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Research paper

Influence of Mulching on Soil Hydrothermal Regime and Yield of Tomato in the Upper Brahmaputra Valley Zone of Assam

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ABSTRACT

The field experiments were conducted during 2019-20 and 2021-22 to study the effect of soil hydrothermal regimes under different mulching materials on growth and yield of the tomato. It was planted on four dates (25-October, 14-November, 3-December and 8-January) with the three mulch treatments, i.e., non-mulch (M_0), rice straw (M_1), and black polythene (M_2). The results revealed that the crop planted on 14th November had highest yield under all mulch treatments. The yield under black polythene (392.6 q ha^{-1}) increased by 47.8% than the non-mulch (265.7 q ha^{-1}) treatment. Based on the findings from the first crop season, a mid-term correction was implemented in the 2021–22 field experiment by planting tomatoes at the optimum time (14 November) and applying four mulch treatments, including the three used in the previous year along with an additional transparent polythene mulch (M_3). Across seasons, mulching significantly altered soil temperature and moisture regimes during the critical growth period, thereby influencing the growth and yield of the crop. The highest and statistically at par yields were recorded under M_2 (370.6 q ha^{-1}) and M_3 (374.6 q ha^{-1}), which decreased significantly under M_1 (336.1 q ha^{-1}) and M_0 (249.3 q ha^{-1}). Polythene mulches considerably increased the weekly mean night soil temperature (by up to 1.84°C in 2019–20 and 5.1°C in 2021–22), which alleviated the adverse effects of prolonged exposure to sub-optimal (<10°C) night temperatures and contributed to higher yields of tomato under black and transparent polythene mulches (M_2 and M_3).

***Keywords**:* Tomato, Polythene mulching, Soil temperature, Soil moisture, Base temperature of tomato

Tomato *(Lycopersicon esculentum* L.) is one of the most remunerative and widely grown vegetable crops in India. Our country is the second largest producer of tomato in the world after China (Sarmah *et al.,* 2024). It is also an important vegetable crop of Assam, grown in an area of 18.28 thousand hectares with a production of 396.024 thousand MT (Sarmah *et al.,* 2024). The growth, development, yield, and quality of tomato crop are highly influenced by various meteorological parameters among which air temperature and soil moisture are vital (Kumari *et al.,* 2014). The crop is affected by deficit as well as surplus soil moisture and endures a wide range of temperatures. The minimum and maximum cardinal temperature of the crop is identified as 10°C and 38°C, respectively (Nicola *et al.,* 2009), however, according to FAO (2012), the base temperature of the crop is 7°C. For the better growth of most of the tomato varieties the optimum temperature lies between 21°C and 24°C (Naika *et al.,* 2005). It has also been reported that when temperatures persistently remained below 10-12ºC for several consecutive days, productivity is reduced (FAO, 2013), while high temperatures during fruit development stage can reduce fruit size and yield (Sato *et al.,* 2000).

In the state of Assam, the tomatoes are planted during the *rabi* season, from late September to early December. During the active growth period of the crop, the daily minimum temperature goes below 10°C for more than two months from December to the mid-February. Exposure of the crop to low night temperatures from December to mid-February, adversely affects both vegetative and reproductive growth, resulting in delayed development and prolonged fruit maturation. After mid-February, a rapid increase in

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both day and night temperatures negatively affect fruit development, resulting in smaller fruit size and a reduction in overall marketable yield. Moreover, due to low and irregular distribution of rainfall during the growing season of the crop, soil moisture in the root zone of the crop is not maintained at the desired level and progressively declines as the season advances.

