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RESEARCH ARTICLE

Enhancing yield and quality of muskmelon (*Cucumis melo* L.) through strategic planting dates and mulching techniques in low tunnel conditions

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Abstract

Climate change and a growing population demand the adoption of new technologies to enhance food production. Off-season cultivation of muskmelon facilitates early market availability, meeting food demands and ensuring better prices for farmers. To evaluate the growing conditions for muskmelon under Punjab's agro-climatic conditions, an experiment was conducted from 2019-2021 at the Vegetable Research Farm, Punjab Agricultural University, Ludhiana. This study was aimed to assess the influence of planting time during the off-season on the growth, yield and quality parameters of muskmelon. The study included eight treatments, comprising four planting dates- 15th November, 15th December and 15th January under low tunnels and 15th February under open-field conditions combined with two mulching treatments: black polyethylene mulch and no mulch. Various meteorological, growth, yield and economic parameters were assessed. The results revealed that low tunnels and mulching significantly influenced soil and air temperatures and relative humidity. Enhanced plant growth was observed under low tunnels, with the longest vine length at maturity recorded for the January sowing. The highest number of fruits per plant was recorded in the February and November sowings. The maximum total yield was achieved with the November planting, followed by the December planting, attributed to enhanced photosynthetic activity under low tunnels. Black polyethylene mulch also significantly improved plant growth, yield and fruit quality compared to bare soil. The highest net returns were obtained with the 15th November transplanting under low tunnels combined with black polyethylene mulch, yielding a cost-benefit ratio of 1:2.06.

Keywords: low tunnel; mulch; muskmelon; off-season cultivation

Introduction

India has varied agro-climatic conditions, with the North Indian plains experiencing temperature extremes ranging from 4-15 °C in winters to as high as 45 °C in summers. Muskmelon, being a warm-season crop requires high temperature, low rainfall and low humidity for its successful growth. High humidity deteriorates the quality of muskmelon fruits. Thus, harvesting the fruits before the onset of rains becomes necessary (1). Various measures have been implemented to mitigate the impact of varying climatic conditions on both vegetable production and the economy. India, being the second largest producer of vegetables globally, has reached the production potential of 219.6 million metric tonnes. Even so, the productivity and quality of the crops remain static due to various biotic and abiotic stresses in open field conditions. The environment, being a critical determinant of crop production, is undergoing constant change, necessitating the use of protective structures (2).

Protected cultivation means growing crops under controlled conditions of temperature, humidity, light and other factors (3). They ensure both qualitative and quantitative production of vegetables throughout the year. Protected structures comprise greenhouse, polyhouse, high tunnels, low tunnels, etc (4). They protect crops from frost and heavy rains and enhances the growth and development of the crop (2, 5) in turn increasing productivity (6) and leading to fruit precocity, allowing growers to get the premium prices occurring early in the harvest season (7). Low tunnels are most suitable for vegetable crops among the protected structures. Low tunnels are flexible, transparent semi-circular structures with 0.5 m height and 1 m width. They are installed over the individual beds of vegetables and can be dismantled and utilized again next year. The low tunnels have a direct effect on relative humidity and air temperature and, an indirect effect on soil moisture and soil temperature. They replicate greenhouse conditions, thus effectively trapping CO_2 overnight, increasing plant photosynthesis in the daytime and boosting yields. Additionally, tunnels enable plants to intercept solar radiation, enlarging leaf area and boosting productivity (8). In fact, this technique mitigates the adverse effects of climate change on fruit cultivation (9).

Protecting crops under a plastic tunnel (polyethylene) generates changes in the environmental conditions of temperature, light and relative humidity that might affect the physiological responses of the plant. They warm up the soil, protect the plants from cold injury and advance the crops over the normal season by 30 to 40 days (10). For earliness, low tunnel production is a better option as they are cost-effective thus, can be easily affordable by small and marginal farmers. Low tunnels protect the crop during the winter season by creating a favourable microclimate for the successful cultivation of early season crops (11). Even though this technology requires some initial investment, the benefit of extending the cultivation season of these major cucurbits by 30 -40 days has made it cost-effective.

Cucurbits, when grown during their main season, the vegetable markets are flooded with these vegetables and sometimes the vegetable growers cannot recover the cost of cultivation. However, the same vegetables are sold at very high prices during the off-season in several parts of the country (12, 13). The demand of off-season vegetables is increasing rapidly in several big cities of the country. Using low tunnel technologies will increase growers' awareness of the benefits of reducing frost risk and improving profitability and earliest harvest.

The use of plasticulture techniques such as mulches and row covers has proven to be successful. The primary purpose of plastic mulches is to increase soil temperature, but they are also beneficial for conserving soil moisture and controlling weeds and insects (14-17). Under black polythene mulch, plants showed greater vegetative growth by promoting higher biomass, advanced development, early harvest and increased yield (18, 19).

Considering all the above, the present study was designed to determine the optimal sowing date and growing conditions for achieving the earliest possible yield and maximizing market returns.

Materials and Methods

The present study was conducted at the Vegetable Research Farm. The biochemical analysis was done at the Biochemistry Laboratory of Punjab Agricultural University, Ludhiana, during the months of October to April in the years 2019-20 and 2020-21. Ludhiana is situated at a mean elevation of 247 m above sea level, at 30° 54' N latitude and 75° 48' E longitude. The place experiences an extremely hot and dry summer between April and June, followed by dry winters.

The meteorological data recorded during the crop season (2019-21) is presented in Fig. 1. The average rainfall of the area is 600 mm most of which is received during July-to mid-September. A soil analysis conducted on an experimental farm revealed the following well drained sandy loam, soil with a pH 8.2, organic carbon 0.22 %, available N 126.22 kg/ ha, P_2O_5 22.6 kg/ ha and available K_2O 147 kg/ ha.

The experiment was conducted as a randomized block design with three replications. The total number of treatments was eight, which included four dates for planting i.e., 15th November, 15th December and 15th January under low tunnels conditions and 15th February under open conditions; under two mulching conditions; black polythene mulch and no mulch (bare soil). The hybrid MH-27, developed by Punjab Agricultural University, comprised the planting material. Its vines are vigorous and dark green. Fruits are round, light yellow, sutured and netted. It has tolerance towards wilt and root knot nematodes. It has a long shelf life suitable for long distance transportation.

Nursery sowing was done 30 days before transplanting in protrays and protected from cold and frost in December and January. MH-27 was sown and transplanted in the field for two seasons 2019-20 and 2020-21 at different dates under different mulch conditions as per treatments. The seedlings of muskmelon were transplanted in a double-row system on both sides of 3 m wide beds, with a spacing of 60 cm between two hills. Iron arches were fixed manually to cover the paired rows of the muskmelon at a distance of 3 m and at a height of 45 cm above the ground. Low tunnels were removed after 15th February.

