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Impact of deficit irrigation and plastic mulch on economics of capsicum grown under naturally ventilated polyhouse

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Abstract
Impact of deficit irrigation and plastic mulch on economics of drip irrigated capsicum crop under the naturally ventilated polyhouse was studied under this experimental trial. Present study includes six drip irrigation levels viz., 100%, 90%, 80%, 70%, 60% and 100% (Control without mulch) of crop evapotranspiration with four replications to assess their impact on economics of crop inside the naturally ventilated polyhouse. Capsicum (*Capsicum annuum* L. Indra Variety) plants were grown under the naturally ventilated polyhouse and irrigated through drip irrigation system. The gross cost of cultivation of capsicum production under T1 treatment was maximum (500130.2 Rs/ha) and minimum is treatment T_6 (492510.4 Rs/ha). Maximum net income was gained from treatment T_3 (1205550.1 Rs/ha) whereas minimum net income was reported in treatment T_5 (-21546.8 Rs/ha). Maximum output-input ratio was observed in treatment T_3 (3.41) and minimum output-input ratio was reported in treatment T_5 (0.96). Thus, the results revealed that highest B: C ratio was found at drip irrigation level equal to 80% of crop evapotranspiration under the naturally ventilated polyhouse. Results showed that 80% of crop evapotranspiration is more beneficial in terms of yield & net benefit obtained and thus should be practiced to enhance water use efficiency in irrigated areas.

Keywords: Deficit irrigation, drip irrigation, naturally ventilated polyhouse, plastic mulch, capsicum

1. Introduction
Vegetable is one of the most important constituent in a balanced food diet around the globe for optimum growth of human being. Its nutritional quality makes it one of the most consumable and generally taken as raw, in salads and also used in many fast foods items these days as taste enhancer. Its demand has increased recently in India and thus huge scope for farmers to generate more income in short span. India contributes one fourth of world production of capsicum with an average annual production of 0.9 million tons from an area of 0.885 million hectare with a productivity of 1266 kg per hectare.

India is the second largest producer of vegetables in the world and the concerted efforts of vegetable research and emergence of corporate sector in vegetable seeds have contributed immensely in enhancing productivity and production of vegetables in our country but still there exists a gap of 10.1% in national productivity in comparison to global scenario. Further, 62.1% (18 out of 29 states) states in the country are having lower productivity in comparison to national productivity of vegetable 17.8 t/ha (Anonymous, 2016) [2]. In Rajasthan through 17720 ha area production is 17530 tonne and yield 0.99 t/ha.

Polyhouse cultivation gives higher yield, higher productivity, better quality produce and production throughout the year (Neelam and Rajput, 2010) [7]. Capsicum, also known as sweet pepper, bell pepper or *Shimla mirch* is one of the popular vegetables grown throughout India. It is rich in Vitamin A (8493 IU), Vitamin C (283 mg) and minerals like Calcium (13.4 mg), Magnesium (14.9 mg) Phosphorus (28.3 mg) Potassium, (263.7 mg) per 100 g fresh weight. Capsicum is a cool season crop, but it can be grown round the year using protected structures where temperature and relative humidity (RH) can be manipulated. This crop requires day temperature of 25-30 ˚C and night temperature of 18-20 ˚C with relative humidity of 50- 60%. If temperature exceeds 35 ˚C or falls below 12 ˚C, fruit setting is affected (Shankara *et al*., 2011) [9]. Capsicum yields in open field cultivation ranges between 20-40 t/ha, where as in a greenhouse the yield range is from 100-120 t/ha (Thangam *et al*., 2013) [10].

Drip is an irrigation technology known to increase the control of water application and offers several advantages to growers. It reduces soil evaporation and weed population, increases plant transpiration, and when well-managed, excessive water drainage is unlikely to occur, thus allowing nutrients to be retained in the root zone for prolonged periods.