A falling night temperature below 10°C during the active growth period (December to the first week of February) and depletion of soil moisture particularly in the latter part of the growing season (December onwards) of the crop (Panging *et al.,* 2019), are the two major limiting factors hindering the growth and yield of tomato in the state. Moreover, such abiotic stresses are likely to be aggravated in future due to increase in weather variability driven by climate change (Neog *et al.,* 2020), which affect the growth of the *rabi* crops grown in the state (Panging *et al*., 2019). However, these problems can be addressed by changing surface energy balance, thereby modify microclimate in the crop field with respect to soil temperature and moisture regime in the root zone. Mulching is a common practice used to regulate microclimate both beneath and above the soil surface, mainly by soil temperature and moisture in addition to weed control, improves the physical, chemical, and biological properties of soil and ultimately enhances the growth and yield of crops (Saikia *et al.,* 2014, Kundu *et al.,* 2019). The modification of microclimate through mulching with the different mulch materials is not similar, as the alteration of the surface energy balance due to mulching varies with the nature of mulching materials (Mendonça *et al.,* 2021). The organic mulches such as straw, dried leaves, etc. are poor conductor of heat and reflect more and absorb less solar radiation. Therefore, the maximum amount of the net radiation available in the mulched surface with organic materials is partitioned into sensible heat and moves upward, while the conduction of heat into the soil surface is much less and lowers soil heat flux. Additionally, organic mulches reduce the rate of evaporation; therefore, a small amount of net radiation on the mulched surface is partitioned into latent heat flux (Panging *et al.,* 2019). On the other hand, in the case of black polythene mulch, most of the incident radiation is absorbed by the mulched surface and the net radiation available at the surface is converted to sensible heat flux alone, which moves in both upward and downward direction to the soil surface. As no water from the soil surface is available for evaporation, the conversion of net radiation into latent heat flux is negligible with use of black polythene mulch (Abhivyakti *et al.,* 2016). Thus, black polyethylene mulch alters the surface energy balance, reducing soil evaporation, thereby limiting the proportion of net radiation that is converted into latent heat flux (Ham & Tarara, 1999). In a transplant polythene mulch, the entire incident solar radiation passes to the soil surface and therefore almost 90% of the incident solar radiation is converted to soil heat flux (Rosenberg, 1974; Streak *et al.,* 1994).

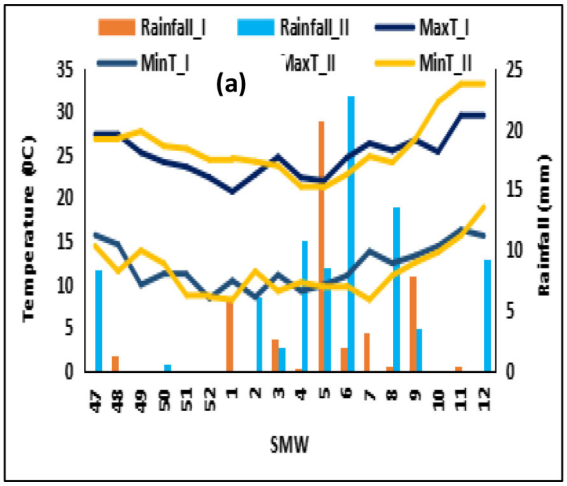
The hypothesis was that mulching and agronomic manipulations such as changing planting time might create a congenial microclimate for matching growing periods to fit in the required microclimate for growth, development, and yield of the crop. Therefore, the study was conducted to evaluate the effect of altered hydro-thermal regimes under modified microclimate with respect to soil temperature and soil moisture on the growth, development, and yield of the tomato crop using different types of mulching materials.

