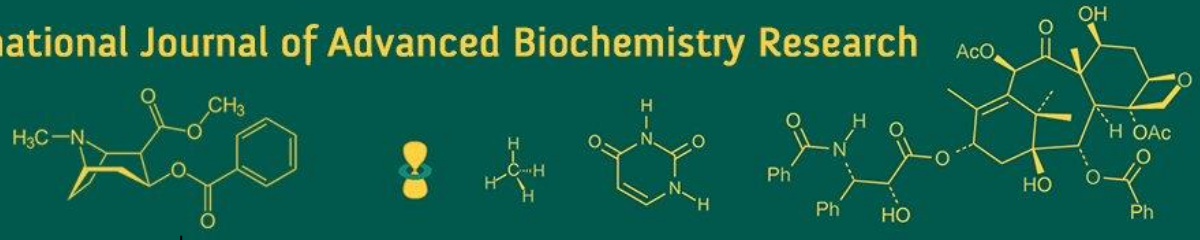
International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; 8(8): 827-830
www.biochemjournal.com
Received: 03-05-2024
Accepted: 08-06-2024

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Impact of mulching and fruit thinning practices on the economic viability of watermelon

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DOI: https://doi.org/10.33545/26174693.2024.v8.i8k.1872

Abstract
Watermelon is economically important vegetable crops for farmer during summer season. Mulching and fruit thinning help to increase yield of watermelon which ultimately help to increase farmers' incomes. An experiment was carried out at Polytechnic in Horticulture, ASPEE College of Horticulture, Navsari Agricultural University, Paria, Valsad, Gujarat (India) during the summer seasons of 2022 and 2023. The experiment was laid out in Randomized Block Design with factorial concept (FRBD), which comprising four mulching treatments namely, M_1: black polyethylene mulch (50 µ), M_2: silver-black polyethylene mulch (50 µ), M_3: white plastic mulch (50 µ) and M_4: control (without mulch) with three fruit thinning treatments namely, F_1: maintaining two fruits per vine, F_2: maintaining three fruits per vine and F_3: maintaining four fruits per vine. All the twelve treatment combinations repeated thrice. The maximum net realization (840108 ₹ ha^{-1}) and BCR (3.41) were recorded in silver-black polyethylene mulch @ 50 µ with maintaining three fruits per vine (M_2F_2).

Keywords: Mulching, thinning, economics, viability and watermelon

1. Introduction
In India, the agricultural sector plays a crucial role in the country's economy with contributing 18.3% to the GDP in the fiscal year of 2022-23. Approximately seventy percent of the rural population in India is directly or indirectly reliant on agriculture for their livelihoods. Horticulture represents a significant aspect of Indian agriculture with the cultivation of horticultural crops expanding steadily over the years. Among the various horticultural crops, vegetable crops have shown a substantial growth with consistently accounting for a large proportion (59-61%) of the horticultural output in the past five years. The production of vegetable crops has notably increased from 101.2 million tonnes to 184.40 million tonnes between the periods of 2004-05 and 2017-18. This growth is aligned with an increase in the cultivated area, which stood at 10,259,000 hectares. The total production reached 184,394,000 metric tonnes with reflecting an average productivity of 17.97 tonnes per hectare during this period (Chaudhari *et al*., 2023) [1].

The botanical name of watermelon is *Citrullus lanatus* L. (2n = 22), it is recognized by various common names in different parts of country *viz*., *Tarbuj*, *Kalingad*, *Kalindi*, *Matira*, *Kaniphal*, *Manthan*, *Thannir* and *Palampanna*. Botanically fruit is pepo. It contains about 6% sugar and 92% water by weight. Like many other fruits, it is a source of Vitamin C. The composition of watermelon per 100 g edible portion at maturity includes: water 91.5 g, energy 134 kj (32 kcal), protein 0.6 g, fat 0.4 g, carbohydrate 7.2 g, calcium 8 mg, phosphorous 9 mg, iron 0.17 mg, thiamine 0.08 mg, riboflavin 0.02 mg, niacin 0.2 mg, folate 2 mg and ascorbic acid 9.6 mg. China is the leading producer followed by Turkey. Spain is a leading exporter followed by Mexico and United States. But United States is the leading for importing followed by Germany and Canada. India ranks 25th in production and grow on area of 110 thousand hectares with an overall production of 2787 thousand MT along with 25.34 t ha^{-1} productivity. Watermelon is commercially grown in India in subtropical as well as tropical states. Uttar Pradesh, Andhra Pradesh and Karnataka are leading states in production (Anon., 2022) [2].

Now a days, water scarcity and weeds are the major problems in the cultivation of vegetable crops. Availability of water is the most common limiting factor for the growth of most of

crops, especially in arid and semi-arid regions. Weeds reduce the yield of the main crop and increasing the cost of cultivation. Mulching is one of the important cultivation practices, which provides the opportunity to control the weeds, conserve the soil moisture as well as increasing the crop yield and income of the farmers (Rao *et al.*, 2017) [3].

