.

Table 2. Comparative performance of different technologies on yield attributing characters and economic status (2017-2018)

Treatment	Yield component			No. of irrigation required	Yield (t/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	C:B ratio
	No. of effective branches/ plant	No. of fruits/plant	Test wt. (10 fruit wt.)						
T_1 : Farmers' practice Flood irrigation without mulching and need based irrigation	8^{b}	51^{c}	629^{c}	8^{a}	36^{d}	172355	263600	91245	1.53
T_2: Technology option-1 - mulching with Jute felt and need based irrigation	9^{b}	56^{bc}	671^{bc}	6^{b}	48.7^{c}	216000	375000	159000	1.74
T_3: Technology option-II - Poly mulching and need based irrigation	12^{a}	64^{a}	784^{a}	5^{b}	58.7^{a}	222100	412600	190500	1.86
T_4: Technology option-III- Straw mulching and need based irrigation	10^{ab}	62^{ab}	704^{b}	6^{b}	51.8^{b}	183400	314300	130900	1.71

Values are means ± SEm, n = 5 per treatment group.

Means in a row without a common superscript letter differ (*P* = .05) as analyzed by one-way ANOVA and the DUNCAN test.

3.2 Number of fruits per plant

The study showed that the mulching techniques significantly increased the fruit per plant as compared to the farmer's practices. From the two year observations (2016-2017 and 2017-2018) the picture was crystal clear that maximum number of fruits per plant was obtained in poly mulching and need based irrigation treatment (T_3) followed by T_4, T_2 and T_1 (Table 1 and 2). Comparison of different mulches reveled that maximum value was found in poly mulching (black polythene mulch) which was significantly higher than other mulching treatments, whereas minimum number of fruits per plant was observed in control (Flood irrigation without mulching and need based irrigation) that were 52 (Table 1) and 51 (Table 2) fruits per plant in the consecutive years of study. Among mulches, black polyethylene treatment produced significantly higher fruit yield and number of fruits per plant than organic mulches and no mulch this might be the result of weed free field, less nutrient loss through leaching favorable soil temperature and moisture [21]. Similar findings were also obtained mulched and non-mulched plots [22, 23, 24, 25, 26].

3.3 Fruit weight

Significant effects were found on weight of mature tomatoes in Rocky cultivars under different treatment mulched conditions. Among mulch treatments, it is clear from the data (Table 1 and 2) that black polyethylene mulch significantly increased the weight of the fruits over control. Maximum test fruit weight was in black polythene mulch (784.0 g in the year 2017-2018, Table 2 and 778.5 g in 2016-2017, Table 1) which was at par with straw mulch (test weight of 10 fruits were 704.0 g and 699.9 g in 2017-2018 and 2016-2017) and found higher than all other treatments, whereas minimum was observed in Farmers' practice *i.e.,* T_1 (641.6 g and 629.0 g in back to back experimental seasons). Weight of fruits under mulch conditions was found to be highest and same characters were lowest in control or no mulch treatments [27]. This increase in tomato yield may be due to the better development of roots and vegetative growth, better nutrients uptake in mulched plots, and less normal leaching of nitrogen. Tomato grown under plastic mulches resulted in significant increase in yield, earliness and fruit quality [28].

3.4 Number of irrigation

When compared to other mulches plastic mulches are completely impermeable to water; it therefore prevents direct evaporation of moisture from the soil and thus limits the water losses and soil erosion over the surface. In this manner it plays a positive role in water conservation. The suppression of evaporation also has a supplementary effect; it prevents the rise of water containing salt, which is important in countries with high salt content water resources. It was reflected in the experiment also. As per depending on the soil status and growing condition of the plant irrigation activities was taken in the consideration. It was documented from the overall study of two consecutive years (Table 1 and 2) that the less number of irrigations (6 ~~nos~~. in first year and 5 ~~nos~~. in second year) was needed in the poly mulch situation (T_3) in respect to other treatments as per the optimum plant vigour as well as plant health considering the soil status. Whereas maximum number of irrigation was given in farmers' practices (T_1). Highest water use efficiency in application of irrigation at developmental stages of solanaceous crops [29].