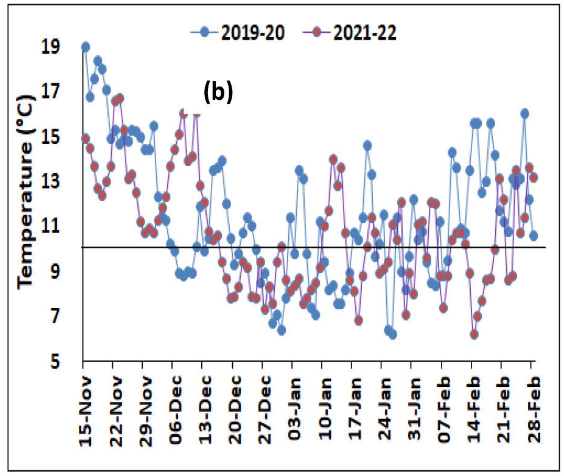
MATERIAL AND METHODS

A field study was conducted at Horticultural Research Farm of Assam Agricultural University, Jorhat, Assam (26.74°N, 94.2046°E and 87 m above msl) during *rabi* 2019-20 (I) and 2021-22 (II) years with tomato variety- *Arka Rakshak* in rainfed condition. During 2019-20 year, the variety was grown in factorial RBD with four dates of planting (25-October, 14-November, 3-December and 8-January) and three mulch treatments, *viz*., Non-mulch (M_0), Rice-straw mulch (M_1) and Black polythene mulch (M_2). During 2021-22, the same variety of the crop was planted with mid-term correction on optimum planting time (14-November) with four mulching treatments, *viz.*, Non-mulch (M_0), Rice-straw mulch (M_1), Black polythene mulch (M_2) and Transparent polythene mulch (M_3). In both the crop seasons, the maximum and minimum soil temperatures were recorded with soil thermometers placed at 5 cm and 10 depths of soil in selected plots representing different treatment combinations. Soil samples from two depths, *viz.,* 0 to 15 cm and 15 to 30 cm were collected using screw auger at 10 days interval during crop growing season. They are weighed, oven dried at 105°C and reweighed for estimating gravimetric soil moisture percentage and converted to the depth units by multiplying with bulk density following Neog *et al.,* (2013). The observations on plant phenological stages and yield attributing characters, such as plant height, number of branches and fruits per plant, and fruit weight were taken. Plant samples were taken periodically at 15 days interval for leaf area analysis start from 30 days after planting. The harvest was done manually from one square meter area placed randomly within plot at the two places. It is to be mentioned that to avoid complexity and for better evaluation of the effect of mulching, the data generated for the second date (14 November) of planting in the first crop season along with data generated in the second crop season are considered in this research.

The first crop season (2019-20) was comparatively dryer; the station received a rainfall of 44.6 mm, while it received an almost doubled amount of rainfall (86 mm) during the second crop season (2021-22). However, the second crop season was relatively warmer than the first crop season (Fig. 1a). The range of weekly mean maximum and minimum temperatures throughout the crop growing period during the first crop season were 20.5 to 29.5°C and 8.4 to16.6°C with their respective averages of 25.0°C and 12.0°C, while during the second crop season, the ranges varied from 21.2 to 33.2°C and 8.2 to 18.9°C with the respective averages of 25.9°C and 12.6°C, respectively.

It was observed that daily minimum temperatures recorded were consistently far below (up to 6.2 °C) the base temperature (10 °C) of tomatoes (Kumar *et al.,* 2012) for a considerable period in both crop seasons (Fig. 1b). During 2019–20, from the first week of December to the first week of February, the daily minimum temperature remained below 10 °C on 56 percent of the days. Similarly, in 2021-22, from mid-December to the third week of February, the daily minimum temperature was below 10 °C on 65 percent of the days. Thus, the low night temperatures adversely affect growth and development of tomatoes in both the crop seasons.





(a) (b)

Fig. 1: Weekly variation of maximum and minimum temperatures and rainfall during the crop seasons (a) Weekly variation of rainfall, maximum temperature and minimum temperature (I: 2019-20, II : 2020-21); (b) Daily variation of minimum temperature during critical growth period

RESULTS AND DISCUSSION

Soil temperatures under different soil mulching treatments

During 2019-20, the soil temperature at 5 cm and 10 cm depth of soil were recorded twice a day from 46th to 12th SMW in eight randomly selected plots representing all the treatment combinations. The weekly means of soil temperature recorded in two depths of soil under different mulching treatments were calculated and the deviation in soil moisture under mulched treatments from the non-mulched treatment (M_0) were calculated and presented Fig. 2(a). The weekly morning soil temperatures under both rice straw (M_1) and black polythene mulch (M_2) were higher by 0.3 to 1.2 and 0.8 to 2.4, respectively as compared to non-mulched treatment. On the other hand, the weekly evening soil temperature was reduced by 0.65 to 1.5°C under rice straw mulch (M_1), but increased by 1.71 to 2.55 °C under black polythene mulch.

During the second crop season (2021-22), the deviation of mean weekly morning and evening temperatures at 5 and 10 cm soil depth under different mulching treatments from the soil temperature under non-mulch treatment (M_o) were calculated and presented in Fig. 2(b). At 5 cm depth, the increase in weekly mean morning soil temperature under black polythene mulch (M_2), transparent polythene mulch (M_3), and straw mulch (M_1) as compared to that recorded under non-mulch treatment (M_0) varied from 1.3 ºC to 3.0 ºC, 0.8 ºC to 2.4 ºC and 0.1 to 1.8 ºC, respectively. Thus, the increase in soil temperature was the maximum under black polythene mulch and the minimum under straw mulch. However, in the evening, the increase in soil temperature at the same soil depth was relatively higher under transparent polythene mulch as compared to the black polythene mulch. The deviation of soil temperature under transparent polythene mulch (M_2) and black polythene mulch (M_3) as compared to that recorded under non-mulch treatment ranged from 1.1 ºC to 5.1 ºC and 0.2º C to 4.5ºC, respectively. Contrary to the polythene mulches, the deviation of soil temperature under the straw mulch in the evening was negative and varied from -0.1 ºC to -2.3 ºC.

