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Performance of Row Cover with Mulch on Early Sowing of Watermelon in Semi-Arid Region

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Abstract

The experiment was conducted during the months of January to March in the year 2023 at Department of Renewable Energy Engineering, Junagadh Agricultural University, Junagadh (Gujarat). A field experiment was conducted to assess the performance of mulch and row covers in early watermelon cultivation with the primary aim on strategically removing row covers days after sowing. Randomized Block Design was employed with featuring of three treatments (mulching without row cover, mulching with row cover for 30 days and mulching with row cover for 45 days). Various yield and yield attribute parameters were recorded and analysed. The research findings indicated that the removal of row covers 30 days after sowing significantly influenced main vine length (2.72 m), number of nodes per main vine (36.40), number of fruits plant^{-1} (2.53), yield plant^{-1} (4.21 kg) and yield ha^{-1} (62.32 t ha^{-1}). Removal of row covers 30 days after sowing exhibited higher net returns (₹ 4, 85, 419 ha^{-1}) and higher benefit-cost ratio (4.52). Removal of row cover 45 days after sowing significantly reduced the watermelon yield. The results unveiled that mulching with a row cover aster 30 days of sowing is the optimal approach for increasing watermelon yield and net returns in early watermelon cultivation.

Keywords: Cost economics, early cultivation, mulch, row cover, watermelon

1. Introduction

Water is a critical resource that sustains life, drives economic growth and contributes to overall well-being (Morris, 2019). Groundwater contributes 50 to 80% of all domestic water use and 45 to 50% of all irrigation in India (Roy et al., 2022). Nonetheless, mounting pressure due to population expansion and the requirement for increased food production strains the water resource system. Water scarcity is the main concerns in semi-arid region where uncertain rainfall and over exploitation water are prominent. The adoption micro irrigation with mulch (Satasiya et al., 2022) system might mitigate the water scarcity in agricultural crop production. Drip irrigation providing precise water supply directly to the root zone which is more efficient than conventional method (Bhasker et al., 2018, Wang et al., 2022). It enhances yield, quality, water and fertigation use efficiency especially for high-value crops like watermelon (Nisha et al., 2020). Drip irrigation improved water savings, reduced labour, less weed and pest infestation and shortened growth cycles (Zhang et al., 2022).

Mulching has become an important practice in modern field production due to benefits such as increase in soil temperature (Shilpa et al., 2022, Prajapati and Subbaiah 2019), reduced weed pressure (Mzabri et al., 2021), moisture conservation (Prajapati and Subbaiah 2018, Satasiya et al., 2022), reduction of certain insect pests (Patil et al., 2013), reducer soil erosion (Prosdocimi et al., 2016), higher crop yields (Satasiya et al., 2022, Prajapati and Subbaiah, 2015) and more efficient use of soil nutrients (Franquera, 2015).

Row covers act as mini-greenhouses, protecting plants from cold waves and pests (Skidmore et al., 2019; Lopez-Martínez et al., 2021). Row cover protects the external condition of environment like frost, snowfall, high wind velocity, thrust of winter wave, reduces erosive energy of soil, reduces the pest and insect attack, enhance plant growth and development by modifying air temperature, soil temperature, humidity and light around the covered plants (Ruíz-Machuca et al., 2015; Goldwater et al., 2016; Lopez-Martínez et al., 2021; Ubelhor et al., 2014). Row covers combined with mulch improve crop performance, yield and protection against adverse conditions (Kosterna, 2014; (Ruíz-Machuca et al., 2015). Xian and Zili (2016) established optimal drip irrigation schedules for watermelon in plastic sheds and determining distinct water supply conditions at various growth stages which offering valuable insights for precision watermelon cultivation management.