Moreover, drip offers an opportunity to inject soluble fertilizers combined with irrigation, a process known as fertigation. (Cabrera *et al.*, 2016) [3]. Its adoption increases of water use efficiency (60-200%), saves water (20-60%), reduces fertilization requirement (20-30%) through fertigation, produces better quality crop and increases yield (7-25%) as compared with conventional irrigation (Kaushal *et al.*, 2012) [5].

Sweet pepper consumption in India is increasing now-a-days due to increasing demand by urban consumers. There is a good demand for export too. The export market needs fruits with longer shelf life, medium size, tetra lobed fruits with an attractive dark colour, mild pungency and good taste. But, the supply is inadequate due to low productivity of the crop. Keeping in view of these aspects, the present study was a modest attempt to analyze the economics of capsicum production with different irrigation treatments under protected condition with drip irrigation system.

Cost of cultivation under protected condition includes all the cost incurred annually for the maintenance cost was divided into variable and fixed costs. The variable cost items were costs on materials, labour and interest on working capital at the rate of 9 per cent per annum. Fixed cost includes rental value of land, interest on fixed capital at the rate of 9 per cent amortized costs for the period of six months. Gross returns are the values of total quantity of capsicum produced at the prices, where the product is sold. B: C ratio was obtained by dividing total returns from a unit with total cost of a unit. Less works have been reported on the cost economics of protected cultivation, plastic use and drip irrigation together which is essential from farmer's perspective. Thus, present study explore the scope of protected cultivation for growing drip irrigated capsicum under plastic use in terms of cost of cultivation, net benefit and benefit-cost ratio.

2. Material and Methods

2.1 Description of study area

A naturally ventilated polyhouse is situated at the Plasticulture farm of College of Technology and Engineering, MPUAT Udaipur (At the elevation 582.17 m above mean sea level, 24º 35'31.5" to 24º 35'38.5" N-latitude, 73º 44'18.2" to 73º 44'21.1" E-longitude). Udaipur comes under dry, sub-humid agro-climatic region. It receives an average annual rainfall of 654.3 mm, most of the received during the period of July to September. The maximum temperature goes as high as 46 °C during summer and minimum as below as 5 °C during winter months. The atmospheric humidity is high from June to October.

2.2 Experimental details

The experiment was conducted during the period of March, 2017 to August, 2017 in randomized block experimental design method with four replications under the naturally ventilated polyhouse. Thereafter, six treatments were also randomly arranged in the equally sized beds of 8m × 1m area. The total area of the experimental field size was 192 m^2. The deficit irrigation treatments were given below:

T_1: Drip irrigation with 100% of ET_c with mulch
T_2: Drip irrigation with 90% of ET_c with mulch
T_3: Drip irrigation with 80% of ET_c with mulch
T_4: Drip irrigation with 70% of ET_c with mulch
T_5: Drip irrigation with 60% of ET_c with mulch
T_6: Drip irrigation with 100% of ET_C without mulch (Control)

2.3 Calculation of cost of cultivation

- A separate cost of cultivation, yield, gross income, and net income of capsicum was calculated, considering the 1 square meter area and it was multiplied by 192 square meter area for protected cultivation. On the basis of calculated data input-output ratio or income on per rupee investment has been calculated.
- Two components of cost of cultivation namely fixed and variable cost has been considered for analysis.
- Items for fixed costs are-

i) Rental value of land-Assumed as it is prevailing in the locality.
ii) Depreciation of structure and drip irrigation system was considered @ 10% of the value of the structure including drip irrigation system.
iii) Interest on fixed capital was taken as 12% of the total fixed capital.
iv) Maintenance charges on structure and drip irrigation system were considered as 2% of its costs of framing structure, establishment of drip irrigation system and crop training system considering the ideal size of protected structure i.e. 192 square meter area.