In both the crop seasons, higher morning soil temperature in the plots covered with mulch materials of any kind as compared to non-mulched plots was probably due to the insulating effect of mulch materials over the soil surface, which restricted the temperature inversion from the soil (Awal & Khan, 1999). The radiative cooling of the soil surface covered by polythene sheet was lower as compared to the surface covered by straw mulch, which resulted in an increase in morning soil temperature under polythene mulch as compared to that under straw mulch (Ham *et al.,* 1993). Recording of the highest evening soil temperature under a transparent polythene sheet (M_3) might be because that transparent polythene sheet allows incoming solar radiation to reach the ground surface, while, at the same time, restricting the loss of long-wave radiation from the soil surface which resulted in an increase in net radiation balance at the soil surface and enhanced the flow of heat to the underlying soil profile and caused an increase in soil temperature. The lower increase in evening soil temperature in the case of black polythene (M_2) mulch as compared to transparent polythene mulch (M_3) might be because, unlike transparent polythene, black plastic mulch absorbed almost all the incoming solar radiation and re-radiated absorbed energy in the form of thermal radiation to the atmosphere as well as the underlying soil surface. Both black polythene and transparent polythene mulches restricted the loss of water from the soil surface as evaporation, thereby; they reduced the loss of latent heat of evaporation from the soil surface. Hence, most of the net radiation available at the soil surface is converted into the soil heat flux, resulting in an increase in soil temperature under both black and transparent polyethylene sheets as compared to the non-mulched and straw mulching. The organic mulches modify the surface energy balance by reducing the interception of incoming solar radiation, increasing surface reflection, and decreasing heat conductivity (Stigter *et al.,* 2018) and this might be the reason for recording the lowest evening soil temperature in the plots covered with straw mulch. In non-mulched plots, the entire incident solar radiation was absorbed by the soil surface, which is why more radiation is partitioned into soil heat flux as compared to that under straw mulch. This might be the reason for recording

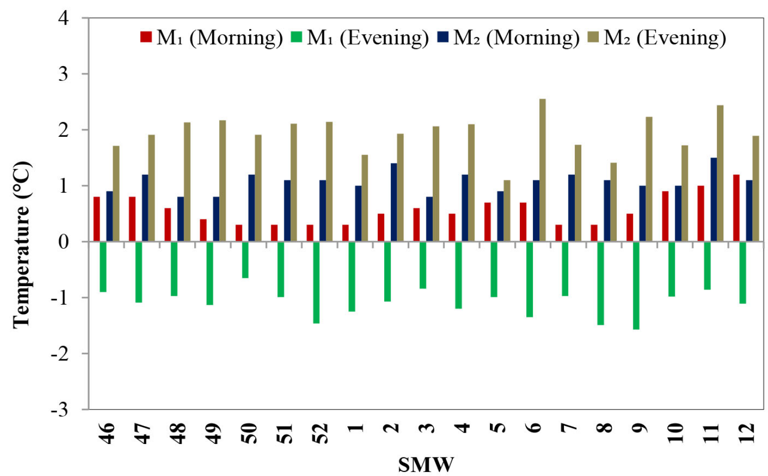


Fig. 2(a): Deviation of soil temperature from non-mulched (M_o) condition under different mulching treatments in *Arka Rakshak* during *rabi*, 2019-20 (Where, M_1: Straw mulch and M_2: Black polythene mulch).