Fruit thinning is a crucial practice in watermelon cultivation. This process involves removing extra fruits from the vine to promote healthy growth and improve overall fruit quality. The significance of fruit thinning can not be overstated, as directly affects the yield and market value of watermelon. One of the main reasons for fruit thinning is to allow the remaining fruits to reach their full potential. By removing extra fruits, plant can allocate its resources more efficiently which ensuring that each remaining fruit receives an adequate supply of nutrients and water. This promotes optimal growth and development resulting in big, sweet and juicy fruits. Fruit thinning helps prevent overcrowding on the vine. When watermelon fruits are too close together, they can rub against each other which causing damage and increasing the risk of disease. By thinning the fruits, growers can create more space between them it reducing the likelihood of physical damage and improving air circulation around the plant. It minimizes the risk of fungal infections and other diseases that thrive in humid environments. Watermelon grow in clusters may ripen at different rates which resulting in inconsistent quality and taste. By thinning the fruits, growers can ensure that the remaining ones ripen evenly which enhancing the overall market value of the crop (Da Silva *et al.*, 2019) [4].

2. Materials and Methods

2.1 Experimental site and weather Data

The present investigation was carried out during summer season 2022 and 2023 at Polytechnic in Horticulture, ASPEE College of Horticulture, Navsari Agricultural University, Village: Paria, Taluka: Pardi, District: Valsad. Geographically, Polytechnic in Horticulture, ASPEE College of Horticulture, Paria comes under the tropical climatic zone and agro climatic zone of South Gujarat Heavy Rainfall Zone-I and Agro Ecological Situation-II. The monsoon commences from the second week of June and lasts up to the first week of October and confines mostly to the South-West monsoon. The average annual rainfall ranges between 1500 to 2000 mm and relative humidity of 75 to 97% during the monsoon. The winter sets in usually by the end of October. The temperature starts decline from the middle of November. The December and January months are coldest in the year. Usually the summer season commences during the middle of February and the temperature reaches to maximum in April and May, hence these two months are the hottest. Owing to its vicinity to Arabian Sea, the climate of this place remains humid throughout the year.

2.2 Treatment Details

Factor 1: Mulching (M)	Factor 2: Fruit thinning (F)
M_1: Black polyethylene mulch (50 µ) M_2: Silver-black polyethylene mulch (50 µ) M_3: White plastic mulch (50 µ) M_4: Control (without mulch)	F_1: Maintaining two fruits per vine F_2:Maintaining three fruits per vine F_3: Maintaining four fruits per vine

Treatment Combinations

M_1F_1	:	Black polyethylene mulch (50 µ) and Maintaining two fruits per vine
M_1F_2	:	Black polyethylene mulch (50 µ) and Maintaining three fruits per vine
M_1F_3	:	Black polyethylene mulch (50 µ) and Maintaining four fruits per vine
M_2F_1	:	Silver-black polyethylene mulch (50 µ) and Maintaining two fruits per vine
M_2F_2	:	Silver-black polyethylene mulch (50 µ) and Maintaining three fruits per vine
M_2F_3	:	Silver-black polyethylene mulch (50 µ) and Maintaining four fruits per vine
M_3F_1	:	White plastic mulch (50 µ) and Maintaining two fruits per vine
M_3F_2	:	White plastic mulch (50 µ) and Maintaining three fruits per vine
M_3F_3	:	White plastic mulch (50 µ) and Maintaining four fruits per vine
M_4F_1	:	Control (without mulch) and Maintaining two fruits per vine
M_4F_2	:	Control (without mulch) and Maintaining three fruits per vine
M_4F_3	:	Control (without mulch) and Maintaining four fruits per vine

2.3 Methodology of applications

Plastic mulches were applied before seed sowing which covered 66.67% area. Fruit thinning operations were carried out when the fruits were at their initial stage as per treatment details. Maintain three side shoot per vine

2.4 Calculation of Cost for Cultivation

Calculation of cost of cultivation include Cost A, Cost B, Cost C, Gross return, Net return and Benefit Cost Ration. Cost of cultivation was calculated by the formula which given below (Raju and Rao). Detail of cost of fixed cost, Variable cost and economics of watermelon productions as affected by mulching and fruit thinning was given in table 1, 2 and 3, respectively.

