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Economics of watermelon production under different water-saving technologies in Kalyana Karnataka Region

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Abstract

This study investigates the economic analysis of watermelon production by using water saving technologies in Kalyana-Karnataka region. Where, Koppal, Raichur and Bidar districts were selected purposively based on highest area and production under watermelon. A sample of 90 watermelon farmers were selected who have practiced drip, mulching and flood technology were selected for primary data. Tabular analysis and functional analysis were employed for analysis of data. Cost of cultivation for watermelon production under drip (Rs. 43,489.90) was higher compared to watermelon production under mulching and flood irrigation method (Rs. 37430.60 Rs.) and (Rs. 28569.67). Similarly, the yield and gross returns were higher for watermelon production under drip method (10.25 tonnes/acre, Rs. 79437.50) than in watermelon production under mulching (8.81 tonnes/acre, Rs. 60935.80) in flood method (7 tonnes/acre, Rs.38500.00). Net returns were higher for drip method (Rs. 35947.91) compared to mulching (Rs. 23505.20) and flood method (Rs. 9930.33) due to difference in the selling price. Cultivation of watermelon under drip was found to be profitable when compared to mulching and flood method as supported by a magnitude of B: C ratio of 1.82, 1.62 and 1.37, respectively. Output per acre-inch of water was more in drip (2.62 tonnes) as compared to mulching and flood (1.79 and 0.97 tonnes), respectively.

Keywords: Drip, mulching, flood, resources, efficiency.

Introduction

Watermelon: (*Citrullus Lanatus*) is a native of tropical Africa, where it was used by the feral tribes for many years. Watermelon originated in the Kalahari Desert, South Africa, where it was widely cultivated before spreading too many countries around the world. It was also known in China, India and the Arab countries from 1500 B.C. In the 16th century, it also started to be cultivated in Europe, from where the colonists took it to America. According to FAO (2022) statistics, world's largest producers of watermelon are China (80 million tonnes) Turkey, Iran, Brazil, and Uzbekistan remain key contributors, though their production levels are each under 4 million tonnes.

In India, the watermelon area in 2022 was 1,08,000 hectares, with total production around 2.92 million tonnes. Uttar Pradesh (620,000 tonnes), Andhra Pradesh (360,000 tonnes), Karnataka (337,000 tonnes), Tamil Nadu (216.25 MT), Odisha (226.98 MT), West Bengal (234.30 MT), Madhya Pradesh (234.30 MT) (Anonymous, 2022c) [5] were the leading states in the production of water melon (215.34 MT). In Karnataka state, watermelon occupies an area of 6671 hectares. Koppal district is the leading watermelon producing district, where the area under watermelon is 992 hectares, followed by the Chamarajnagar (945 ha) and Belagavi (867 ha) (Anonymous, 2022a) [3]. Karnataka ranked 1st with a horticultural area of 23.25 lakh hectares, contributing 9.08 per cent to the country's total horticultural area. With 183.46 lakh MT of production, the state is 8th in position, contributing 5.93 per cent to the country's overall production of horticultural crops (Anonymous, 2022b) [4].

Watermelon cultivation is highly sensitive, over irrigated field leads to nutrients leaching, grows competition of weeds and water-stressed field leads to not growing a healthy crop which may lead to a loss for farmers which is normally input-intensive crop and groundwater table also going down in the study area which may lead to loss of area under cultivation. By conducting this study we can show cultivators the feasibility of water-saving technology along with sustainable use of water and increasing profitability of crops in the area and encouraging farmers to adopt water-saving technology in their field. Nowadays, a lot of emphasis has been given for the adoption of micro irrigation systems to fruits, vegetables, oilseeds and other commercial crops. In order to increase the productivity and production of watermelon with efficient water use, there is a need to have information about irrigation scheduling, water requirement and water saving due to drip and mulching in watermelon. The economic analysis of water-saving technologies in watermelon production demonstrates significant long-term benefits. Technologies such as drip irrigation, mulching, soil moisture sensors and rainwater harvesting reduce water usage and enhance yields. Drip irrigation, though initially costly, offers substantial water savings and a 20-30 per cent yield increase, with a payback period of 2-3 years.

