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RESPONSE OF CUCUMBER CROP (*Cucumis sativus* L.) TO DRIP IRRIGATION SYSTEM UNDER VARIOUS MULCHES

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ABSTRACT

The field experiment on 'Effect of different irrigation levels of drip irrigation system coupled with various mulches on growth and yield of cucumber (*Cucumis sativus* L.)' was undertaken at Dr. Balasaheb Sawant Konkan Krishi Vidyapoeeth, Dapoli during 2006. The experiment was laid out in split plot design. There were sixteen treatment combinations comprising of four different types of mulches i.e. without mulch (MT_1), white transparent polythene mulch (MT_2), black polythene mulch (MT_3) and paddy straw mulch (MT_4) and four levels of irrigation i.e. control (IL_1), 50 per cent ET (IL_2), 75 per cent ET (IL_3) and 100 per cent ET (IL_4) under drip and replicated five times. The conventional method of irrigation without mulch was taken as control. From the study, it was revealed that the maximum yield of 270 q ha^{-1} was obtained in the treatment combination of white transparent polythene mulch and irrigation level of 100 per cent ET followed by 252.2 q ha^{-1} in the treatment combination of white transparent polythene mulch with control irrigation and black polythene mulch with irrigation by 100 per cent ET by drip. The individual effect of mulch, irrigation and the interaction effect were found to be significant. Even after applying the water of 100 per cent ET for getting the maximum yield (256.5 q ha^{-1}), there was 41.48 per cent saving of water over control. It was revealed from the data that, the maximum benefit : cost ratio was observed (1.90) in treatment combination of transparent polythene mulch with irrigation level of 100 per cent ET, followed by straw mulch with irrigation level of 100 per cent ET (1.73). The maximum net income (Rs. 85,704 ha^{-1}) was observed in treatment combination of white transparent polythene mulch and irrigation level of 100 per cent ET by drip, i.e. about 249 per cent more than the control treatment. It was followed by transparent polythene mulch with control irrigation (Rs. 47,604 ha^{-1}) and black polythene mulch and irrigation level of 100 per cent ET by drip (Rs. 47,260 ha^{-1}).

(**Key words*:* Cucumber, irrigation, mulch, net income, B:C ratio**)

INTRODUCTION

Cucumber cultivation area in Maharashtra State and India is 0.005 M ha and 0.02 M ha with production of 18 t ha^{-1} and 6.67 t ha^{-1}, respectively (Jagtap, 2008). This indicates the area and productivity of cucumber is very low, which needs to be increased substantially by way of developing suitable package of practices. The fruit and vegetable intake among the population in India, Mali and Pakistan is about 100 gram $capita^{-1}$ day^{-1} or less, compared to 300 grams consumed in Australia, several European countries and the USA. Even so, the fruit and vegetable consumption in these high income countries are still less than the WHO/FAO recommended level of 400 grams or five servings day^{-1} (Pollack, 2001). Of the various vegetables grown, cucumber has high place in the diet as a rich source of carbohydrates as a breakfast fruit and as an ingredient of salads. It forms an important and big group of vegetable in our diet due to its high nutritive value (44.5 g of average nutritive value 100 g^{-1} dry matter). The conventional irrigation methods do not apply water efficiently and distribute uniformly causing water losses due to conveyance, seepage, deep percolation especially in light textured soil occurring in most part of Konkan region. As water is scarce commodity, it should be used judiciously. The drip irrigation is the best option for overcoming these problems. The mulching plays an important role in controlling evaporation. In recent years, different kinds of mulching material have been used in controlling evaporation and conserving soil moisture. Clear plastic mulch transmits 85 to 95 per cent solar radiation through it and helps in raising the soil temperature by 4 to 8^0C (Shinde *et al*., 2006).

Limbulkar *et al.* (1998) conducted a field experiment on study of yield response of cucumber variety Himangi to micro irrigation at M.P.K.V., Rahuri. They reported that the yield obtained due to treatment of 110 per cent pan evaporation was significantly superior over all other treatments, but yield of cucumber irrigated with 90 per cent pan evaporation treatment by drip irrigation was higher (23.175 t ha^{-1}) than irrigated with 90 per cent pan evaporation treatment by surface irrigation. Siwek *et al.* (2003) studied the effect of some kinds of direct plant covering as four perforated polythene films and non-woven polypropylene and soil mulching with black polythene film on the soil temperature and yield