Cost A: It is sum of fixed cost and variable cost

Cost B: It obtained by Gross return divided by 16

Cost C: Sum of Cost A and Cost B is called as Cost C

Gross return: Total curd yield multiplied by price of 1kg curd (here, price of 1kg fruit is Rs. 10)

Net return: Gross return – Cost C

BCR = (Net income)/(Cost C)

3. Results and Discussion

Cost of production of watermelon variety Sugar Queen distinctly influence by mulching and fruit thinning. Economics was calculated by Cost A, Cost B, Cost C along with Gross income, Net income and BCR, which was illustrated in Table 1. Cost of cultivation had been worked out as per prevailing market prices and details are

demonstrated in Table 2 and Table 2. Data present in Table 1 indicated that the treatment combination of M_2F_2 treatment combination (silver-black polyethylene mulch @ 50 µ and maintaining three fruits per vine) had maximum net income (₹ 8,40,108) along with higher BCR (3.41) per hectare. On other hand, treatment combination of M_4F_1 (control and maintaining two fruits per vine) noted lower net income (₹ 5,30,563), while the M_4F_2 treatment combination (control and maintaining three fruits per vine) examined minimum BCR (2.53).

Result regarding economics was might be due to M_4F_1 had the lowest total cost due to absent of mulching. But on other hand the yield in M_4F_1 was lowest as compare to other treatment combinations which leads to low net income as compare to the other treatment combinations. Where in treatment combinations of M_4F_1 total cost was maximum among the other treatments due to application of mulching but yield of fruit was maximum as compare to the other treatment combinations which ultimately increase the net income as well as BCR. Although, plant of silver-black polyethylene mulch (50 µ) and maintaining three fruits per vine gave the higher yield as compare to other treatment combinations. The results might be due to, silver-black mulch recorded the highest plant height, number of leaves and leaf length resulting in higher photosynthetic rate which leads to more synthesis and translocation of photosynthates toward the fruit formation and with three fruits per vine, there is an optimal balance between resource allocation and fruit load. This allows the plant to efficiently distribute nutrients and water among the fruits which promoting their growth and development. On the other hand, maintaining two fruits per vine may lead to larger individual fruit sizes but could potentially limit the overall yield due to a lower fruit count. Similarly, maintaining four fruits per vine may increase the fruit load which possibly straining the plant's resources and impacting the overall yield negatively which may help in increasing watermelon yield there by increased the productivity and ultimately increase the net income as wall as BCR of watermelon production (Sibale *et al.*, 2015) [5]. The findings presented above are in agreement with the results obtained by Parmar *et al.* (2013) [6] in watermelon, More *et al.* (2014) [7] in tomato, Luis *et al.* (2008) [8] in cucumber and Ekwu *et al.* (2010) [9] in okra.

Table 1: Economics of watermelon production (₹ ha^{-1}) as affected by mulching and fruit thinning

Treatment Combinations	Yield (kg ha^{-1})	Fixed cost (₹ ha^{-1})	Variable cost (₹ ha^{-1})	Cost A	Cost B	Cost C	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	BCR
1	2	3	4	5	6	7	8	9	10
M_1F_1	78530	1,13,774	52,773	1,66,547	49,081	2,15,628	7,85,300	5,69,672	2.64
M_1F_2	102840	1,13,774	59,224	1,72,998	64,275	2,37,273	10,28,400	7,91,127	3.33
M_1F_3	92030	1,13,774	62,163	1,75,937	57,519	2,33,456	9,20,300	6,86,844	2.94
M_2F_1	80510	1,13,774	57,971	1,71,745	50,319	2,22,064	8,05,100	5,83,036	2.63
M_2F_2	108660	1,13,774	64,806	1,78,580	67,913	2,46,493	10,86,600	8,40,108	3.41
M_2F_3	101860	1,13,774	68,146	1,81,920	63,663	2,45,583	10,18,600	7,73,018	3.15
M_3F_1	76320	1,13,774	48,052	1,61,826	47,700	2,09,526	7,63,200	5,53,674	2.64
M_3F_2	82130	1,13,774	52,653	1,66,427	51,331	2,17,758	8,21,300	6,03,542	2.77
M_3F_3	81940	1,13,774	56,654	1,70,428	51,213	2,21,641	8,19,400	5,97,760	2.70
M_4F_1	73660	1,13,774	46,226	1,60,000	46,038	2,06,038	7,36,600	5,30,563	2.58
M_4F_2	74330	1,13,774	50,313	1,64,087	46,456	2,10,543	7,43,300	5,32,757	2.53
M_4F_3	81880	1,13,774	55,088	1,68,862	51,175	2,20,037	818800	5,98,763	2.72

Table 2: Details of cost of inputs (fixed cost)