Methodology

Sampling procedure and Selection of the districts

The three districts *viz.* Koppal, Raichur and Bidar districts of Kalyana Karnataka were purposively selected as these districts majorly grow watermelon in Rabi. Hence these districts are selected for the study area. Two taluks from each district were selected based on watermelon production. Multistage purposive random sampling technique was adopted. The second stage comprised of selection of taluks from Koppal, Raichur and Bidar district in Kalyana-Karnataka. In this stage, out of four taluks of Koppal district, two taluks namely Yalburga and Koppal were selected and in Raichur district, two taluks namely Lingasugur and Sindhanur were selected for the study. In Bidar district two taluks namely Bhalki and Humnabad were selected because watermelon production was more prevalent and potential in these taluks.

From each taluk five farmers who practiced drip irrigation, five farmers who were following mulching technique and five farmers who adopted flood irrigation method were selected. In all 90 sample farmers were selected for the study and also 30 watermelon traders selected in the study area. The technique of tabular analysis was employed for determining the cultivation cost and returns of watermelon under different technologies. The tables were made separately for operation wise labour requirements, input management, cost of cultivation, marketing management etc. Tabular presentation was adopted to compile the general characteristics of the sample farmers such as input management, labour management, market intermediaries to determine the resource structure, cost structure, returns, profits and opinion regarding the production and marketing. Simple statistical tools like averages and percentages were used to compare, contrast and interpret results properly.

Analytical tools

Production functions analysis

The transformation of inputs into output is described by the production function. The per farm crop production function can be specified as follows.

$$Y = f(X_1, X_2 \ldots\ldots Xn) \ldots\ldots (1)$$

Where, Y is the per farm output of particular crop with given set of inputs $X_1, X_2 \ldots X_n$. In functional analysis it would be essential to choose an appropriate form of production function taking into consideration the data to be analysed. The Cobb-Douglas production function frame work has been widely used in studies on Indian agriculture (Heady and Dillon, 1964). Cobb-Douglas specification is an homogeneous function that provides scale (parameter) factor enabling one to measure the returns to scale and to interpret the elasticity co-efficient with relative ease. But at the same time it makes several restrictive assumptions like constant elasticity co-efficient implying constant shares for the inputs, rate of substitution between the inputs is unitary elastic, production function becomes linear in logarithmic form and output expansion path is assumed to pass through the origin.

The Cobb-Douglas type of production function fitted per farm is specified as below was used for further analysis.

$$Y = a X_1^{b1} X2^{b2} X3^{b3} X4^{b4} X5^{b5} X6^{b6} X7^{b7} X8^{b8} e^{u} \ldots\ldots (2)$$

Where,
Y = Output
a = Intercept
X_1 = Land (acre)
X_2 = Seeds (kg)
X_3 = Farm yard manures (cart load)
X4 = Human labour (man days)
X5 = Bullock labour (pair days)
X6 = Fertilizers (kg)
X7 = Plant protection chemicals (₹)
X8 = Machine labour (Hrs.)
U = Error term
bi's = Regression coefficients of i^{th} input

The Cobb-Douglas type of production function was converted into log linear form and the parameters were estimated using the ordinary least square (OLS) technique.

$$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + b_8 \ln X_8 + U \ldots\ldots (3)$$

The regression co-efficients were tested for their significance using 't' test at choosen level of significance while the function as a whole tested using the 'F' test.

$$t = \frac{X_i}{SE(X_i)} \ldots\ldots (4)$$

Where,
X_i = Regression co – efficient of i^{th} input
SE (X_i) = Standard error of i^{th} input

$$F = \frac{R^2/P}{(1-R^2)/(n-1-P)} \ldots\ldots (5)$$

Where,
R^2 = Co-efficient of multiple determination (unadjusted)
P = Number of parameters in the sample
n = Number of observations in the sample
To test the goodness of fit of the estimated function, the adjusted co-efficient of multiple determination (R^2) was calculated using the formula.

$$R^2 = \frac{\text{Regression sum of squares}}{\text{Total sum of squares}}$$

$$R^2 = \frac{[1-(1-R^2)]}{[(n-1)/(n-P)]} \ldots\ldots (6)$$

Variables in the equation 6 are same as defined in equation 5.