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of cucumber Marinda. The early and marketable yields of fruits were the highest in case of applying polythene film with perforations of 6 cm in diameter as a direct cover. Tiwari *et al.* (2003) conducted an experiment on lateritic sandy loam soils of Kharagpur to evaluate the feasibility of growing cabbage crop under drip irrigation with mulches. They concluded that yields were recorded as 111.72, 108.87 and 107.94 $t.ha^{-1}$ for drip with plastic mulch, drip with rice husk and drip with paddy straw, respectively. However, the study of mulching coupled with irrigation scheduling was not available for the cucumber crop. In order to increase the productivity and production of cucumber, there is need to have information about mulches and irrigation scheduling through drip and therefore the present study was undertaken.

MATERIALS AND METHODS

The field experiment was conducted on the research farm of Department of Agronomy, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli during *rabi* season in 2006. During the crop period, the maximum and minimum temperature ranged from 27^0C to 37.8^0C and 6^0C to 19.6^0C, respectively; whereas the minimum pan evaporation was 2.8 mm day^{-1} and maximum was 6.7 mm day^{-1}. The topography of the experimental field was uniform and levelled. The soil was sandy clay loam in texture with 26 per cent field capacity and 14 per cent wilting point. The electrical conductivity (EC) and pH of the experimental plot were 0.49 dSm^{-1} and 6.55, respectively. Also, available N, P and K in soil were 400.50, 14.52 and 250.52 kg ha^{-1}, respectively. The reaction of water was normal in nature and low in salinity, thus was safe for irrigation.

The experiment was carried out in split plot design with four main plot treatments MT_1: without mulch, MT_2: transparent polythene mulch, MT_3: black polythene mulch and MT_4: paddy straw mulch and four sub plot irrigation treatments viz., IL_1: control, IL_2: drip with 50 per cent crop ET, IL_3: drip with 75 per cent crop ET and IL_4: drip with 100 per cent crop ET, replicated for five times. The experiment was laid out with sixteen-treatment combination arranged randomly in a field of 32 m x 36 m size with spacing of 1.0 x 0.5 m. The buffer of 1.5 m was left between two successive treatment plots in order to avoid lateral movement of water from one plot to another. The cucumber variety Himangi was sown on 4^{th} Jan. 2006. Each vine was provided with one turbo key dripper of 4 lph discharge. The crop was supplied with farmyard manure @ 2.5 kg pit^{-1} and thoroughly mixed with soil before sowing. The recommended dose of fertilizer at the rate of 135 kg N, 60 kg P_2O_5 and 30 kg K_2O ha^{-1} was applied. Out of which 50 per cent of N, 100 per cent of P and 100 per cent of K were applied as a basal dose and remaining 50 per cent of N was applied as top dressing at the time of flower initiation.

For scheduling of irrigation, reference evapotranspiration (ETo) was worked out by Penman Monteith method (Allen *et al.*, 1998). It was multiplied by the crop coefficients for cucumber given in FAO-56 (Allen *et al.*, 1998) for calculating crop evapotranspiration. The gross irrigation depth was calculated by dividing the net depth of irrigation by uniformity coefficient of the drip irrigation system. The irrigation was scheduled on alternate day basis for all irrigation levels except control in which the 50 mm irrigation depth was applied after occurring of 50 mm cumulative pan evaporation. Total 43 number of irrigations were applied in all irrigation levels except control, in which eight irrigations were applied. The depth of water applied in different irrigation levels and the quantity of water saved as compared to the control is reported in table 1. To study the effect of different treatments on the growth of cucumber vine, the biometric observations like vine length, number of leaves $vine^{-1}$, number of branches $vine^{-1}$ and fruits $vine^{-1}$ were recorded. For recording the observations in each treatment, five vines $replication^{-1}$ were selected for the observation by adopting the standard procedure of sampling technique. The selected observation vines were properly tagged for their identification. The vine length was measured from the ground level upto the base of terminal leaf bud on the main stem at 10, 20, 35, 50, 65 and 80 days after emergence of seeds with the help of measuring tape. The number of leaves and number of branches $vine^{-1}$ were counted in a similar way. The vine length, number of leaves and number of branches $vine^{-1}$ were recorded on 80 days after emergence of seeds are reported in the table 2 to table 4. The fruits were harvested and counted and the average number of fruits $vine^{-1}$ in each treatment were worked out in table 5.