The cultural practices for irrigation, nutrition and pest control were followed as per standard agronomic practices (20). Soil temperature was recorded using a soil thermometer placed at a depth of 5 cm in soil every day at 7.30 AM and 2.30 PM and

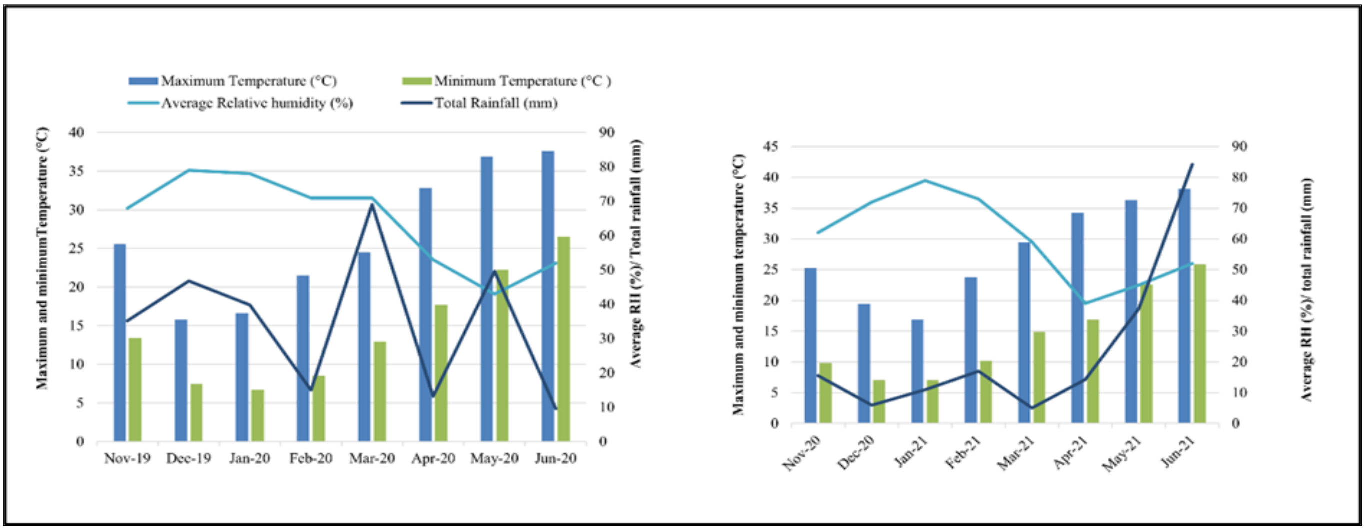

Fig. 1. Monthly maximum temperature (°C), minimum temperature (°C), average relative humidity (%), and total rainfall (mm) recorded during crop season 2019-20 and 2020-21.

the readings were averaged across replications. Maximum and minimum temperatures were recorded by placing the thermometer at middle of the tunnel and outside in an adjoining open field in order to compare the temperature difference inside the low tunnel and the open field. Diurnal cycles of relative humidity were noted every day in the morning and evening with the help of a hygrometer (ApTechDeals HTC-1) placed in the middle of the tunnel and outside in an adjoining open field.

The growth and yield parameters of five plants were measured in each plot at random. The data was recorded for the length of the main shoot, number of primary branches per plant (number of primary branches arising from main stem of each vine), days taken to 50 % flower initiation (number of days from sowing of plant to anthesis of 50 % plants from each plot), number of days to reach first fruit harvest, number of fruits per vine, fruit weight, fruit diameter, total yield and quality parameters such as total soluble solids (Refractometer), dry matter (oven dry method) and ascorbic acid (21). The data recorded for various aspects was statistically analysed using crop production and cost software (CPCS). Analysis of variance (ANOVA) was performed based on a factorial randomized complete block design (RCBD).

Results

Soil temperature (°C)

Fig. 2 depicts the effect of mulch and low tunnel on soil temperature in 2019-20 and 2020-21. An increase of 3.6 °C during 2019-20 and 3.2 °C during 2020-21 was observed in the minimum temperature recorded at 7:30 AM between black polythene mulch and no mulch. Correspondingly, soil temperature recorded at 2:30 PM under black polythene mulch showed an increase of 3.1 °C during 2019-20 and 2.8 °C higher than non-mulch during 2020-21.

Air temperature (°C)

Maximum air temperature showed a difference of 9.5 °C and

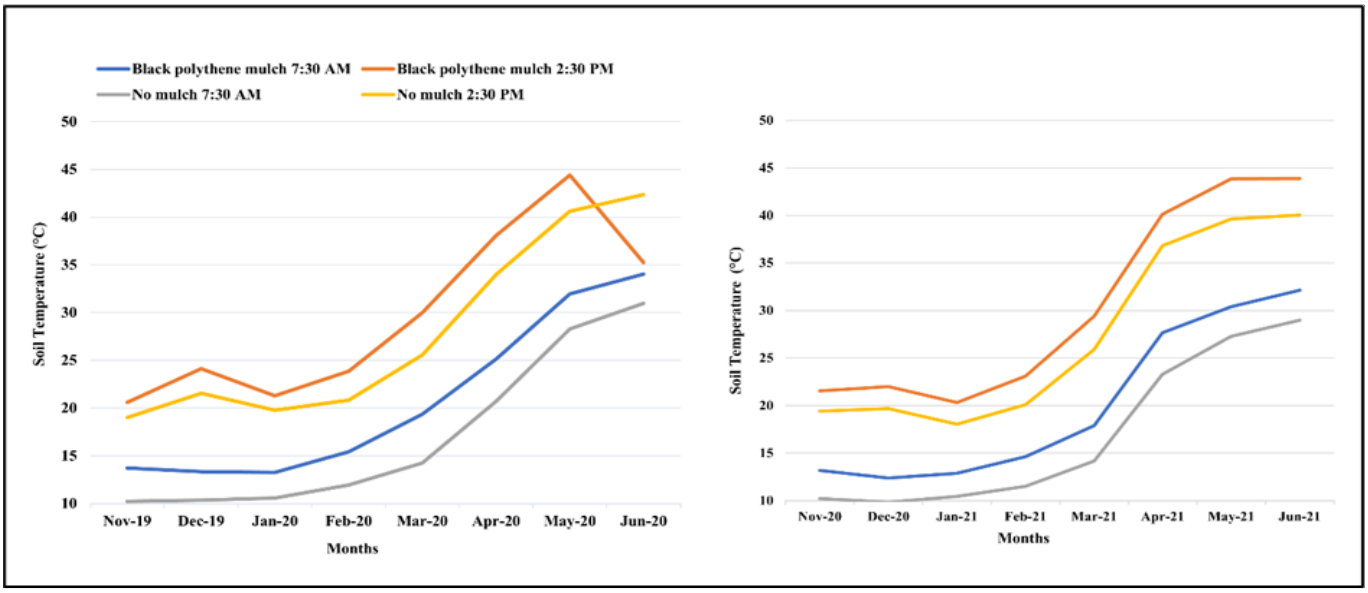

Fig. 2. Soil temperature (°C) under different mulch conditions during 2019-20 and 2020-21.