Watermelon cultivation in the Saurashtra region of Gujarat state has become increasingly profitable. However, early sowing to capitalize on better prices exposes plants to cold waves and pest attacks, affecting crop parameters and yield. Microclimatic conditions surrounding the plants during early sowing significantly influence watermelon crop yield (Satasiya et al., 2024). To mitigate these challenges, adopting drip irrigation alongside mulch and row cover proves beneficial. Research by Ruíz-Machuca et al. (2015) underscores the advantages of mulch and row cover, enhancing soil temperature, growth, nutrient status, and yield, particularly in potatoes. While row covers shield plants from adverse weather and pests, they inadvertently obstruct vital pollinator-flowering interactions. Thus, strategic removal of row covers becomes essential to facilitate pollination, ensuring successful fruit establishment and optimal yields. This approach enhances pollination efficiency, fostering fruitful development and yield progression. By selectively removing row covers during peak pollinator activity, a balanced management approach is achieved, harmonizing protection and pollination goals. Consequently, row covers were systematically removed after 30 and 45 days from emergence to optimize pollination and enhance watermelon yield. Thus, this study focuses on evaluating the impact of row covers and their removal schedule on yield, yield attributes, and economic aspects of early watermelon cultivation.

2. Materials and Methods

2.1. Location and climate

The experiment was conducted during January to March in the year 2023 at Greenhouse complex, Department of Renewable Energy Engineering, College of Agricultural Engineering and Technology, Junagadh Agricultural University, Junagadh located at 21.5°N latitude and 70.1°E longitude with an altitude of 179 meter above mean sea level. The study area is having typically subtropical and semi-arid climate, characterized by fairly cold and dry winter, hot and dry summer and warm and moderately humid during monsoon. May is the hottest months of summer. The last 35 years weather data recorded at the JAU observatory located near to the experimental site showed that the variation in the weekly mean of daily maximum temperature, minimum temperature, relative humidity, wind speed, bright sun shine hours and pan evaporation were from 29.5°C to 39.4°C, 10°C to 26.7°C, 51% to 81%, 10.1 km h^{-1}, 4.2 to 13.4 h. and 3.6 to 10.7 mm, respectively. The average annual rainfall and evaporation is 950 mm and 2482 mm respectively.

2.2. Physiochemical properties of the soil

The texture of the soil are clay and slightly alkaline in nature. The physical properties of the experiment plot like field capacity, specific gravity and dry bulk density are 23.77% 2.5 g cm^{-3} g cc^{-1} and 1.51 g cm^{-3} respectively. The chemical properties of soil are determined and observed 0.55% in organic carbon, 8.1 in pH, medium in available of nitrogen (256 kg ha^{-1}) and phosphorous (30 kg ha^{-1}) and rich in potash (290 kg ha^{-1}).

2.3. Field preparation and layout

The entire field underwent ploughing and harrowing to facilitate deeper rooting, reaching a depth of 15 cm to enhance moisture penetration. The silver black plastic mulch was laid out prior to sowing of watermelon seeds. Silver black polyethylene mulch conservs soil moisture, enhances growth, yield and quality, suppressed weed suppression, regulating soil temperature and also offering economic benefits with the highest cost-benefit ratio as compared to control and other mulching materials (Parmar et al., 2013; Rao et al., 2016; Nithisha and Desta, 2022; Zhang et al., 2022). The experiment consisted of three primary treatments: Mulch without row cover (T_1), Mulch with row cover for 30 days (T_2), and Mulch with row cover for 45 days (T_3) and each treatment was replicated five times. The experiment was organized using a Simple Randomized Block Design. Plot dimensions were set at 1.5×4.0 m^2, forming beds with top widths, bottom widths and heights of 0.60 m, 0.75 m and 0.15 m, respectively. The beds were spaced 1.5 m apart and the crop was sown in 0.5×0.2 m^2 (PP×RR) configurations with two rows per bed. The watermelon variety used was Max F_1 Hybrid (BASF) which was sown after the successful laying of mulch and drip lines facilitated by a mulch laying machine.

2.4. Irrigation and fertigation

The experimental field received irrigation through a drip irrigation system employing a drip line with specifications of 16 mm×2.0 lph×0.40 m, accompanied by appropriately designed head and field units. The Modified Penman-Monteinth FAO 56 method, known for its high efficiency and widespread adoption was employed to ascertain the reference evapotranspiration (Allen et al., 1998). The calculation of the actual irrigation requirement involved multiplying the reference evapotranspiration by the crop coefficient. Fertigation along with drip irrigation significantly impacted watermelon yield (Nisha et al., 2020; Wang et al., 2022). The prescribed dosage of Farm Yard Manure (FYM) at 10 tonsha^{-1} along with fertilizers N_2O:100 kg ha^{-1}, P_2O_5:50 kg ha^{-1} and K_2O:50 kg ha^{-1} was applied. Prior to watermelon seed planting, half of the N and the entirety of P and K were applied as a basal dose. The remaining N was split and applied in equal amounts during the fourth and sixth weeks following planting.