RESULTS AND DISCUSSION

Biometric observations:

The data regarding biometric observations are reported in table 2 to table 5. The transparent polythene mulch treatment recorded significantly superior (increased) vine length, more number of leaves vine^{-1}, branches vine^{-1} and fruits vine^{-1} over the rest of the treatments. The black polythene mulch recorded significantly superior growth attributes over straw mulch and without mulch, while application of straw mulch showed its supremacy over without mulch. The irrigation by drip at 100 per cent ET recorded significantly more vine length, leaves vine^{-1} and fruits vine^{-1} than other treatments, while more number of branches vine^{-1} was observed in control irrigation. Drip irrigation at 50 per cent ET at all mulching levels recorded significantly higher vine length, number of leaves vine^{-1}, number of branches vine^{-1} and number of fruits vine^{-1} as compared to other treatment combination. Application of transparent polythene mulch to cucumber at all levels of irrigation recorded significantly superior above mentioned biometric observations as compared to other treatment combinations.

Serhat and Cigdem (2009) conducted an experiment on deficit irrigation effects on cucumber yield in unheated greenhouse condition. They applied water to cucumber as 100 (K1cp), 75 (K2cp), 50(K3cp), 25(K4cp) and o(K5cp) per cent (as control) of evaporation from a Class A pan corresponding to 2 days irrigation frequency. Irrigation water applied to crops ranged from 75 to 420 mm, and water consumption ranged from 84 to 424 mm. The effect of irrigation water level on fruit length, fruit diameter, fruit weight and dry matter ratio were found to be significantly affected by the irrigation.

Todd *et al.* (2011) studied the yield of spring planted cucumber using row covers, polyethylene mulch and chilling resistant cultivars. They found that the use of mulch and polyester row covers would allow early production of cucumbers (picking and slicing types) in North Corolina. The field could be planted as early as mid-March, thus anticipating traditional cultivation of one month. Furthermore, the use of mulch and row covers increased yield of commercial cultivars dramatically.

Yield of fruits:

The statistical analysis revealed that different mulches influenced the average yield of fruits significantly (Table 6). The data on average yield of fruits at the time of harvest as influenced by different treatments are presented in table 7. The mulching treatment transparent polythene mulch gave maximum yield of 265.8 q ha^{-1} , which was significantly superior over the other three mulching treatments. The treatment without mulch gave minimum yield (170.8 q ha^{-1}), while the treatment straw mulch gave significantly superior yield over the without mulch. This might be due to the favorable microclimate status in the root zone of crop.

Similarly, irrigation levels had significant effect on the average yield of fruit. The maximum average yield (256.5 q ha^{-1}) was obtained in the 100 per cent ET irrigation by drip which was significantly superior to the average yield obtained in all other treatments. The lowest average yield of fruits was registered in irrigation at 50 per cent ET by drip (158.1 q ha^{-1}). This decrease in yield might be due to lower application of water than required by the crop. The interaction between mulches and irrigation levels for yield of fruits was significant.

The maximum average yield (361.5 q ha^{-1}) of fruits was reported in the treatment transparent polythene mulch with irrigation level of 100 per cent ET by drip and was found significantly superior over rest of the treatments. It was followed by transparent polythene mulch with irrigation level of 75 per cent ET by drip (270.0 q ha^{-1}); followed by transparent polythene mulch with control irrigation method (252.2 q ha^{-1}) and black polythene mulch with irrigation level of 100 per cent ET by drip (252.2 q ha^{-1}). This indicates the superiority of transparent polythene mulch for increasing the yield. These results are almost similar with those obtained by Yaghi *et al.* (2013). They studied the effect of two types of plastic mulch i.e. transparent and black with drip irrigation on water requirement and cucumber yield. The results of the study indicated that drip irrigation with transparent mulch treatment excelled all other treatments for yield and water use efficiency

(WUE). The yield of 63.9 t ha^{-1} and WUE was 0.262 t ha^{-1} mm^{-1} in drip irrigation with transparent mulch, while in drip irrigation with black mulch it was 57.9 t ha^{-1} and 0.238 t ha^{-1} mm^{-1}, respectively. The cucumber yield and WUE declined in the remaining treatments of drip irrigation with no mulch and surface irrigation with no mulch to reach 44.1 t ha^{-1} with WUE 0.153 t ha^{-1}mm^{-1} and 37.7 t ha^{-1} with WUE of 0.056 t ha^{-1} mm^{-1}, respectively. Serhat and Cigdem (2009) observed highest yield of 148 and 108 t ha^{-1} for the K1cp and K2cp treatment, respectively. Crop yield response factor (ky) was 1.213.