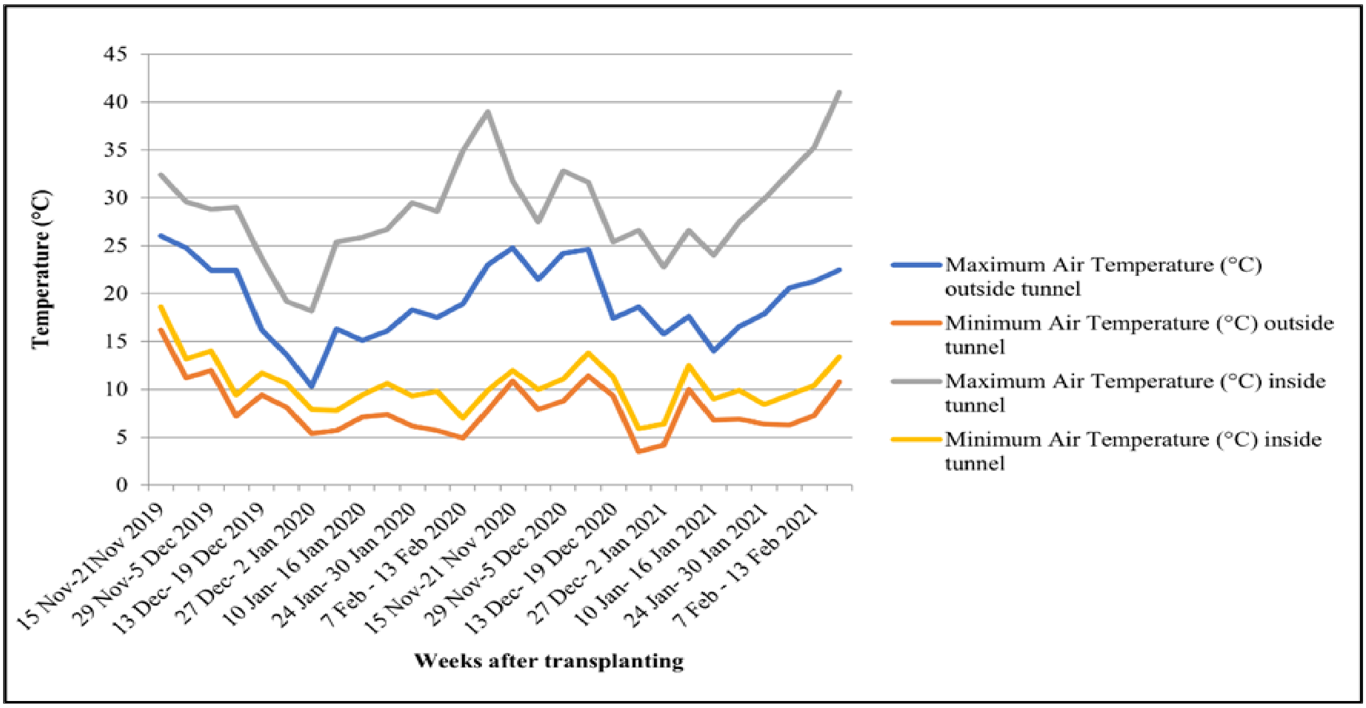

Fig. 3. Air temperature (°C) outside and inside low tunnel during 2019-20 and 2020-21.

9.85 °C in the low tunnel compared to open field conditions during 2019-20 and 2020-21. There was a lesser difference noted in minimum air temperature increased by 2.5 °C and 2.4 °C inside the tunnel during both cropping seasons (Fig. 3).

Relative humidity (%)

Fig. 4 depicts the relative humidity throughout the crop season. In the cropping season 2019-20, the maximum RH under low tunnel was 7.6 % lower than in open field conditions. However, the minimum RH was 13.5 % higher than open field conditions.

Dates of sowing

A review of data presented in the Fig. 5 depicts the growth parameters. Fig. 6 represents yield and flowering parameters. Fig. 7 depicts quality parameters recorded during 2019-20 and 2020-21, respectively. The measurements of vine length taken at 60 and 90 days after planting indicated that the highest vine length (62.13 cm and 61.49 cm; 110.27 cm and 108.50 cm) was observed in the February sown crop during 2019-20 and 2020-21, respectively. At the time of maturity, vine length was highest in the January sown crop (195.26 cm and 197.61 cm) in both seasons. February planting in the open condition had the lowest days to 50 % flowering (33.33 and 32.83). Of the various planting dates in low tunnels, January planting showed minimum days to 50 % flowering (50.50 and 50.33).

In 2019-20 and 2020-21, the maximum number of fruits was noted under February (4.85) and November (4.00) planting, respectively. The average fruit weight was recorded under November planting in both the cropping seasons (847.50 g and 855.23 g). Fruit diameter was found to be higher in January planting (17.65 cm) and November planting (17.66 cm) in 2019-20 and 2020-21, respectively. But statistical analysis of data revealed that there were no significant differences among the dates of planting. The highest total yield was recorded in the November planting (188.41 q/ha and 190.93 q/ha), followed by December planting (181.74 q/ha and 183.23 q/ ha).

The total yield of November planting was 7.64 % and December planting was 3.50 %, significantly higher than February planting. Marketable yield was recorded to be maximum in November planting (179.93 q /ha and 179.99 q/ ha) followed by December planting (171.02 q/ ha and 170.76 q/ ha). Fruits obtained from 15th February had a maximum TSS of 11.89 °Brix, followed by 15th January (11.82 °Brix). During the cropping seasons of 2019-20 and 2020-21, the temperature at the time of harvesting was 35.7 °C and 36.2 °C, respectively. Mean ascorbic acid content was found to be highest on 15th December planting and mulched plots (22.17 and 21.39 mg/100 mg). Dry matter accumulation was highest in crop plants transplanted on 15th February (8.37 and 8.55 %).

Effect of mulching

Mulched plants recorded the highest vine length at 60 days (53.79 cm, 53.63 cm), 90 days (94.11 cm, 93.76 cm) and at the time of maturity (198.53 cm and 200.02 cm) in 2019-20 and 2020-21, respectively. There was no significant difference between mulched and non-mulched plots for days to 50 % flowering. Plants that were mulched exhibited an earlier time to the first harvest (90.83 days) in comparison to non-mulched plants (98.75 days). Utilization of mulch resulted in a higher number of fruits than non-mulch. However, statistical analysis of the data revealed that there were no significant differences. During both cropping seasons, covering the soil with black polythene mulch was observed to increase the diameter of the fruit significantly. The fruit diameter noted under mulched plants was 18.14 cm and 18.09 cm during 2019-20 and 2020-21, respectively. Mulched plants gave a higher yield by 5.31 % in comparison to non-mulched plants. The fruits cultivated under mulch conditions exhibited higher TSS content, measuring 11.85 °Brix, compared to non-mulched plants, which had a TSS content of 11.38 °Brix. Both ascorbic acid (21.95 and 21.99 mg/ 100 mg) and dry matter content (8.55 and 8.56 %) were noted to be higher in fruits obtained from mulched plants when compared to non-mulched plants (ascorbic acid: 20.93 and 21.08 mg/ 100 mg) and (dry matter: 8.00 and 8.09 %).