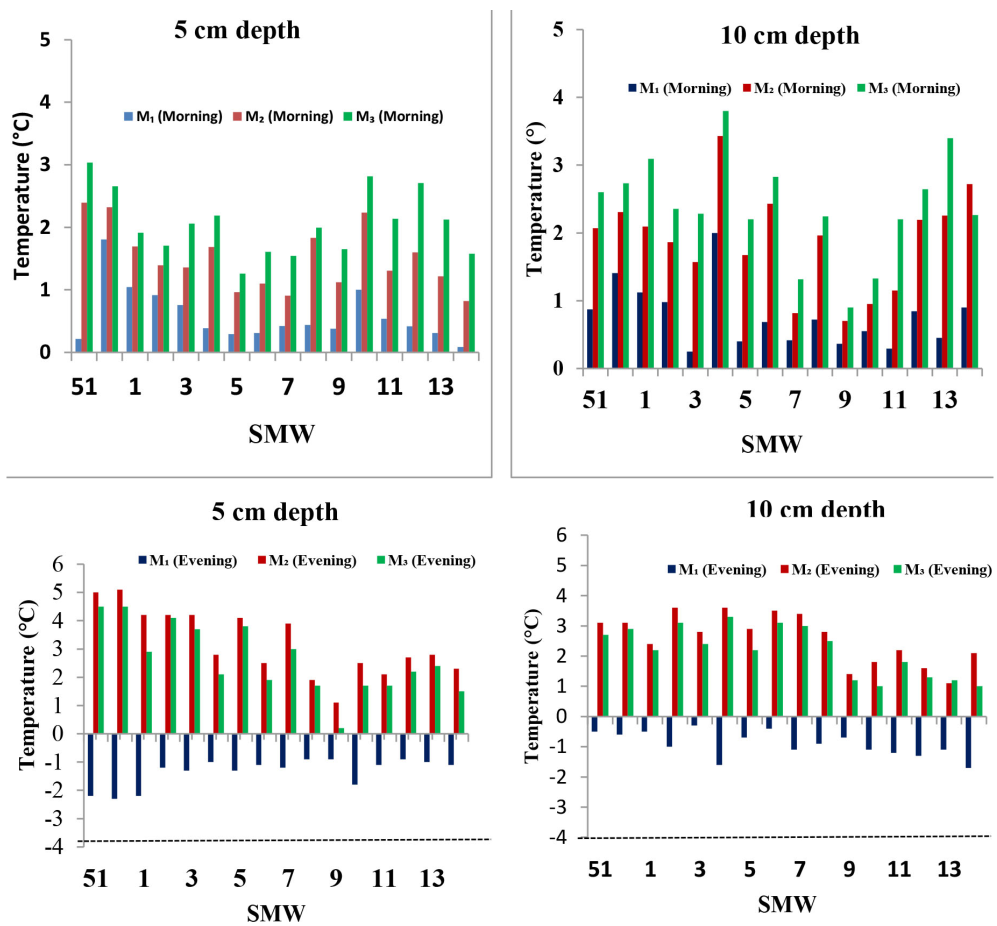


Fig. 2(b): Deviation of soil temperature from non-mulched (Mo) condition under different depths of soil and mulching treatments in Arka Rakshak during rabi, 2021-22 (M_1: Straw mulch; M_2: Black polythene mulch and M_3: Transparent polythene mulch)

lower temperatures under non-mulch treatment as compared to those recorded under polythene mulches. The above results are also supported by the findings of Pramanik *et al.,* (2015) and Stigter *et al.,* (2018), who reported that the evening soil temperatures under straw mulch were always lower as organic mulches modify the surface energy balance by reducing the interception of incoming solar radiation, increasing surface reflection, and decreasing heat conductivity.

Table 1: Effect of mulching on soil moisture content in normal time planted crop (14th November) in *Arka Rakshak* during *rabi* 2019-20

Days after planting	Moisture depth (mm) in 30 cm layer of soil under			Change in soil moisture content (%) as compared to non-mulch treatment	
	M_0	M_1	M_2	M_1	M_2
0	89.00	89.40	89.21	0.4	0.2
15	85.50	87.56	88.00	2.4	2.9
30	81.20	84.52	86.00	4.1	5.9
45	80.21	83.50	85.61	4.1	6.7
60	78.56	79.52	81.23	1.2	3.4
75	76.19	78.56	79.21	3.1	4.0
90	77.23	79.80	78.90	3.3	2.2
105	72.36	77.85	76.89	7.6	6.3
120	68.90	72.35	74.58	5.0	8.2
Mean	78.79	81.45	82.18	3.5	4.4

(Where, M_0: Non-mulch; M_1: Rice-straw mulch and M_2: Black polythene mulch)