Allocative efficiency

Given the technology, allocative efficiency exists when resources are allocated within the farm according to quantity which implies the proper level of input use in production. To decide whether a particular input is used rationally or

irrationally, its marginal value products would be computed. If the Marginal Value Product (MVP) of an input just covers its acquisition quantity, it is said that is used efficiently.
The MVP was calculated at the geometric mean levels of variables by using the following formula

$$\text{MVP } i^{th} \text{ resource} = b_i \times \frac{\text{GM (Y)}}{\text{GM (X)}}$$

Where,
GM (Y) = Geometric mean of the output
GM (X) = Geometric mean of i^{th} input
b_i = The regression coefficient of the i^{th} input

A ratio of the value of marginal product (MVP) to the factor price (MFC) was compared and if it is more than unity implied that the resources were advantageously employed. If the ratio was less than one, it suggested that the resource was over utilized.

The criterion for determining optimality of resource use

MVP/MFC > 1 underutilization of resources
MVP/MFC = 1 optimal use of resources
MVP/MFC < 1 excess use of resources

Results and Discussion

Cost of cultivation in watermelon production under different water-saving technologies

Material cost

Understanding the resources used, costs, returns, investment patterns and other factors is crucial. In Table 1. We can observe the average per acre total cost of cultivation. The overall cost incurred by watermelon cultivars for cultivation under drip irrigation was Rs. 43489.90 per acre. The total variable cost was 85.40 per cent of the total cost. The distribution pattern of operating costs under different inputs observed that the maximum share of cost was accrued on fertilizer (13.07%), followed by seeds (12.64%), mulching sheet (9.19), drip laterals (8.23%), plant protection chemicals was (7.21%), irrigation charges (3.56%), FYM (2.85%) and herbicides (0.88%). These results align with a previous study Veeresh (2021) [10]. The overall cost incurred by the watermelon cultivars under mulching method was Rs. 37430.60 per acre. The share of total variable cost was 83.18 per cent of the total cost. The distribution pattern of operating costs under different inputs observed that, the maximum share of seeds (14.42%), fertilizer (11.25%), mulching sheet (10.68%), plant safety chemicals was (8.28%), irrigation charges (3.07%), FYM (3.33%) and herbicides (0.79%). In flood method, the total cost incurred by the watermelon cultivars was Rs. 28569.67 per acre. The share of total variable cost was 78.59 per cent of the total cost. The distribution pattern of operating costs under different inputs observed that, the maximum share of seeds (16.45%), fertilizer (14.77%), plant safety chemicals was (9.76%), FYM (4.30%), irrigation charges (2.61%) and herbicides (1.04%).

Labour cost

Watermelon cultivation is a labor-intensive activity, with seed sowing, intercultural activities, chemical fertilizer application and plant protection chemical application requiring the most effort. Intercultural operations often necessitate significantly more work than normal operations. It also observed that a large proportion of the overall cost of cultivation has been incurred on human labour. The expenditure incurred towards the human labour, bullock labour and machine labour used in watermelon production was 18.59, 2.25 and 2.47 per cent of the total cost of cultivation, respectively. In mulching method the expenditure incurred towards the human labour, bullock labour and machine labour used in watermelon production was 21.40, 2.76 and 3.15 per cent, respectively of the total cost of cultivation.
In flood method, the significant operations that require more labour were seed sowing, chemical fertilizer and application of plant protection chemicals. The expenditure incurred towards the human labour and machine labour used in watermelon production was 22.12 and 4.07 per cent of the total cost of cultivation, respectively.

Interest on working capital

By assigning eight per cent interest per year to the total working capital, the variable cost was estimated. The interest on working capital worked out to be Rs. 1915.21 per acre for the production of watermelon, which was 4.40 per cent of the overall cost of cultivation. Under mulching method the interest on working capital worked out to be Rs. 1463.66 per acre for the production of watermelon, which was 3.91 per cent of the overall cost of cultivation. The interest on working capital worked out to be Rs. 981.02 per acre for the production of watermelon under flood irrigation, which was 3.43 per cent of the overall cost of cultivation.
Under drip method, the total variable cost was Rs. 37144.47 per acre. The variable cost was 85.40 per cent of the overall cost of cultivation. The total variable cost was Rs. 31137.66 per acre in the mulching method. Under flood method, the total variable cost was Rs. 22455.52 per acre. The variable cost was 78.59 per cent of the overall cost of cultivation for the study area.