2.4 Items for variable cost

i) Depreciation of covering material of structure- it is fact that the life of covering material of structures are 3 years, thus 33% value of its cost was considered in this component
ii) Maintenance charges of covering material were considered as 2% of its price of UV stabilized plastic coverings. Poly sheet was purchased @ Rs. 74 per square meter and insect net was purchased at the same rate i.e. on Rs. 40 per square meter. Working capital- total working capital only for 6 months is added for each crop. It included the charges for field preparation, high yielding variety seeds, farm yard manure, fertilizers, pesticides, land revenue, electricity charges and casual labour charges for green house.
iii) Interest on working capital is calculated only for 6 months for each crop as per their life span.

3. Results and Discussion

All the biometric and reproductive parameters differed significantly due to different irrigation treatments. The plant height, number of leaves, time required for first harvest were maximum under T_3 at all stages of crop growth viz., 30, 60, 90, 120 and 150 DAT. The number of flowers and fruits per plant was higher under T_3 at all stages of crop growth viz., 60, 90, 120 and 150 DAT (Days after transplanting). The maximum (180 cm and 57.28) plant height and no. of leaves, maximum (17.78 and 11.31) number of flowers and fruits were recorded under T_3 at 150 DAT, respectively. Similar findings were recorded by Arya *et al.*, (2017) [1].

The maximum time taken for flower initiation (26.00) and that for first harvest (60.00) were recorded under T_3. The maximum (51.07%) fruit set was recorded under T_3. Maximum no. of fruits (11.31), individual fruit weight (94.33 g), fruit yield per plant (1065.98 gm), fruit yield per sqm area (4263.93 gm), fruit yield (42.64 ton/ha). Among the different irrigation treatments maximum values were recorded in T_3 for all observations.

This might be due to better micro-climate responsible for efficient water utilization at early crop growth stages, which ultimately lead to more number of flowers and hence more number of fruits in T_3. On the other hand least values were

recorded under T_5 this might be attributed to reduced number of flowers produced rather than poor fruit set (Masuda and Hayashi, 1957) [6]. It reveals that both the excess as well as less supply of water has resulted into less number of fruits plant-1. Hence, controlled irrigation is essential for having higher fruit number in capsicum as this crop is sensitive to both excess and under irrigations (Anonymous, 2009) [1]. Figures of experiment are given below:

Fig 1: Soil sampling for irrigation scheduling of capsicum crop

Fig 2: Glimpse of fresh capsicum at harvest

Table 1: Cost of cultivation and output-input ratio of capsicum crop under naturally ventilated polyhouse

S. No.	Item	T_1	T_2	T_3	T_4	T_5	T_6
A	**Fixed cost**						
1	Depreciation Value @ 6.67% + Interest @ 9% + Maintenance Charge @ 2% of structure with drip Irrigation system in 192 m^2 area @ Rs. 775/sqm per crop of 6 months	6572	6572	6572	6572	6572	6572
2	Seeds @ 10 gm/192 sqm area @ Rs. 75000/- per kg	750	750	750	750	750	750
3	Field preparation @ Rs. 200/192 sqm area	200	200	200	200	200	200
4	FYM,2.5 kg/sqm @Rs.1.5/kg	720	720	720	720	720	720
5	Fertilizer (Rs/192 sqm area)	144	144	144	144	144	144
6	Pesticides (Rs/192 sqm area)	96	96	96	96	96	96
7	Labour charges (Rs/192 sqm area)	650	650	650	650	650	800
		2560	2560	2560	2560	2560	2710
B	**Variable Cost**						
1	Irrigation Water Charges (Rs/192 sqm area)	15	14	13	12	11	50
2	Mulch matreial (Rs/192 sqm area)	325	325	325	325	325	0
3	Working capital (Rs/192 sqm area)	2900	2899	2898	2897	2896	2760
4	Interest on working capital @ 9% p.a.	130.5	130.5	130.4	130.4	130.3	124.2
	Total (A+B) (Cost of cultivation)	3030.5	3029.5	3028.4	3027.4	3026.3	2884.2
A.1	Depreciation Value @ 6.67% + Interest @ 9% + Maintenance Charge @ 2% of structure with drip Irrigation system in 192 m^2 area @ Rs. 775/sqm per crop of 6 months	6572	6572	6572	6572	6572	6572
	Total Cost of production/192 sqm area (Cost of cultivation + cost for structure setup)	9602.5	9601.5	9600.4	9599.4	9598.3	9456.2
	Total Cost of cultivation/ha	500130.2	500075.8	500021.4	499966.9	499912.5	492510.4
	Yield of produce(kg/192 sqm area)	500.1	599.8	818.7	424.2	229.6	330.1
	Selling price, (Rs/kg)	40	40	40	40	40	40
	Gross income (Rs/192 sqm area)	20003.1	23991.9	32747.0	16969.8	9184.6	13205.5