Table 2: Effect of mulching on soil moisture content under different types of mulching in *Arka Raksha* during *rabi* 2021-22

Days after transplanting	Moisture depth (mm) in 30 cm layer of soil				Change in moisture content (%) as compared to non-mulched treatment		
	M_0	M_1	M_2	M_3	M_1	M_2	M_3
0	67.77	70.08	75.73	78.51	2.31	7.95	10.74
15	65.18	67.37	73.73	76.01	2.19	8.55	10.84
30	61.01	65.03	71.92	72.85	4.02	10.91	11.84
45	52.44	60.49	69.06	70.46	8.05	16.62	18.02
60	70.18	62.87	67.16	68.27	-7.31	-3.02	-1.91
75	88.49	75.04	67.27	68.42	-13.45	-21.22	-20.07
90	83.13	73.88	65.73	69.30	-9.26	-17.41	-13.84
105	73.89	71.99	64.06	66.44	-1.91	-9.84	-7.45
122	82.16	76.68	66.68	68.58	-5.48	-15.28	-13.57
Mean	71.58	69.27	69.04	70.98	-2.31	-2.55	-0.60

(Where, M_0: Non-mulch; M_1: Rice-straw mulch; M_2: Black polythene mulch and M_3: Transparent polythene mulch)

Variation of soil moisture under different mulching treatments

Soil moisture data taken from the upper 30 cm layer of soil at 15 days interval starting from the day of planting and change in soil moisture content under rice straw and black polythene as compared to non-mulched treatment during 2019-20 was calculated and presented in Table 1. Overall, the average soil moisture retention in the upper 30 cm soil profile during the crop growth period of tomato was maximum under black polythene (82.18 mm), followed by straw-mulch treatment (81.45 mm) and non-mulch (78.79 mm). During the entire crop growing season, soil moisture content was increased by 3.5 and 4.4 percent under straw (M_1) and black polythene mulch (M_2), respectively, as compared to non-mulch treatment (M_0). The highest soil moisture retention was observed under black polythene as it formed a barrier for the evaporation loss of water, thereby increase soil moisture retention.

Soil moisture content and change in soil moisture content under rice straw, transparent polythene and black polythene as compared to non-mulched treatment during 2021-22 was calculated and presented in Table 2. As a whole, the average soil moisture in the upper 30 cm soil profile during the crop growth period was unexpectedly the highest under non-mulch treatment (71.6 mm), followed by black polythene mulch (71 mm), straw mulch (69.3 mm) and transparent polythene mulch (69 mm). The mean decreases in soil moisture content with respect to non-mulch treatment for the entire crop growth period were 2.54 mm (transparent mulch), 2.31 mm (straw mulch), and 0.6 mm (black polythene mulch). The unusual highest overall average soil moisture retention during the crop growing period was the maximum under non-mulch treatment (M_0) was probably due to the occurrence of considerably higher amounts of rainfall from the several numbers of days at the reproductive stage of the crop. Though removed regularly, the weeds which grew under transparent polythene mulch might be the reason for a marginal decrease in soil moisture retention under the transparent polythene mulch (69.04 mm) as compared to the black polythene mulch. Comparatively higher soil moisture retention under the straw mulch treatment as compared to polythene mulches might be because the straw mulch allowed the entry of rainwater to some extent into the soil, and it also reduced the loss of evaporation from the soil surface. Though polythene mulches dropped down the evaporation from the soil to a greater extent, at the same time it obstructed the penetration of rainwater into the soil and caused rain to run off over the mulch. Thus, advantages of occurrence of rainfall can't be acquired for recharging the soil moisture under polythene mulches (M_2 and M_3).

Table 3: Performance of *Arka Rakshak* grown under different microclimates during *rabi* 2019-20 and 2021-22

Micro-climates	Max LAI	Dry matter (g plant^{-1})	No. of branches plant^{-1}	No. of fruits plant^{-1}	Fruit weight (g plant^{-1})
		Rabi, 2019-20			
Non-mulch (M_o)	2.58	207.0	9.8	46.2	59.8
Rice-straw (M_1)	3.16	303.0	13.0	58.7	66.3
Black polythene (M_2)	3.26	344.0	12.5	56.5	75.7
Mean	3.0	284.7	11.8	53.8	67.3
C.D. (at 5%)	NS	NS	1.3	7.8	3.4
		Rabi, 2021-22			
Non-mulch (M_o)	2.05	206.7	9.7	45.3	54.5
Rice-straw (M_1)	2.35	206.7	12.3	58.3	60.7
Black polythene (M_2)	2.50	343.9	13.3	62.7	64.0
Transparent polythene (M_3)	2.62	345.0	13.7	64.7	67.5
Mean	2.4	265.6	12.3	57.8	61.7
C.D. (at 5%)	NS	NS	2.56	4.97	1.93