Fixed cost

Depreciation, land revenue, land rental value and interest on fixed capital are all factored into the overall fixed cost. The rental value of the land for one crop was considered to be the standard in the area. The findings demonstrate that, the expenditure incurred on depreciation of farm implements, land revenue, rental value of land and interest on fixed capital contributed for 1.49, 0.57, 11.08 and 1.43 percent of the watermelon production under drip method, respectively. In the mulching method the expenditure incurred on depreciation of farm implements, land revenue, rental value of land and interest on fixed capital contributed for 1.65, 0.74, 12.82 and 1.58 per cent of the watermelon production. In flood method, the expenditure incurred on depreciation of farm implements, land revenue, rental value of land and interest on fixed capital contributed for 2.24, 0.91, 16.10 and 2.14 per cent, respectively of the watermelon production.
For all farmers, land revenue was almost equal, but there was a difference in the rental value of land depending on soil productivity and land quality. The total fixed cost for

producers of watermelon under drip, mulching and flood was Rs. 6345.43, Rs. 6292.94 and 6114.15 representing 14.59, 16.81 and 21.40 per cent, respectively of the total cost of cultivation in the study area per acre.

It is evident from the table that the human labour portion accounts for 18.59 percent and 21.40 per cent of the total cost of cultivation in the watermelon production under drip and mulching method among the various costs incurred in the production. High labour force was required for intercultural activities such as roughing, thinning, weeding, fertilizer application and application of chemicals for plant protection. These findings were in line with Ahmed *et al*. (2017).

Table 1: Cost of cultivation in watermelon production under different water-saving technologies, (Rs. per acre)

SL. No.	Particulars	Drip method		Mulching method		Flood method	
I.	**Variable cost**	**Cost (Rs.)**	**%**	**Cost (Rs.)**	**%**	**Cost (Rs.)**	**%**
A.	**Material cost**						
1	FYM	1240	2.85	1250	3.33	1230	4.30
2	Seed	5500	12.64	5400	14.42	4700	16.45
3	Chemical fertilizers	5685.73	13.07	4214.11	11.25	4220	14.77
4	PPC	3136.76	7.21	3132.35	8.28	2788.67	9.76
5	Herbicides	385.29	0.88	299.36	0.79	304.15	1.04
6	Polythene mulching sheet	4000	9.19	4000	10.68	-	-
7	Drip laterals	3582.35	8.23	-	-	-	-
8	Irrigation charges (Fuel and lubricants)	1552.08	3.56	1150.15	3.07	745.82	2.61
B.	**Labour cost**						
1	Human labour	8088.23	18.59	8012.35	21.40	6320.75	22.12
2	Bullock labour	980.85	2.25	1035.72	2.76	-	-
3	Machine labour	1077.97	2.47	1179.96	3.15	1165.11	4.07
C.	Interest on working capital @ 8%	1915.21	4.40	1463.66	3.91	981.02	3.43
	Total variable cost (A+B+C)	37144.47	85.40	31137.66	83.18	22455.52	78.59
II.	**Fixed costs**						
1	Depreciation	650	1.49	620	1.65	640	2.24
2	Land revenue	250	0.57	280	0.74	260	0.91
3	Rental value of land	4819.85	11.08	4800	12.82	4600	16.10
4	Interest on fixed capital @ 12%	625.58	1.43	592.94	1.58	614.15	2.14
	Total fixed cost	6345.43	14.59	6292.94	16.81	6114.15	21.40
	Total cost (I+II)	43489.90	100.00	37430.60	100.00	28569.67	100.00

Returns realized in watermelon production under different irrigation methods

Drip method

The findings presented in Table 2 on farmers yield and returns showed that the average watermelon fruit yield was 10.25 tonnes per acre in the study area. The selling price of watermelon in drip method was Rs.7750/tonne. Larger and better-quality fruits were sold at a higher market price. The drip-irrigated treatments produced sweeter watermelon than the furrow irrigated ones. Drip irrigation was a suitable alternative in water-scarce situations or where fruit quality was a concern, with total soluble solids (TSS) being a key metric for growers. The results of the study are in line with Kumar (2018) [7] who conducted study on production management of watermelon cultivation.