Cost-benefit ratio

The highest net returns were observed with transplanting on November 15th under low tunnels with black polythene mulch. These returns were significantly greater compared to the farmers' standard practice of transplanting on February 15th without mulch, with a notably improved cost-benefit ratio. The net returns were significantly higher, amounting to Rs. 2,15,626, with a cost-benefit ratio of 1:2.06, compared to the farmers' usual practice of transplanting on 15th February without mulch (Rs. 52671). The second most profitable method was the 15th November transplanting with low tunnels but without mulch, with a net return of Rs. 197,936 and cost-benefit ratio of 1:2.05 (Table 1).

Discussion

Soil temperature significantly affects seed germination, plant growth and development, nutrient availability and soil moisture content (22). Mulch traps solar radiation beneath the soil surface, thereby altering soil temperature (23). As a result, mulch insulates the soil and protects crop plants from frost and chilling (24). Comparative analysis of soil temperature in black polythene mulch and bare soil conditions showed that black polythene mulch recorded maximum soil temperature. Similar patterns in soil temperatures were observed and the increment in soil temperature was linked to the entrapment of infrared radiations by black polythene mulch (25, 26).

The role of air temperature is significant in determining the growth of plants and it varies for different species. Each plant has a specific range of temperature in which it grows best and this temperature range affects the crop yield. Therefore, the air temperature was monitored and recorded weekly throughout the cropping season. To promote growth in muskmelon during the winter months, it is imperative to provide suitable temperature conditions that low tunnels can fulfil. Compared to open field conditions, the tunnel environment consistently exhibited elevated maximum air temperatures across both cropping seasons. This increase is primarily attributed to the tunnel's capacity to trap solar radiation, thereby enhancing thermal conditions. In contrast, the rise in minimum air temperatures within the tunnel was comparatively moderate. Similar air temperature trends reported in previous studies consistently demonstrate that low tunnels are effective in increasing air temperature and creating a favourable environment for plant growth (27).

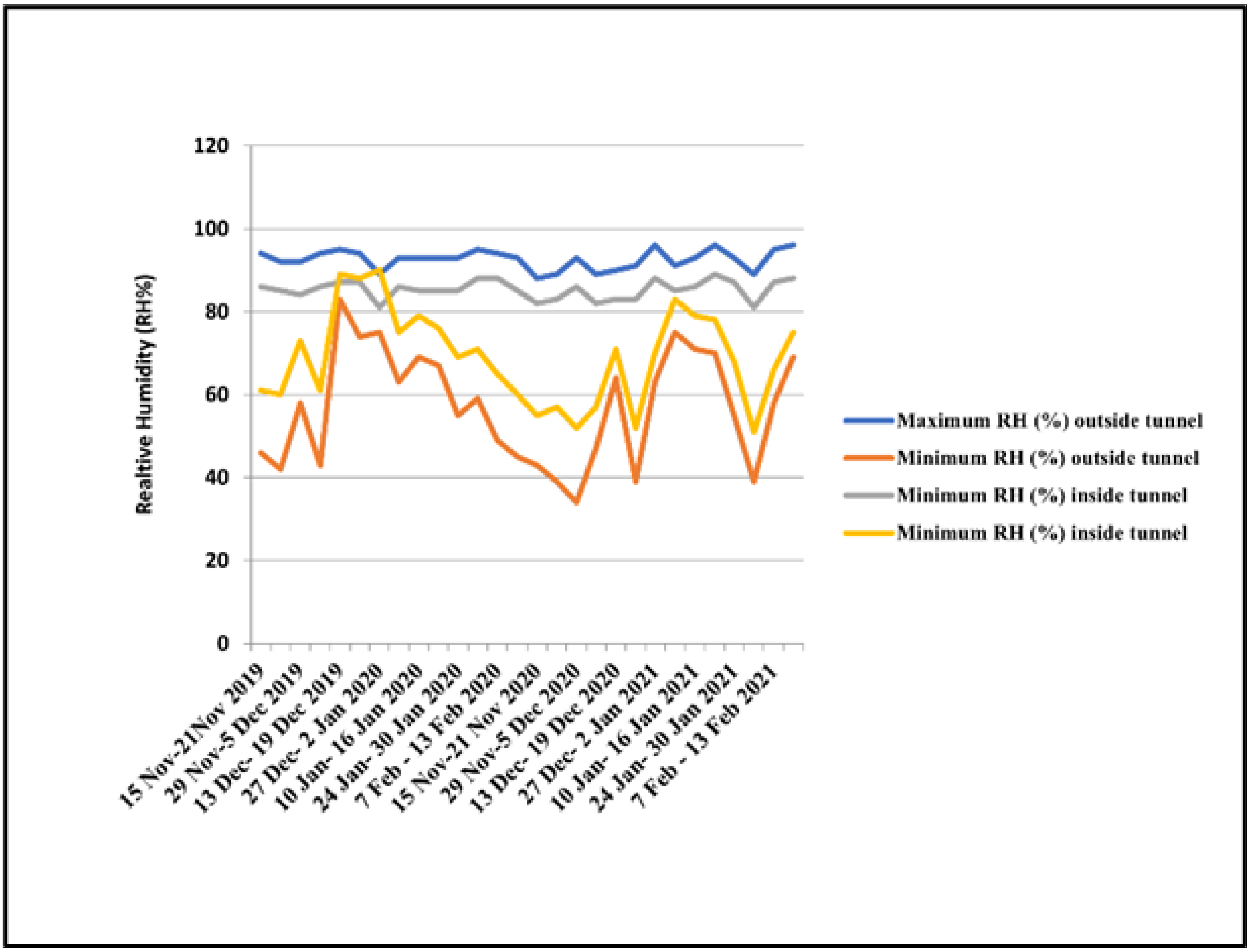

Fig. 4. Relative humidity (%) outside and inside low tunnel during 2019-20 and 2020-21.