Morphophysiological parameters under different microclimate

The data on maximum LAI, total biomass production, number of fruits per plant, fruit weight per plant, and yield under different microclimates are presented in Table 3 and Table 4. A perusal of data (Table 3) revealed that during the first crop season, the maximum LAI was recorded under black polythene (3.25), followed by straw mulch (3.16) and non-mulch (2.58) conditions. During the second crop season, LAI reduced in the same sequence under different mulching treatments, except transparent mulching under which LAI was the highest. On the other hand, irrespective of mulching treatments, higher LAI was recorded during the first crop season compared to the second crop season. Increasing morning soil temperature, particularly between December and mid-February, might increase crop growth, causing an increase in the LAI under polythene and rice straw mulches. It was observed that the more increase in the morning soil temperature, higher the LAI recorded under different mulches. During the first crop season, compared to non-mulched conditions, the change in soil moisture retention under black polythene (4.4%) and rice straw (3.5%) mulches was positive, which favoured vegetative growth of the crop and resulted in an increasing LAI under these treatments (Table 3). However, during the second crop season, the advantage of mulching on soil moisture retention was not realized due to receiving excessive rainfall. The higher air temperatures and increased rainfall with more cloudy days contributed to the rise in evening relative humidity, which created a congenial environment for the observed higher incidence of late blight disease in the second crop season. That might be the cause of reducing canopy coverage and leaf area index (LAI) across all mulching treatments in the second crop season compared to the first crop season. The above results are supported by the findings of Dhaliwal *et al.,* (2019), who reported that plastic mulches significantly modified soil temperature and moisture regimes, thereby enhancing vegetative growth and leaf area index.

In both crop seasons, the total biomass production was higher in the crop grown under black polythene, as compared to rice straw and non-mulched treatments; however, biomass production was marginally higher under transparent mulching than the black polythene mulching during the second crop season (Table 3). The total biomass production was highest under transparent and black polythene mulching compared to other mulching treatments in both crop seasons, which might be due to the creation of a better thermal regime with profuse canopy coverage and higher LAI under these micro-climates. Less canopy coverage with less LAI due to the incidence of the crop by late blight disease as influenced by higher amount of rainfall with more number of cloudy days and higher relative humidity might be the main cause of less biomass production during the second crop season.

No significant difference in number of branches per plant was observed between M_1 (13.0) and M_2 (12.5) in 2019-20 and among M_1 (12.3), M_2 (13.7), and M_3 (13.3) in 2021-22. However, in both crop seasons, branches per plant were reduced significantly under the non-mulched condition (M_1) compared to polythene and organic mulching treatments. Irrespective of mulching treatments yield attributing characters, *viz*., number of branches, fruits per plant and fruit weight was higher in the first crop season than in the second crop season (Table 3) for the same reason of increasing LAI and biomass production in that year. Analysis also revealed that in both crop seasons, the number of fruits per plant was reduced significantly under non-mulch conditions compared to other mulching treatments. The number of fruits per plant was statistically at per under M_1 (58.7) and M_2 (56.5), and M_2 (62.7) and M_3 (64.7) during 2019-20 and 2021-22, respectively. However, fruit numbers per plant under M_1 (58.3) reduced significantly compared to M_3 during the second crop season. Unlike other crop growth parameters, the recording of more number fruits per plant during the second crop season (57.8), as compared to the first crop season (53.8) was probably attributed to the higher relative humidity that prevailed during the reproductive stages due to occurrence of more rainfall with more number cloudy days in that season. The results were supported by Wen *et al.,* (2018), who reported that increasing relative humidity (70 to 90%) could effectively increase the rate of flowering, fruit set and fruit numbers.