Description	Rate	Cost (₹)
1. Preparatory tillage		
i) Ploughing by tractor with rotavater plough (8 hr.)	@ ₹ 500/hr.	4,000
ii) Ploughing by tractor with cultivator (8 hr.)	@ ₹ 600/ hr.	4,800
iii) Ploughing by tractor with M. B. plough (8 hr.)	@ ₹ 600/ hr.	4,800
Total		13,600
2. Manures		
i) FYM @ 20 ton/ha	@ ₹ 800/ton	16,000
ii) Expenditure on manure application	@ ₹ 200/ton of FYM	4,000
iii) Urea @ 100 kg ha^{-1}	@ ₹ 5.92 per kg	592
iv) SSP @ 50 kg ha^{-1}	@ ₹ 8.80 per kg	440
v) MOP @ 50 kg ha^{-1}	@ ₹ 34 per kg	1,700
Total		22, 732
3. Layout and Seed Sowing		
i) Layout, preparation of beds, making furrows and earthing up (6 labours for two days)	@ ₹ 268/labour/day	3,216
ii) Seed require (3.5 kg)	@ ₹ 395 per 50 g	27,650
iii) Sowing of seeds (35 labours for one day)	@ ₹ 268/labour/day	9,380
iv) Gap filling (5 labours for one day)	@ ₹ 268/labour/day	1,340
Total		41,586
5. Irrigation application		
i) Installation of drip system (20 labours for one day)	@ ₹ 268/labour/day	5,360
ii) Cost of drip system (₹ 75,000 per ha and longevity is about 10 years)	@ ₹ 7,500 per year	7,500
iii) Irrigation-12 (@ 20 hours for one ha.)	@ ₹ 40/hours	9,600
Total		22,460
6. Plant protection		
i) Labour for spraying (2 men for spray)	@ ₹ 268/labour/day	4,288

ii) Chlorpyrifos (@ 2 lit/ha) 1 spray	@ ₹ 475/lit	950
iii) Thiamethoxam (@ 400 ml/ha) 3 spray	@ ₹ 895/lit	1,074
iv) Imidacloprid (@ 300 ml/ha) 2 spray	@ ₹ 1340/lit	804
v) Profenofos (@ 1 lit/ha) 2 spray	@ ₹ 460/lit	920
Total		8,036
7. Harvesting		
ii) Uprooting the plants (20 labours for one day)	@ ₹ 268/labour/day	5,360
Total		5,360
Grand total		1,13,774

Table 3: Details of operational cost (variable cost)

Treatments	Cost of Mulching (₹ per ha)	Application Cost of Mulching (₹ per ha)	Cost of Fruit Thinning (₹ per ha)	Cost of Weeding (₹ per ha)	Transportation Cost @ ₹ 10/100 kg	Harvesting Cost (₹ per ha)	Treatment Cost (₹ per ha)
M_1F_1	27,500.00	2,680.00	6,700.00	0.00	7,853.00	8,040.00	52,773.00
M_1F_2	27,500.00	2,680.00	6,700.00	0.00	10,284.00	12,060.00	59,224.00
M_1F_3	27,500.00	2,680.00	6,700.00	0.00	9,203.00	16,080.00	62,163.00
M_2F_1	32,500.00	2,680.00	6,700.00	0.00	8,051.00	8,040.00	57,971.00
M_2F_2	32,500.00	2,680.00	6,700.00	0.00	10,866.00	12,060.00	64,806.00
M_2F_3	32,500.00	2,680.00	6,700.00	0.00	10,186.00	16,080.00	68,146.00
M_3F_1	23,000.00	2,680.00	6,700.00	0.00	7,632.00	8,040.00	48,052.00
M_3F_2	23,000.00	2,680.00	6,700.00	0.00	8,213.00	12,060.00	52,653.00
M_3F_3	23,000.00	2,680.00	6,700.00	0.00	8,194.00	16,080.00	56,654.00
M_4F_1	0.00	0.00	6,700.00	24,120.00	7,366.00	8,040.00	46,226.00
M_4F_2	0.00	0.00	6,700.00	24,120.00	7,433.00	12,060.00	50,313.00
M_4F_3	0.00	0.00	6,700.00	24,120.00	8,188.00	16,080.00	55,088.00

Mulch price
1. Black polyethylene mulch = 2750 ₹ per 1000 m^2.
2. Silver-black polyethylene mulch = 3250 ₹ per 1000 m^2.
3. White plastic mulch = 2300 ₹ per 1000 m^2.

Cost of labour = 268 day^{-1}
Labours required for mulch application = 10
Labours required for fruit thinning = 25
Labours required for weeding = 30 for 1 time (3 weeding)
Labour required for harvesting
F_1 treatment = 15 labours for 2 time
F_2 treatment = 15 labours for 3 time
F_3 treatment = 15 labours for 4 time

4. Conclusion
The results of present study inferred that watermelon crop mulch with silver-black polyethylene mulch @ 50 µ (with 66.67% area coverage) and maintaining three fruits per vine were recorded maximum net realization (840108 ₹ ha^{-1}) and BCR (3.41). The control and maintaining two fruits per vine noted lower net income (₹ 5,30,563), while the control and maintaining three fruits per vine examined minimum BCR (2.53).

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