Gross returns of Rs. 79437.50 per acre and net returns of Rs.35947.60 per acre in the study area were realized by the watermelon production under drip method.

The cost of production per tonne of watermelon was Rs. 4242.91 per acre, with a cost-benefit ratio (return per investment rupee) of 1.82. From the above estimates, the cost and return results demonstrated that the production of watermelon production under the drip method in the study area was profitable with a benefit-cost ratio (return per rupee of investment) of 1.82.

Mulching method

In mulching method yield and returns showed that the average watermelon fruit yield was 8.81 tonnes per acre and the selling price was Rs. 6916.66/tonne. It is slightly less when to compare to drip method.

Gross returns of Rs. 60935.80 per acre and net returns of Rs. 23505.20 per acre in the study area were realized by the watermelon production under mulching method.

The cost of production per tonne of watermelon was Rs. 4248.64 per acre, with a benefit-cost ratio (return per rupee of investment) of 1.62.

Flood method

The average watermelon fruit yield was 7tonnes per acre and the selling price of watermelon under flood method was Rs.5500/tonne. This system used river or canal water as the source of irrigation water, which was filtered with a sand media filter for drip irrigation but left unfiltered for furrow irrigation. The quality of the fruit may be harmed as a result of excessive fertilizer use, making it less tasty and appealing. As a result of the small size and poor quality of the fruit, it was sold at a lower market price and cull fruit was not counted because they were too small or defective.

Gross returns of Rs. 38500 per acre and net returns of Rs. 9930.33 per acre in the study area were realized by the watermelon production under flood method. The cost of production per tonne of watermelon was Rs. 4081.38 per acre, with a cost-benefit cost ratio (return per rupee of investment) of 1.37.

Table 2: Returns realized in watermelon production under different irrigation methods

SL. No.	Particulars	Unit	Methods of irrigation		
			Drip	Mulching	Flood
1	Quantity sold	Tonnes/acre	10.25	8.81	7.00
2	Selling price	Rs./tonne	7750.00	6916.66	5500.00
3	Gross returns	Rs./acre	79437.50	60935.80	38500.00
4	Net returns	Rs./acre	35947.60	23505.20	9930.33
5	Gross returns	Rs./tonne	7750.00	6916.66	5500.00
6	Net return	Rs./tonne	3507.08	2668.01	1418.61
7	Cost of production	Rs./tonne	4242.91	4248.64	4081.38
8	B:C ratio		1.82	1.62	1.37

Resource use efficiency in watermelon production under drip, mulching and flood method

The results of the regression analysis for the production of watermelon under drip method by the sample respondents are shown in Table 3. The regression coefficient for FYM (0.981), seed (0.131), human labour (0.513), machine labour (0.545), polythene mulching sheets (0.085) and drip laterals (0.155) were positive and significant at 5 per cent and 10 per cent probability levels. With these results it is obvious that the positive and significant variables are strongly attributable to the increase in yield. The coefficient of multiple determinations (R^2) of watermelon production under drip method was 0.85, which means that 85 per cent of the variation in watermelon yield under drip irrigation method was explained by the independent variables used in the model, although the remaining 15 per cent of the variation was explained by the error term. The sum of elasticity i.e., ($\sum b_i$) was 1.25, suggesting an increase in the returns to scale (more than unity). A one per cent increase in all inputs used in production at the same time will increase output by 1.25 times.

In case of the mulching method, FYM (0.464), seed (0.074), bullock labour (0.275) and polythene mulching sheet (0.081) have significantly influenced on yield at 5 per cent and 10 per cent probability levels. With these results it is obvious that the positive and significant variables are strongly attributable to the increase in yield. The coefficient of multiple determinations (R^2) of watermelon under mulching method was 0.84, which means that 84 per cent of the variation in watermelon yield under mulching irrigation method was explained by the independent variables used in the model, although the remaining 16 per cent of the variation was explained by the error term. The sum of elasticity i.e., ($\sum b_i$) was 1.15, suggesting an increase in the returns to scale (more than unity). A one per cent increase in all inputs used in production at the same time will increase output by 1.15 times.