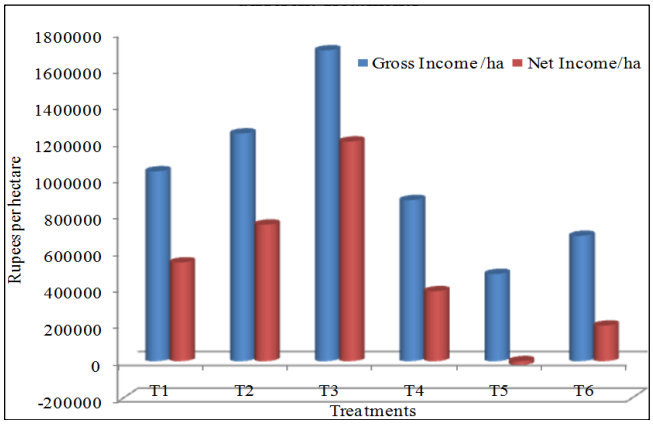

Fig 3: Comparison of capsicum's gross income and net income under different treatments

B:C Ratio: It compares various kinds of treatments/scenarios and also one of the most important used factor in economics so that best among available option can be chosen to maximize resource use. Under this experiment, its value was varied from maximum 3.41 in treatment T3 due to better crop growth and highest production while 0.96 minimum in treatment T5 because of lesser yield as compare to other treatments. Cost of cultivation under different had less influence on BC ratio under different treatments as compare to impact of irrigation levels on the yield production which has ultimately affected net income generated.

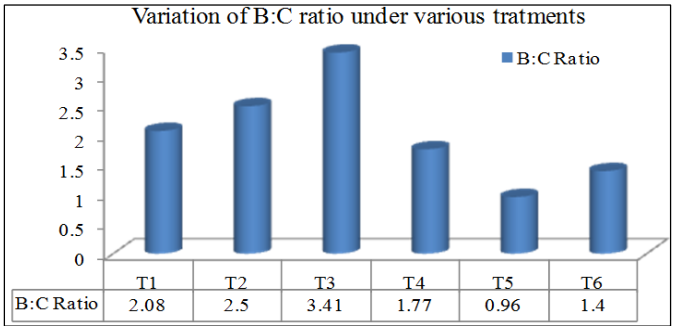

Fig 4: Variation of B:C ratio under various treatments

4. Conclusions

The results of this study showed that deficit irrigation practice can save up to 20% of irrigation water with higher crop yield, net benefit and benefit-cost ratio. Crop economics worked out for different treatments has revealed that maximum cost of cultivation was observed in treatment T_1 (500130.2 Rs/ha) and minimum is treatment T_6 (492510.4 Rs/ha. It was found that maximum net income was gained from treatment T_3 (1205550.1 Rs/ha) whereas minimum net income was reported in treatment T_5 (-21546.8 Rs/ha) which is mainly due to variation of yield under treatments. Thus, the results revealed that all the vegetative parameters, reproductive parameter, quantity parameter and input-output ration was found maximum in the drip irrigation applied with 80% of crop evapotranspiration (ETc) with mulch i.e. treatment (T3). Experimental findings suggested that net benefit and benefit-cost ratio found higher under treatment T3 and thus it shall be promoted to increase resource efficiency under similar condition. A 20% saving of irrigation water may give flexibility to irrigators and policy makers to bring more area under assured irrigation availability.

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