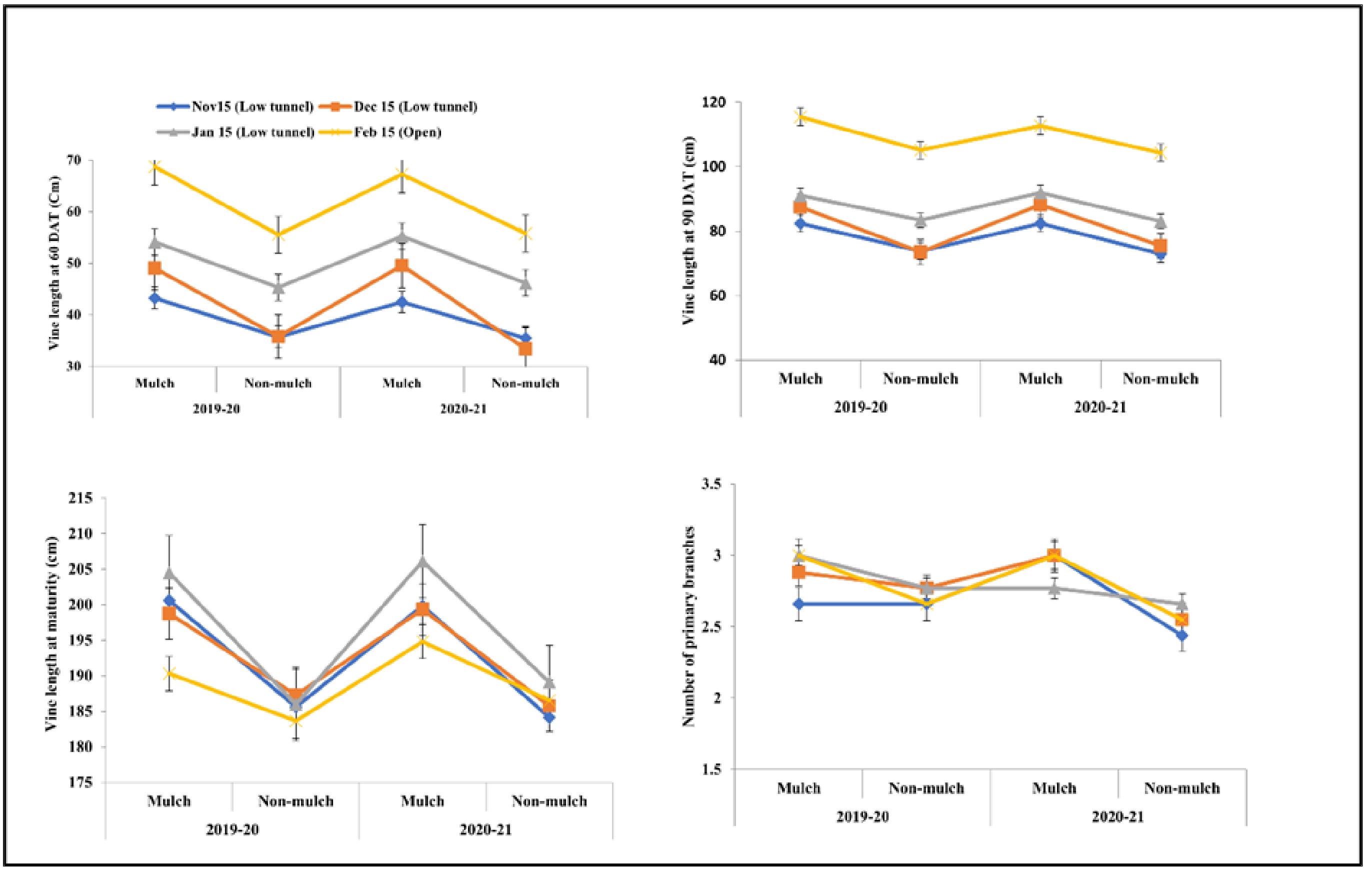

Fig. 5. Growth parameters recorded during 2019-20 and 2020-21.

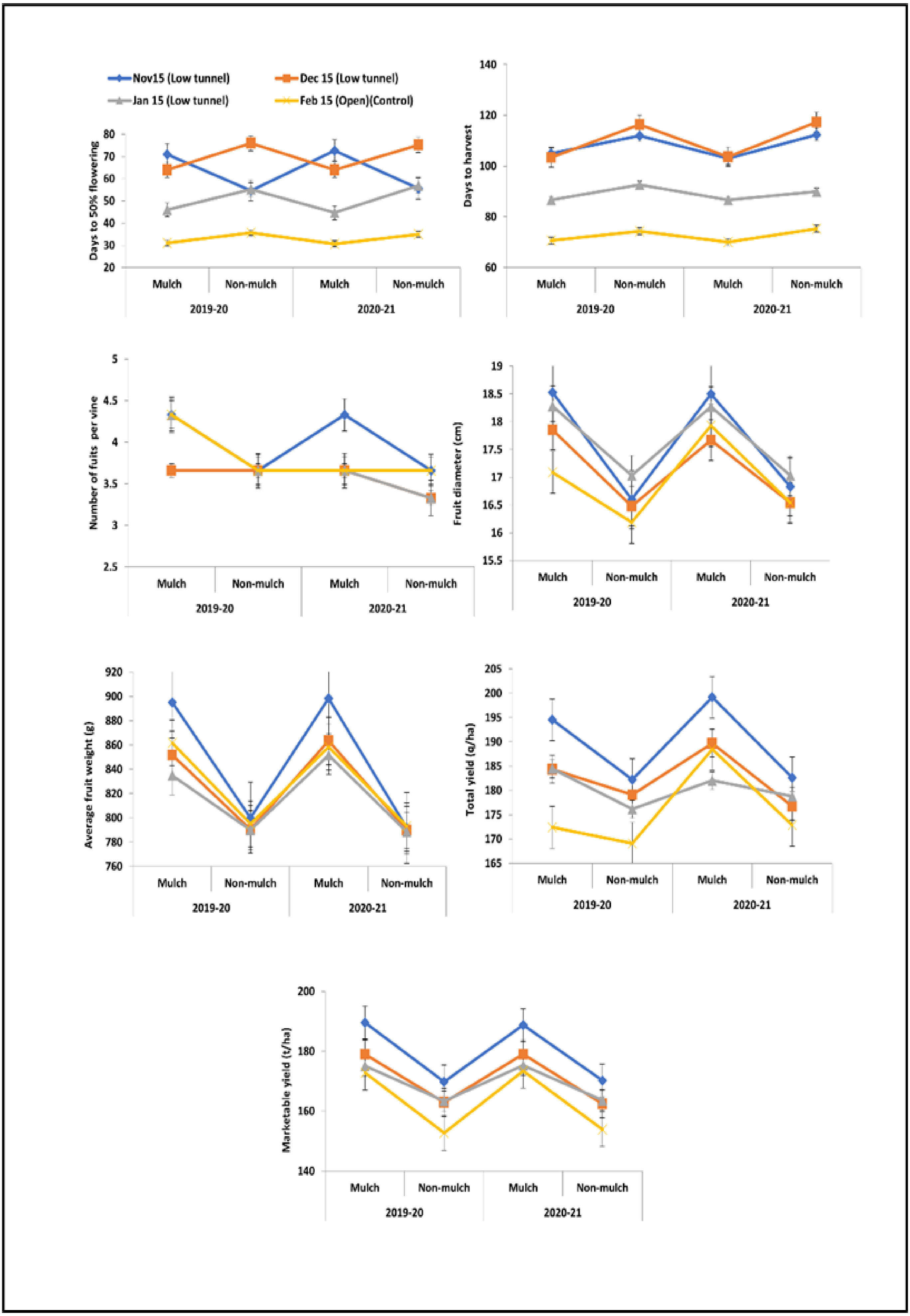

Fig. 6. Flowering and yield parameters recorded during 2019-20 and 2020-21.