It was observed that the mulching treatments significantly influenced the fruit weight per plant in both crop seasons. During the first crop season (2019-20), the highest and the lowest fruit weight per plant was under black polythene (75.7 g) and non-mulch (69.8 g) treatments, respectively. During 2021-22, the highest fruit weight per plant was recorded under the transparent

Table 4: Fruit yield of tomato variety *Arka Rakshak* grown under different mulching treatments

Microclimates	Fruit yield (q ha^{-1})	
	2019-20	2021-22
Non-mulch (M_o)	265.7	249.3
Rice-straw (M_1)	353.7	336.1
Black polythene (M_2)	392.6	370.6
Transparent polythene (M_3)	-	374.6
Mean	337.3	332.7
C.D. (at 5%)	15.0	6.30

polythene sheet (67.5 g), followed by black polythene (64.0 g), rice straw (60.7g), and non-mulch (54.5 g) treatments. The recording of the maximum weight per fruit under the polythene mulches (M_2 and M_3) was attributed to the highest LAI, and biomass production as compared to other mulching treatments (M_0 and M_1), while the lowest fruit weight per plant recorded under non-mulch treatment (M_0) was attributed to the poor overall growth of the crop under these microclimates. Recording of lower fruit weight per plant in the second crop season might be due to increased rainfall activities during the reproductive growth, which accelerated disease development and ultimately decreased fruit weight. The findings of Jędrszczyk *et al.,* (2016) support the above results, who reported that air temperature from planting to flowering positively, while rainfall during the reproductive stage negatively influenced the fruit weight in tomato.

A perusal of data (Table 4) revealed that the yield of tomato varied from 249.3 to 392.6 q ha^{-1} regardless of mulching treatments and crop seasons. Despite recording a higher number of branches and fruit numbers per plant, recording of lower tomato yield during 2021-22 (332.7 q ha^{-1}) compared to 2019-20 (337.3 q ha^{-1}) was probably due to the occurrence of very high rainfall with evening high humidity during the reproductive stages (60 days after planting), creating a congenial environment for incidence of late blight disease irrespective of mulching treatments, resulted in decrease in LAI, biomass production, fruit weight and finally yield of the tomato. The highest fruit yield was achieved under M_2 (392.6 q ha^{-1}) during 2019-20, while during 2021-22, the highest fruit yield was recorded under M_3 (374.6q ha^{-1}), followed by M_2 (370.6 q ha^{-1}), although statistically at par. The highest yield might be attributed to higher LAI and biomass production with higher fruit weight per plant under improved soil hydrothermal conditions in terms of soil temperature and soil moisture content (in the case of the first crop season) during the critical growth period under polythene mulching (M_2 and M_3). Although there was an increase in morning soil temperature and soil moisture retention (in the first crop season) during the critical growth period of the crop under rice straw mulching (M_1), the increase was comparatively lesser than that observed under polythene mulching (M_2 and M_3). For this reason, a significant increase and decrease in tomato yield under rice straw mulching (M_1) was observed compared to non-mulched (M_2) conditions and polythene mulching (M_3), respectively. Reduction in tomato yield during seasons with high rainfall and humidity was also reported by Dhaliwal *et al.*, (2019), which may be attributed to increased disease incidence adversely affecting canopy development. The results of the current investigation are in agreement with the findings of Kumari *et al.,* (2014) and Dhaliwal *et al.,* (2019), who reported higher tomato yield under polythene mulch due to improved soil hydrothermal conditions, which enhanced biomass production and fruit weight.

CONCLUSION

Low minimum temperatures prevailing from December to mid-February, frequently falling below the base temperature of the tomato crop during its critical growth stages, adversely affected the productivity of the tomato variety *Arka Rakshak*. However, the application of transparent and black polythene mulches substantially improved crop productivity by increasing soil temperatures, particularly during morning hours, compared to rice straw mulch and non-mulched conditions during the critical growth period. This increase in soil temperature mitigated the adverse effects of low temperatures, while variation in seasonal rainfall also influenced the performance of the crop. Improved soil moisture conservation under black polythene mulch contributed to higher yield during the first season compared to rice straw mulch or non-mulched crop. In the second season, higher rainfall reduced the influence of soil moisture as a limiting factor, and mulching had a relatively limited effect on soil moisture conservation. Overall, the study indicates that using polythene mulches effectively modifies the crop microclimate by improving soil thermal and moisture regimes, thereby enhancing tomato yield even under the recommended planting period.

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