3.5 Yield

It can be opined from the overall study that the much higher yield can obtained from mulched plots than non-mulched plots. It can be referred that the mulched environment was responsible for far better yield of tomato. Different level of yield hike was signified by the various type mulch and it was also dislocated in the present investigation also. Statistically significant difference was observed in yield plant due to use of different mulching materials. The maximum yield was recorded from T_3 treatment (60.3 t/ha and 58.7t/ha in two consecutive years), while the minimum yield plant was obtained from farmer's practices (non-mulched plot) 38.7 t/ha in 2016-2017 and 36 t/ha in 2017-2018 (Table 1 and 2). Temperature of soil was higher and weed was almost nil under black poly ethylene mulch than the other mulch resulting higher yield of tomato. In the year 2017-18 maximum

marketable yield (Table 2) was found in black polythene mulched plot (58.7 t/ha) followed by straw mulched plot (51.8 t/ha) whereas the result was slightly differ from the first year study. From the Table 2 it can be inferred that the highest marketable yield 60.3 t/ha found from black plastic mulched plot followed by mulched with jute felt (52.42 t/ha). It can be inferred from the study that yield (t/ha) differed significantly due to use of different mulching. From overall observations of two years it can be concluded that whereas black poly much responsible for higher production of tomato but non-mulched resulted minimum production (Table 1 and 2). It might be occurred due to the effect of black poly ethylene as such poly ethylene helps to retain higher soil moisture and temperature compared to other mulch materials. The same trend of the result in tomato production using poly ethylene mulch was observed in the present study [30, 31, 32].

3.6 Economics

The results showed that tomato production can be described as a labour intensive business venture. Among the list of cost items for the tomato production technology, labour alone accounts for more than 70% of the cost of operations. The cost structure of the trails indicates that a potential user of the mulching technology requires additional investment of organic and inorganic mulch. It can be reported that maximum return can be fetched from black poly mulch. From two years proven that the highest net return was recorded in black poly mulch (2016-2017), Rs. 2,11,910 /– per ha and Rs 1,90,500/– per ha (2017-2018) followed by jute felt and straw mulch. Cost benefit ratio were recorded the highest (1.96 and 1.86) for poly mulch followed by jute felt and straw mulch than without mulch (1.58 and 1.53) for two consecutive rabi seasons.

4. CONCLUSION

The maximum growth and yield contributing characters were recorded from black polythene mulch. Plastic mulch is more effective in the control of weed infestation. Temperature rise under the plastic mulch did not impair crop growth. From the results of this study, it could be concluded that black polythene mulch showed the general desirable impacts under this region on tomato growth and yield attribute performances. The increase in yield of black mulched was probably associated with the conservation of moisture, improved micro-climate both beneath and above the soil surface, light reflection and great weed control which reflected also in terms of higher return.

REFERENCES

1. Suresh BV, Roy R, Sahu K, Misra G, Chattopadhyay D. Tomato Genomic Resources Database: An integrated repository of useful tomato genomic information for basic and applied research. PLoS One. 2014;9(1): e86387. doi:10.1371/journal.pone.0086387.
2. Guil-Guerrero JL, Rebolloso-Fuentes MM. Nutrient composition and antioxidant activity of eight tomato (*Lycopersicon esculentum*) varieties. Journal of Food Composition Analysis. 2009;22:123-129.
3. Kamenetzky L, Asis R, Bassi S, de Godoy F, Bermúdez L, Fernie AR, Sluys MV, Vrebalov J, Giovannoni JJ, Rossi M, Carrari F. Genomic analysis of Wild tomato introgressions determining metabolism and yield associated traits. Plant Physiology. 2010;152:1772-1786.
4. Ugonna CU, Jolaoso MA, Onwualu AP. Tomato Value Chainin Nigeria: Issues, challenges and strategies. Journal of Scientific Research and Reports. 2015;7(7):501-515.
5. Mac Gillivary JH. Vegetable Production. McGraw hill Book Company, New York. 1961.
6. Annonymous. Training manual: winter vegetables and spices production. Horticulture Research and Development project (FAO/UNDP/AsDB Project: BGD/87/025). DAE and BADC. 1995.
7. Ma YO, Han QH. Effect of wheat straw mulch on the growth, development and yield of maize. Acta Agric Boreali-sinica. 1995;10(1):106-111.