In flood irrigation method, FYM (1.167), human labour (0.04), machine labour (0.009) were positive and non-significant. Seed (-1.614) and bullock labour (-1.284) were negative and significant at 5 per cent and 10 per cent of the probability level, respectively. It shows that the negative and significant variables have a negative impact on yield. From the results, it is obvious that the positive and significant variables are strongly attributable to the increase in yield. Positive and non-significant variables do not contribute much to yield. The coefficient of multiple determinations (R^2) of watermelon under flood method was 0.73, which means that 73 per cent of the variation in watermelon yield under flood irrigation method was explained by the independent variables used in the model, although remaining 27 per cent of the variation was explained by the error term. The sum of elasticity i.e., ($\sum b_i$) was 0.53, suggesting decrease in the returns to scale (less than unity). A one per cent simultaneously increase in all inputs would yield 0.53 per cent rise in output and results were in accordance to Ajewole (2015) [2] and Veeresh (2021) [10] study.

Table 3: Regression estimates of watermelon production under different water-saving technologies

SL. No.	Variables	Parameters	Regression – Coefficients		
			Drip	Mulching	Flood
1	Intercept	a	5.655 (4.016)	12.282* (1.069)	16.901 (10.538)
2	FYM	X1	0.981** (0.430)	0.464** (0.099)	1.167 (1.073)
3	Seed	X2	0.131*** (0.07)	0.074** (0.035)	-1.614** (0.924)
4	Human labour	X3	0.513** (0.216)	0.057 (0.038)	0.04 (0.118)
5	Bullock labour	X4	0.116 (0.138)	0.275* (0.073)	-1.284*** (0.639)
6	Machine labour	X5	0.545*** (0.268)	0.118 (0.107)	0.009 (0.096)
7	Herbicides	X6	0.091 (0.133)	0.056 (0.049)	0.758** (0.252)
8	Chemical fertilizer	X7	-0.281* (0.065)	-0.022 (0.062)	0.701 (0.370)
9	PPC	X8	0.009 (0.076)	0.054 (0.033)	0.757** (0.171)
10	Polythene mulching sheet	X9	0.085** (0.048)	0.081*** (0.043)	-
11	Drip laterals	X10	0.155** (0.069)	-	-
12	R^2value	R^2	0.85	0.84	0.73
13	Returns to scale	Σb_i	1.25	1.15	0.53
14	No. of observations	N	30	30	30

Note: Figures in the parentheses indicate standard errors of respective regression coefficients and ***, ** and * indicate significant at one per cent, five per cent and ten per cent level of probability, respectively.

Comparison of MVP to MFC ratio in the three technologies under watermelon production

The ratios of marginal value products (MVP) of various resources to their respective marginal factor costs (MFC) were computed for watermelon production in drip, mulching and flood technologies and are presented in Table 4. As evident from Table 3 in drip method the ratio of MVP to MFC was greater for bullock labour (0.084), herbicides (0.065), FYM (0.049), drip laterals (0.002), human labour (0.016), seed (0.002), fertilizer (0.032), machine labour (0.39), herbicides (0.065) and plant protection chemicals (0.007). This indicated the under use of these resources in drip method. Hence, there is a scope for using additional unit of these resources to increase the returns of watermelon production in drip method.

In case of mulching method, the ratio of MVP to MFC for bullock labour (0.185) machine labour (0.09), chemical fertilizer (0.002), plant protection chemicals (0.004), polythene mulching sheet (0.005), seed (0.001), human labour (0.001) and herbicides (0.031) in watermelon production this indicated the under use of these resources. Hence, there is a scope for using additional unit of these resources to increase the returns of watermelon production in mulching method.

In case of flood method the ratio of MVP to MFC for FYM (0.02), human labour (0.009), machine labour (0.006), herbicides (0.384) indicated the underuse of these resources. Hence, there is a scope for using the additional unit of these resources to increase the returns of watermelon production in flood method. Whereas, the ratio of MVP to MFC for seed (0.003), bullock labour (0.507), chemical fertilizer (0.02) and plant protection chemicals (0.041), have shown less than unity, implying their excess use in watermelon production activity. It indicates that excess utilization of resources watermelon production activities in the study area and the result was in line with Paled and Guledgudda (2018) and Veeresh (2021) [10] studies.