2.5. Covering of row cover

Non-woven crop protection fabric (1.6 m×800 m×17 GSM) of white colour was utilized to cover the crops. In recent times, covers placed over low tunnel hoops or low pipe-framed structures have gained popularity. Consequently, the row cover was manually laid directly onto the beds following the installation of a plastic stick. For this purpose, a plastic stick with a diameter of 5 mm and a length of 6 feet was employed. This plastic stick is crafted from a non-metallic material that is twice as strong as steel yet 75% lighter. It ensures a smooth surface that doesn't damage the covering material and remains perfectly straight and allowing for convenient storage. Moreover, it facilitates easy adjustments to the tunnel's height and width.

2.6. Removal of row cover

The timing of removal of row cover in watermelon can vary depending on various factors such as climate, variety of watermelon and local growing conditions (Vyas et al., 2014). During the flowering and fruiting stages of watermelon, proper air circulation and pollination are essential. If the row cover is not removed before these stages, it directly affects the yield of watermelon, despite the favourable crop parameters observed under the row cover. Therefore, row cover was removed after and 30 and 45 days after sowing to establishment of general guideline to get rid of row cover from the watermelon crop.

2.7. Crop harvesting and observation of crop parameter

Watermelon was harvested after 65 days of sowing depending on the variety and climatic condition. The crop parameters *i.e.* main vine length, number of nodes per main vine length, number of fruit per plant, yield per plant and yield per ha were recorded at the time of harvesting. Watermelon is ready to harvest when vine tendrils was begin to turn brown and die off.

2.8. Economics

Total cost of cultivation was calculated by the summation of seasonal fixed cost, common cost of cultivation, variable cost of cultivation. The seasonal fixed cost of cultivation includes the drip irrigation system, mulch and row cover. The cost of drip irrigation system was estimated considering one hectare square field. The rate of components and tax was considered as per price fixed by GGRC (Gujarat Green Revolution Company), Vadodara, Gujarat for the year 2022. The fixed cost of drip irrigation system was calculated considering the 10 years life of system serving for three seasons. System serving for season and 9% rate of interest.

cost=p{1/1-(i+1)-n)}

Where,

P=Cost of drip irrigation/ha,

i=interest rate (i.e. 9%),

n=life of the drip (10 years)

The common cost of cultivation includes the irrigation, fertigation, seeds, land preparation and mulch laying. The variable cost of cultivation was included like plant protection and labour cost. The gross return was calculated from the sales of the fruit accruing to the market price of ₹ 10 kg^{-1}. The net return was calculated by deduction of total cost of cultivation from the gross return. The benefit cost ratio of watermelon cultivation was worked out for each treatment by dividing the gross income with total cost of cultivation.

3. Results and Discussion

3.1. Yield and yield attribute

The crop yield and yield attribute parameters were recorded for five randomly selected plants in each replication of the treatments. The average of them was used for statistical analysis. The observed data of the main vine length, number of nodes per main vine length, number of fruit plant^{-1}, yield per plant and yield ha^{-1} are presented in Table 1. The research results revealed that the effect of mulch and row cover for 30 days (*i.e.* T_2) was found significant. The main vine length, number of nodes per main vine length, number of fruit plant^{-1}, yield plant^{-1} and yield ha^{-1} were recorded significantly higher as 2.72 m, 36.40 No./main vine, 2.53 No./plant and 4.21 kg plant^{-1} and 62.32 t ha^{-1} respectively in treatment T_2. Similar results were also in line with results obtained by Kosterna, 2014, Ruíz-Machuca et al., 2015 and Rao et al., 2016 in watermelon crop. Satasiya et al., 2022 and Prajapati and Subbaiah, 2015 also obtained higher yield in summer groundnut and cotton respectively, in drip irrigated mulch treatment.