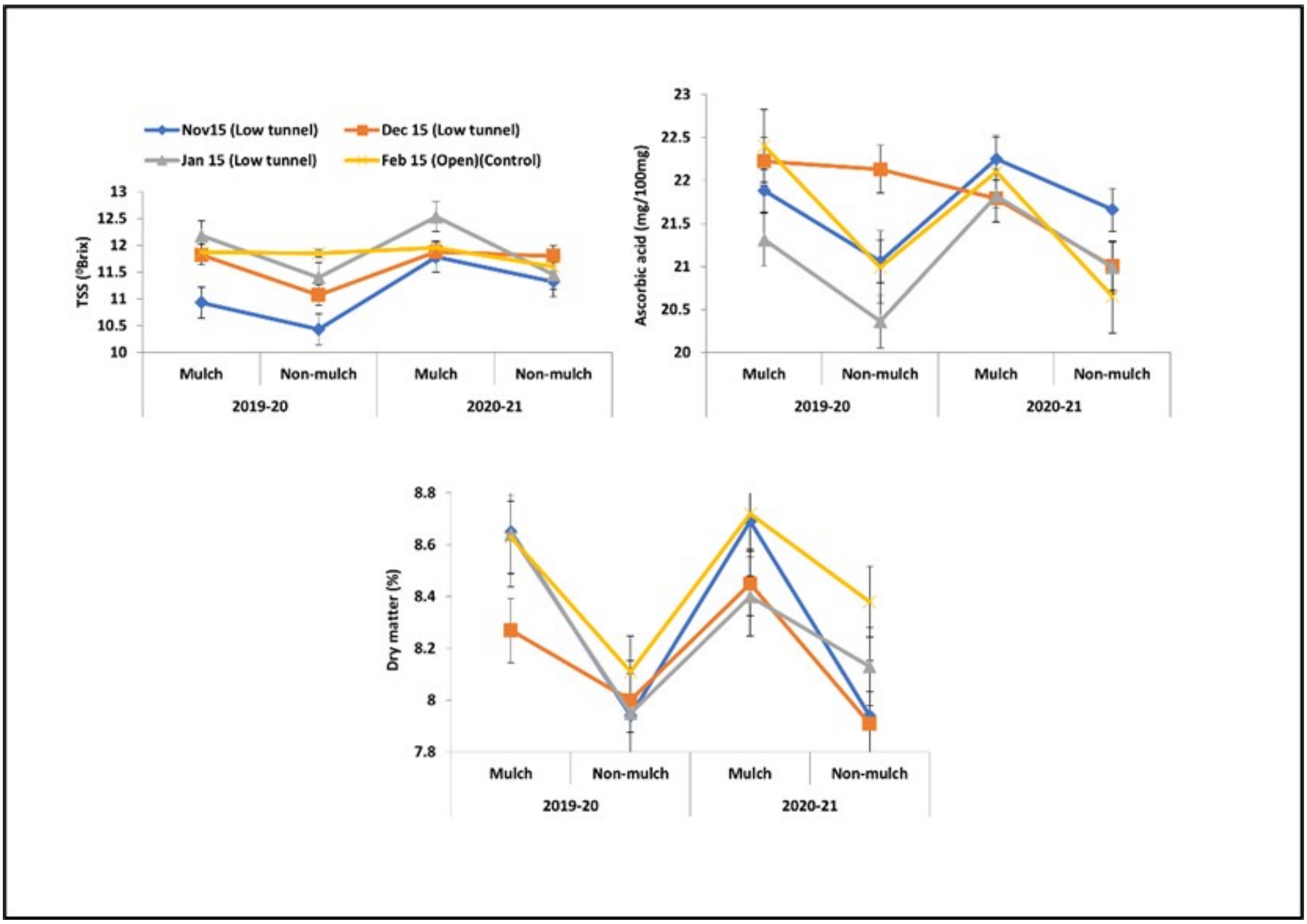

Fig. 7. Quality parameters recorded during 2019-20 and 2020-21.

Table 1. Average cost-benefit ratios under different treatments

Treatments	Marketable yield (q/ ha)	Cost of cultivation (Rs)	Gross return (Rs)	Net return (Rs)	Cost: benefit ratio
15 November + mulch	224.07	109789	336105	226316	1:2.06
15 November + non-mulch	196.15	96289	294225	197936	1:2.05
15 December + mulch	203.64	109789	305460	195671	1:1.78
15 December + non-mulch	191.37	96289	287055	190766	1:1.98
15 January + mulch	187.28	109789	149824	40035	1:0.36
15 January + non-mulch	179.49	96289	143592	47303	1:0.49
15 February + mulch	167.03	137944	133624	46835	1:0.53
15 February + non-mulch	159.95	75289	127960	52671	1:0.69

- Cost of produce: Rs 1500 / quintal in March- April
- Cost of produce: Rs 800 / quintal in May- June
- Cost of low tunnel material: Rs 23000 / hectare
- Cost of black polythene mulch: Rs 25000 /hectare
- Cost of labor: Rs 4500/ hectare/weeding

Relative humidity (RH) is the ratio of actual water vapor content to the saturated water vapor content at a given temperature. RH directly controls the rate of transpiration and stomatal aperture of plants, thus indirectly affecting the photosynthesis and yield of the plant. Low tunnels influence the relative humidity by creating a microclimate around the vicinity of the plants. During both the cropping seasons, the maximum relative humidity was lower inside the tunnel compared to the outside environment due to the increased day temperatures, promoting faster evaporation and air circulation. The minimum relative humidity was notably higher than that observed in the open field conditions. This rise may be attributed to restricted air movement and moisture entrapment during the cooler nighttime hours. These contrasting trends suggest that the tunnel microclimate moderates diurnal humidity fluctuations, potentially contributing to more stable atmospheric conditions conducive to plant growth (28).

Dates of sowing

Adjusting the planting schedule to suit specific agro-climatic conditions and utilizing controlled environments can enhance vegetable production during off-seasons. The highest vine length at 60 and 90 days after planting was consistently recorded in the February-sown crop. This can be attributed to the elevated temperatures experienced during the early stages of growth in the February transplanted crop. At maturity, the January-sown crop recorded the greatest vine length in both the cropping seasons. Similar trends were reported where plants grown under a low tunnel exhibited superior vegetative growth and experienced a 10.5 % increase in yield compared to plants grown in open conditions (19).