Table 4: Ratio of MVP to MFC under watermelon production in the study area

SL. No.	Resource	Drip	Mulching	Flood
1	FYM	0.049	0.002	0.02
2	Seed	0.002	0.001	-0.003
3	Human labour	0.016	0.001	0.009
4	Bullock labour	0.084	0.185	-0.507
5	Machine labour	0.39	0.09	0.006
6	Chemical fertilizer	-0.032	-0.002	-0.02
7	PPC	0.007	0.004	-0.041
8	Herbicides	0.065	0.031	0.384
9	Polythene mulching sheet	0.001	0.005	-
10	Drip laterals	0.002	-	-

Water saving and productivity gains through different water-saving technologies in watermelon production

Table 5 presents water saving, yield rise and water use efficiency improvements with drip and mulching over flood method. The reduction in water consumption varies from 10 per cent for drip and 40 per cent for mulching. The level of water-saving was more due to micro-irrigation system used in the analysis of water use efficiency (yield per unit of water consumption) and it is quite beneficial in well-irrigated areas such as arid to semi-arid climate, where farmers have independent irrigation sources for widely spaced row crops. These findings were in line with Kaarthikeyan (2019) [6] and Mallikarjun *et al*., (2015) [8].

The yield of watermelon was more profitable under the drip method as compared to mulching and flood irrigation which is 10.25 tonnes/acre compared to mulching and flood method is 8.81 and 7 tonnes/acre respectively. Water use impact per acre (acre-inch) was more in flood irrigation (7.15 acre-inch) compared to drip and mulching (3.91 and 4.90, respectively). Net return per acre-inch of water was higher in drip irrigation method (Rs. 9193.75) rather than in the mulching and flood method (Rs. 4796.97 and Rs. 1388.85, respectively). Output per acre-inch of water was comparatively more in drip (2.62 tonnes) and less in mulching (1.79 tonnes) and flood irrigation methods (0.97 tonnes).

Table 5: Water saving and productivity gains through different water-saving technologies in watermelon production

SL. No.	Particulars	DMI	MMI	FMI
1	Cost of cultivation per acre	43489.90	37430.60	28569.70
2	Gross return per acre	79437.50	60935.80	38500.00
3	Net return per acre	35947.60	23505.20	9930.33
4	Water use per acre (acre-inch)	3.91	4.90	7.15
5	Net return per acre-inch of water (Rs.)	9193.75	4796.97	1388.85
6	Output (tonnes/acre)	10.25	8.81	7.00
7	Output per acre-inch of water (tonnes)	2.62	1.79	0.97

Note: DMI, MMI and FMI refer to drip method of irrigation, mulching method of irrigation and flood method of irrigation, respectively.

Conclusion

The study results have shown that output per acre inch of water has been high under drip irrigation system compared to mulching and flood irrigation system. Hence, micro irrigation technology needs to be further popularized, which helps in saving water per unit area and also bring more area under irrigation. By conducting this study we can show cultivators the feasibility of water-saving technology along with sustainable use of water and increasing profitability of crops in the area and encouraging farmers to adopt water-saving technology in their field. Nowadays, a lot of emphasis has been given for the adoption of micro irrigation systems to fruits, vegetables, oilseeds and other commercial crops. In order to increase the productivity and production of watermelon with efficient water use, there is a need to have information about irrigation scheduling, water requirement and water saving due to drip and mulching in watermelon. Adopting water-saving technologies in watermelon production can lead to significant economic benefits through improved yields and reduced water usage. While the initial investment varies across technologies, the long-term benefits and cost savings make these technologies viable. Drip irrigation and mulching emerge as highly effective options, offering substantial yield improvements and water savings with relatively short payback periods. Soil moisture sensors and rainwater harvesting also provide economic benefits, especially in optimizing water usage and enhancing sustainability. Overall, the implementation of water-saving technologies is recommended for watermelon farmers to enhance productivity, profitability and environmental sustainability.

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