Table 1: Crop parameters of watermelon at harvest stage

Treatment	Main vine length (m)	No. of nodes plant^{-1} (nos.)	No. of fruit plant^{-1} (nos.)	Yield plant^{-1} (kg.)	Yield (t ha^{-1})
T_1	1.96	28.53	2.00	2.48	37.07
T_2	2.72	36.40	2.53	4.21	62.32
T_3	2.32	27.93	1.13	2.05	32.39
SEm±	0.08	1.15	0.05	0.11	1.87
CD (p=0.05)	0.28	3.74	0.18	0.37	6.08
C.V. %	8.13	8.27	6.44	8.81	9.50

The minimum number of nodes per main vine length, number of fruit per plant, yield plant^{-1} and yield per ha were recorded as 27.93 No./main vine, 1.13 No./plant, 2.05 kg plant^{-1}, 32.39 tha^{-1} respectively in treatment T_3 (*i.e.* mulch with row cover for 45 days). However, the main length was found 1.96 in treatment T_1 (*i.e.* mulch without row cover). The yield attribute parameters were highly significantly influenced by the days of removing of cover.

3.2. Cost of cultivation

The fixed cost of cultivation is calculated as ₹ 33,394 ha^{-1} for treatment T_1 and ₹ 65,062 ha^{-1} for the treatment T_2 and T_3. The common cost of cultivation was ₹ 43,567 ha^{-1} was observed for all treatments. The variable cost of cultivation was found as ₹ 14,510 ha^{-1} for treatment T_1 and ₹ 16,880 ha^{-1} for the treatment T_2 and T_3. The total cost of cultivation was found ₹ 91,471 ha^{-1} in treatment T_1 and ₹ 137811 ha^{-1} for T_2 and T_3. Similar cost of cultivation were obtained for the study of performance of summer groundnut in mulch by Satasiya et al., 2022.

3.3. Gross return and net return

The gross return was found as ₹ 2, 59, 481 ha^{-1}, ₹ 6, 23, 230 ha^{-1} and ₹ 3, 23, 923 ha^{-1} under treatment T_1 (mulching without row cover), T_2 (mulching with row cover for 30 days) and T_3 (mulching with row cover for 45 days) respectively. The highest net return was found as ₹ 4, 85, 419 ha^{-1} under treatment T_2 (mulching with row cover for 30 days) followed by T_3 (₹ 1, 86, 112 ha^{-1}) and T_1 (₹ 1, 68, 010 ha^{-1}). The highest net return was also observed with plastic mulch in watermelon cultivation by Rao et al., 2016 which is in line with the present study.

3.4. Benefit cost ratio

The benefit cost ratio (BCR) of watermelon cultivation is calculated as 4.52, 2.84 and 2.31 for the treatment T_2 (mulching with row cover 30 days), T_1 (mulching without row cover) and T_3 (mulching with row cover 45 days), respectively. These data were accord with study carried out by Parmar et al. (2013) that mulching with row cover for 30 days resulted in the highest net return and found to be more economical with highest cost:benefit ratio.

Table 2: Cost economics of watermelon cultivation (₹ ha^{-1})

Particular	Mulching without row cover (T_1)	Mulching with row cover 30 days (T_2)	Mulching with row cover 45 days (T_3)
Seasonal drip cost	7186	7186	7186
Seasonal mulching cost	26208	26208	26208
Row cover cost	0	31668	31668
Fixed cost of cultivation	33394	65062	65062
Irrigation cost	1480	1480	1480
Fertigation cost	7862	7862	7862
Seedling cost	25500	25500	25500
Bed formation and Mulch laying cost	4900	4900	4900
Land Preparation cost (Harrowing+ Rotavator)	3825	3825	3825
Common cost of cultivation	43567	43567	43567
Plant protection	3660	1830	1830
labor cost	10850	15050	15050
Variable cost of cultivation	14510	16880	16880
Total cost of cultivation	91471	137811	137811
Gross return	259481	623230	323923
Net return	168010	485419	186112
BCR	2.84	4.52	2.35

4. Conclusion

The yield and yield attribute parameters were observed higher in mulching for 30 days removal of row cover. Gross return and net return was found higher in mulching with 30 days after removal of row cover whereas it was found minimum in mulching without row cover. The maximum benefit cost ratio was obtained under mulching with removing of row cover after 30 days. However, it was found minimum 45 days after removal of row cover.

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