8. Opara-Nadi OA. Effect of elephant grass and plastic mulch on soil properties and cowpea yield. In: Mulongoy, K. and Merckx, R. (eds.), Soil organic matter dynamics and sustainability of Tropical Agriculture, John Wiley & Sons, New York. 1993.
9. Hochmuth G, Chandler C, Stanley C, Legard D, Duval J, Waldo E, Cantliffe D, Bish E. Containerized transplants for establishing strawberry crops in Florida. Horticultural Science. 2001;37:443-446.
10. Awodoyin RO, Ogunyemi S. Use of sicklepod, Senna obtusifolia (L.) Irwin and Barneby, as mulch interplant in cayenne pepper, Capsicum frutescens L., production. Emirate Journal Agricultural Science. 2005;17(1):10-22.
11. Samih M Abubaker. Effect of different types of mulch on performance of tomato (*Lycopersicon esculentum* Mill.) under plastic house conditions. Journal of Food, Agriculture & Environment. 2013;11(2):684-686.
12. Erenstein O. Crop residue mulching in tropical and semi-tropical countries: An evaluation of residue availability and other technological implications. Soil and Tillage Research. 2002;67:115-133.
13. Gomez KA, Gomez AA. Statistical procedures for Agricultural Research. John Wiley and Sons, New York. 1984.
14. Hooda RS, Malik YS, Singh, J. Influence of direct seeding, transplanting time andmulching on tomato yield. India. Vegetable Science. 1999;26:140-142.
15. Bhagat RM, Acharya CL. Soil water dynamics during wheat growth under different management practices. Journal of Indian Society of Soil Science.1988;36:389-396.
16. Lal R. Conservation tillage for sustainable Agriculture: Tropic versus temperate environment. Advances in Agronomy. 1989;42:147-151.
17. Sarkar S, Singh SR. Interactive effect of tillage depth and mulch on soil temperature, productivity and water use pattern of rain fed barley (*Hordium vulgare* L.). Soil and Tillage Research. 2007;92:79-86.
18. Sarkar S, Paramanick M. and Goswami, S.B. Soil temperature, water use and yield of yellow sarson (*Brassica napus* L. var. *glauca*) in relation to tillage intensity and mulch management under rain fed lowland ecosystem in eastern India. Soil and Tillage Research. 2007;93:94-101.
19. Khurshid K, Iqbal M, Arif MS, Nawaz A. Effect of tillage and mulch on soil physical properties and growth of maize. International Journal of Agriculture and Biology. 2006;8(5):593- 596.
20. Seyfi K, Rashidi M. Effect of drip irrigation and plastic mulch on crop yield and yield components of cantaloupe. International Journal Agriculture Biology. 2007;9:247-249.
21. Hedau NK, Ranjan JK, Das B, Pragya, Verma RK, Sofi AA. Effect of bio-fertilization and mulch treatments on yield attributes and fruitquality of tomato under hill conditions of Uttarakhand. Indian Journal of Horticulture (Special Issue). 2010;67:259-262.
22. Hudu AI, Futuless KN, Gworgwor NA. Effects of mulching intensity on the growthand yield of irrigated tomato (*Lycopersicon esculentum* Mill.) and weed infestation in semi-arid zone of Nigeria. Journal of Sustainable Agriculture. 2002;21:37-45.
23. Nagalakshmi S, Palanisamy D, Eswaran S, Sreenarayanan VV. Influence of plastic mulching on chilli yield and economics. South Indian Horticulture. 2002;50:262-265.
24. Singh R. Influence of mulching on growthand yield of tomato (*Solanum lycopersicum* L.) in North Indian plains. Vegetable Science. 2005;32(1):55-58.
25. Aruna P, Sudagar IP, Manivannan MI, Rajangam J, Natarajan S.. Effect of fertigation and mulching for yield and quality intomato cv. PKM-1. Asian Journal of Horticulture. 2007; 2(2): 50-4.
26. Kashyap S, Phookan DB, Baruah P, Bhuyan P. Effect of drip irrigation andpolythene mulch on yield, quality, water-use efficiency and economics of broccoli production. Indian Journal of Horticulture. 2009;66:390-392.
27. Agrawal N, Panigrahi HK, Sharma D, Agrawal R. Effect of different colour mulches on the growth and yield of tomato under Chhattisgarh region. Indian Journal of Horticulture. 2010;67:295-300.
28. Baye B. Effect of mulching and amount ofwater on the yield of tomato grown under drip irrigation. Journal of Horticulture and Forestry. 2011;3(7):200-206.

29. Saikia M. Effect of irrigation andmulching on growth, yield and wateruse efficiency of potato in Assam. Potato Journal. 2011;38(1):81-83.
30. Singh R. and Singh L. Effect of plant growth regulators and micro-nutrient mixtures ongrowth and yield of tomato (*Lycopersicon esculentum* Mill.). Allahabad, India. Bioved. 2005;16 (1/2):101-105.
31. Sumiatis NA. Effect of plant growth regulators on flowering and yield of four tomato cultivars planted at Sukamandi in the lowlands. Buletin Penelitian Hortikultura. 1989;15(2):180-190.
32. Decoteau DR, Kasperbauer MJ, Hunt PG. Mulch surface color affects yield of fresh-market tomatoes. Journal of the American Society for Horticultural Science. 1989;114:216-220.