Plastic low tunnels alter the microclimate of the plant by providing more favourable temperatures during the off-season. This results in early and better yields than open field conditions. February planting under open conditions exhibited the shortest duration to 50 % flowering, likely due to the elevated temperatures during this period, which accelerated physiological processes such as bud initiation and floral development, thereby promoting earlier flowering. Among the different planting dates in low tunnels, the January planting resulted in the fewest days to reach 50 % flowering. As the carbon dioxide is trapped in the low tunnel, the soil can be warmed and the crop plants can be protected from frost and cold winds during the winter months. This results in heightened photosynthetic activity and accelerates crop growth compared to the regular season, ultimately leading to early harvesting and attaining higher market value (29).

The number of fruits per vine and the average weight of fruit are crucial factors in determining the yield of the plant, making them key indicators of productivity. In both the 2019-20 and 2020-21 seasons, the highest number of fruits was observed in February and November plantings, respectively. The highest total yield was recorded in November planting, followed by December planting. The total yield from November planting was notably higher than that from February planting, with a significant increase for December planting as well. The augmented yield resulting from early sowing can be attributed to the extended duration of the crop. Low tunnels create favourable conditions for the crop, facilitating optimal growth, flowering and fruiting. This ultimately gives higher yields. The highest marketable yield was observed in the November planting, followed by the December planting.

Fruits harvested in February had the highest TSS content, closely followed by those harvested in January. During the 2019-20 and 2020-21 cropping seasons, the temperature at harvest was recorded at 35.7 °C and 36.2 °C, respectively. Meteorological data indicated that there was ample solar radiation and dry weather during the harvesting period. These conditions resulted in a significant buildup of sugars in the fruits, leading to improved flavour (30). The highest mean ascorbic acid content was observed in the December planting and in the mulched plots. Notably, there was a substantial increase in ascorbic acid content in the early sowing group compared to the late sowing group, due to variations in light intensity. This may be due to the direct correlation between ascorbic acid content and light exposure (31)

The low tunnels maintain the temperature and photosynthetic activity. The light trapped inside the tunnel stimulates the biosynthesis of vitamin C. Dry matter content is a fundamental parameter in the biochemical analysis of crops, providing critical information for nutrient assessment. The highest dry matter accumulation was observed in the crop plants transplanted in February. The combination of row covers and plastic mulch led to earlier and superior quality muskmelons compared to other approaches (32).

Mulching has been proven to effectively control weeds, increase plant growth and retain soil moisture. Mulched plants exhibited better growth, with the longest vine length at various stages of development and reached the first harvest earlier than non-mulched plants. Although there were no significant differences in the time to 50 % flowering or the number of fruits, mulching significantly increased fruit diameter in both seasons. Additionally, mulched plants yielded more, with a higher overall yield compared to non-mulched plants. The utilization of black polythene mulch enhanced the yield of watermelon, resulting in a significant increase by 34.6 %. Fruits grown under mulched conditions showed a higher TSS content compared to those from non-mulched plants (33). Additionally, ascorbic acid and dry matter content were greater in fruits from mulched plants than in those from non-mulched plants, a trend similarly observed in husk tomato plants (34).

Cost benefit ratio

Proposing any new technology requires an understanding of its economic feasibility. An increase in returns under the low tunnel conditions during November transplanting under mulch conditions was primarily attributed to the higher market value of the crop in March-April, which was Rs. 1500 per quintal, compared to the mid-season price of Rs. 800 per quintal. The second most profitable method involved transplanting on November 15th with low tunnels but no mulch, offering a favourable cost-benefit ratio. Similar results were observed when low tunnel technology was used to cultivate muskmelon, summer squash and watermelon. Among these crops, muskmelon cultivated under low tunnels during the early season demonstrated exceptional profitability (35, 36).

Conclusion

Transplanting muskmelons on November 15th under low tunnels with black polyethylene mulch significantly enhanced crop performance in terms of the number of fruits per plant, average fruit weight and total yield. In comparison to planting on bare soil, the use of black polyethylene mulch was advantageous for overall growth, yield and fruit quality. Low tunnels also provided the advantage of early planting and harvesting, allowing growers to command higher prices for their produce before the market prices began to drop during the mid-season. Therefore, transplanting muskmelons on November 15th under low tunnels with black polyethylene mulch not only led to higher yields but also maximized returns and the benefit-cost ratio. Given these advantages, future research should aim to optimize low tunnel microclimates and investigate varied mulching materials toward improving yield and quality and analyze their broader economic returns.

Authors' contributions

AKR was involved in data acquisition, analysis, interpretation and drafting of the manuscript. KS, VS and DT contributed by critically revising the manuscript for important intellectual content and provided final approval of the version to be published. NC provided supervision and expert advice on the analysis of biochemical parameters and contributed to data interpretation. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author used ChatGPT, an AI language model developed by OpenAI, for paraphrasing certain sections of the text to enhance clarity and coherence. After using this tool, the authors carefully reviewed and edited the content as needed and take full responsibility for the final version of the publication.

References

1. Pansare U, Amol K, Dhakne V, Bochare S. Production techniques and constraints in muskmelon (*Cucumis melo* L.) cultivation. Pharma Innov J. 2023;12(9):2456–551.
2. Rakesh Mohan Shukla, Nuzhat Bint Nazir, Pandey Y, Dadhich SM. Influence of protected cultivation structures on vegetable crops. J Agric Ecol. 2024;25(1):116–22. https://doi.org/10.9734/jaeri/2024/v25i1577
3. Pachiyappan P, Kumar P, Reddy KV, Kumar KNR, Konduru S, Paramesh V, et al. Protected cultivation of horticultural crops as a livelihood opportunity in Western India: An economic assessment. Sustainability. 2022;14(12):7430. https://doi.org/10.3390/su14127430
4. Chetna Banjare, Dibyajyoti Mahanta, Sahu P, Choudhary R. A comprehensive review on protected cultivation: Importance, scope and status. Int J Environ Clim. 2024;14(7):46–55. https://doi.org/10.9734/ijecc/2024/v14i74250
5. Li NX, Chen NW, Li NY. Study on photosynthetic characteristics of blueberry in greenhouse. Acta Hortic. 2012;(926):315–19. https://doi.org/10.17660/ActaHortic.2012.926.43
6. Arshad A, Ovidiu Jerca, Chan S, Mihai Cîmpeanu, Drăghici. Study regarding the influence of some climatic parameters the greenhouse on the tomato production and fruits quality. Scientific Papers Series B Horticulture. 2023;69(2):296–306.
7. Demchak K. Small fruit production in high tunnels. Hort Technol. 2009;19(1):44–49. https://doi.org/10.21273/HORTTECH.19.1.44
8. Kołodziejczyk M. Yield-protective efficiency of biological and chemical potato protection against Phytophtora infestans (Mont.) de Bary. Acta Agrophysica. 2018;25(1):59–71. http://doi.org/10.31545/aagr0005
9. Carlen C, Krüger E. Berry production in changing climate conditions and cultivation systems: Further research requirements. Acta Hortic. 2009;(838):225–28. https://doi.org/10.17660/ActaHortic.2009.838.37
10. Singh A, Syndor A, Deka BC, Singh RK, Patel RK. The effect of microclimate inside low tunnels on off-season production of strawberry (*Fragaria × ananassa Duch*.). Sci Hortic. 2012;144:36–41. https://doi.org/10.1016/j.scienta.2012.06.025
11. Kumar S, Singh SS, Kumar A. Management practices of growers using plastic low tunnel on flowering and fruiting behaviour of bitter gourd (*Momordica charantia* L.) during off season. J Pharmacogn Phytochem. 2017;6(6S):942–45.
12. Yadav RK, Kalia P, Choudhary H, Brihamadev ZH. Low cost polyhouse technologies for higher income and nutritional security. Int J Agric Food Tech. 2014;(5):191–96.
13. Singh B, Tomar BS, Hasan M. Plug-tray nursery raising technology for off-season cucurbits cultivation. Acta Hortic. 2010;871(37):279–82. https://doi.org/10.17660/ActaHortic.2010.871.37
14. Leua HN, Zankat SB. Effect of plastic mulch and row cover in vegetable crops. Int J Sci Res. 2024;13(1):183-85. http://doi.org/10.21275/SR24101165144
15. Ramakrishna A, Tam HM, Wani SP, Long TD. Effect of mulch on soil temperature, moisture, weed infestation and yield of groundnut in northern Vietnam. Field Crops Res. 2006;95(2):115–25. https://doi.org/10.1016/j.fcr.2005.01.030
16. Ghosh PK, Dayal D, Bandyopadhyay KK, Mohanty M. Evaluation of straw and polythene mulch for enhancing productivity of irrigated summer groundnut. Field Crops Res. 2006;99(2-3):76–86. https://doi.org/10.1016/j.fcr.2006.03.004
17. Chakraborty D, NagaraJanuary S, Aggarwal P, Gupta VK, Tomar RK, Garg RN, et al. Effect of mulching on soil and plant water status and the growth and yield of wheat (*Triticum aestivum* L.) in a semi-arid environment. Agric Water Manag. 2008;95(12):1323–34. https://doi.org/10.1016/j.agwat.2008.06.001
18. Khan M, Parvej M. Impact of conservation tillage under organic mulches on the reproductive efficacy and yield of quality protein maize. J Agric Sci. 2011;5(2):52. http://doi.org/10.4038/jas.v5i2.2782
19. Minghua F, Wang X, Gu Z, Liao ZX, Zhu AF, Fu MH, et al. Effect of multi-functional plastic film transferring violet ray to red light (VTR) applied in field. Trans Chinese Soc Agric Engg. 2000;16:81–84.
20. Thind SK. Package of practices for cultivation of vegetables. Additional Director of Communication for Punjab Agricultural University, Ludhiana; 2021. Available from: https://www.pau.edu/content/ccil/pf/pp_veg.pdf
21. Analytical Chemists. 15th ed. Association of Official Analytical Chemists, Arlington VA; 1990.
22. Onwuka BM. Effects of soil temperature on some soil properties and plant growth. Scholarly J Agric Sci 2016;6(3):89-93. https://doi.org/10.15406/apar.2018.08.00288
23. Subrahmaniyan K, Zhou W. Soil temperature associated with degradable, non-degradable plastic and organic mulches and their effect on biomass production, enzyme activities and seed yield of winter rapeseed (*Brassica napus* L.). J Sustain Agric. 2008;32(4):611–27. https://doi.org/10.1080/10440040802394927
24. Gordon GG, Foshee WG, Reed ST, Brown JE, Vinson E, Woods FM. Plastic mulches and row covers on growth and production of summer squash. Int J Veg Sci. 2008;14(4):322–38. https://doi.org/10.1080/19315260802215830
25. Sharma UK, Meshram KS. Evaluate the effect of mulches on soil temperature, soil moisture level and yield of capsicum (*Capsicum annuum*) under drip irrigation system. Int J Agric Eng. 2014;8:54–59. http://doi.org/10.15740/HAS/IJAE/8.1/54-59
26. Snyder K, Grant A, Murray C, Wolff B. The effects of plastic mulch systems on soil temperature and moisture in Central Ontario. Hort Technol. 2015;25(2):162–70. http://doi.org/10.21273/HORTTECH.25.2.162
27. Dongre RN, Sharma M, Rajput R, Shankar R, Sonkar S, Patel V, et al. Protected cultivation of horticultural crops: A sustainable approach to climate-resilient agriculture in India. Int J Adv Biochem Res. 2025;9(5):714-20. http://doi.org/10.33545/26174693.2025.v9.i5i.4414
28. López-Martínez A, Molina-Aiz FD, de M, Peña-Fernández A, Baptista F, Valera-Martínez DL. Low tunnels inside Mediterranean greenhouses: Effects on air/soil temperature and humidity. Agronomy. 2021;11(10):1973–73. http://doi.org/10.3390/agronomy11101973
29. Kumar S. Effect of sowing time and planting methods on production of bottle gourd. [CCS Haryana Agricultural University]; 2015.

30. Kaur T, Singh K, Jindal SK, Walia SS, Talwar D. Effect of mulch application and different dates of transplanting under low tunnel on growth, yield and economics of chilli (*Capsicum annuum* L.). Indian J Ext Educ. 2018;54(2):201–10.

31. Acikgoz FE. Determination of yield and some plant characteristics with vitamin C, protein and mineral material content in mibuna (*Brassica rapa* nipposinica) and mizuna (*Brassica rapa* var japonica) grown in fall and spring sowing time. J Tekirdag Agr Fac. 2012;9:64–70.

32. Ibarra-Jiménez L, Munguía-López J, Lozano-del Río AJ, Zermeño-González A. Effect of plastic mulch and row covers on photosynthesis and yield of watermelon. Australian J Exp Agric. 2005;45(12):1653–57. http://doi.org/10.1071/EA04140

33. Adamović B, Paroški D, VojNovemberić D, Ilin Ž. The effect of mulching and low tunnel on the yield, yield components and quality of watermelon. Acta Hortic. 2021;1320:101–108. https://doi.org/10.17660/ActaHortic.2021.1320.13

34. Helaly AA. Effect of polyethylene mulching type on the growth, yield and fruits quality of *Physalis pubescens*. Adv Plants Agric Res. 2017;6 (5). http://doi.org/10.15406/apar.2017.06.00229

35. Singh B, Sirohi NPS, Neubauer E, Chin A. Off-season production of muskmelon under plastic low tunnels. Indian Hortic. 2001;46:15–17.

36. Rani R, Meena SR, Choudhary BR, Jatav MK, Saroj PL, Meena A. Off-season vegetable cultivation under low tunnel technology in Bikaner district of Rajasthan: An economic analysis. Veg Sci. 2022;49 (2):190–96.

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