Water use efficiency (WUE):

The data regarding WUE as influenced by different treatments are presented in table 8.

Different irrigation levels also affected the WUE and it varies from 5.19 to 13.50 q ha^{-1} cm^{-1}. The highest WUE of 13.50 q ha^{-1} cm^{-1} was observed in irrigation level at 50 per cent ET by drip followed by 75 per cent ET by drip (12.85 q ha^{-1} cm^{-1}) and 100 per cent ET by drip (10.96 q ha^{-1} cm^{-1}). The lowest WUE of 5.19 q ha^{-1} cm^{-1} was observed in control treatment as maximum depth of water i.e. 40 cm was applied in that level. The lowest water depth of 11.71 cm was found in irrigation level of 50 per cent ET by drip, followed by 75 per cent ET by drip (17.56 cm) and 100 per cent ET by drip (23.41 cm).

Kirnak and Demirtas (2006) studied effectiveness of different mulch types on fruit yield and plant growth parameters. The black polythene mulch, wheat straw mulch and the combination of both were used along with other stress and unstressed treatments. The WUE ranged from 3.40 to 5.78 kg m^{-3}, while irrigation water use efficiency (IWUE) varied between 3.39 to 6.08 kg m^{-3}. IWUE and WUE were increased under water stress treatment, as mulching significantly reduced the amount of irrigation water required. Both black polythene mulch and wheat straw mulch improved the fruit yield, fruit size, plant dry matter, total leaf area and chlorophyll and increases in these parameters. The present study confirms in study that limiting soil evaporation with mulches helps to save precious irrigation water and to improve WUE and IWUE.

Satpute *et al.* (2008) conducted an experiment to study the effect of fertigation and irrigation schedule on growth and yield of cucumber. They found the water requirement of cucumber through drip and conventional irrigation method as 19.53 cm and 48 cm, respectively, indicating 59.31 per cent saving of water in drip irrigation over conventional method. Serhat and Cigdem (2009) observed highest values for water use efficiency (WUE) and irrigation water use efficiency (IWUE) as 34.91 and 31.90 kg mm^{-1} for the K1cp treatment. Under the conditions that water resources are scarce, it can be recommended that K1 cp treatment is most suitable as a water application level for cucumber irrigation by drip irrigation under unheated greenhouse condition.

The mulching treatment of transparent mulch shown maximum WUE of 11.35 q ha^{-1} cm^{-1}, followed by black polythene and straw mulch with 9.34 and 8.22 q ha^{-1} cm^{-1}, respectively. The lowest WUE of 7.30 q ha^{-1} cm^{-1} was observed in no mulch by Yaghi *et al.* (2013).

Cost economics for cucumber:

The maximum cost of production (Table 9) was observed in treatment combinations transparent polythene mulch with irrigation at 100 per cent ET by drip (95,046/- ha^{-1}) followed by treatment combinations transparent polythene mulch with irrigation at 75 per cent ET by drip (87,396/- ha^{-1}) and transparent polythene mulch with irrigation at 75 per cent ET by drip (Rs. 85,946/- ha^{-1}). The gross monetary returns show the same trend.

The maximum net monetary returns was gained from treatment combination transparent polythene mulch with irrigation at 100 per cent ET by drip (Rs.85,704/-) followed by transparent polythene mulch with control irrigation (Rs. 47,604 ha^{-1}) and black polythene mulch with irrigation at 100 per cent ET by drip (Rs.47,260/-), whereas minimum net income was reported in black polythene mulch with irrigation at 50 per cent ET by drip treatment combination (Rs. 10,594 ha^{-1}). The maximum B:C ratio was observed in treatment combination transparent polythene mulch with irrigation at 100 per cent ET by drip (1.90), followed by straw mulch with irrigation at 100 per cent ET by drip (1.73) and without mulch with irrigation at 100 per cent ET by drip (1.70) and straw mulch with irrigation at 75 per

Table 1. Depth of water applied and saving of water in different irrigation levels

Sr. No.	Irrigation levels	Depth of water applied, (cm)	Per cent saving in water over control
1.	Control	40.00	-
2.	50 % ET by drip irrigation	11.71	70.73
3.	75 % ET by drip irrigation	17.56	56.09
4.	100 % ET by drip irrigation	23.42	41.46

Table 2. Effect of mulches and irrigation levels on vine length

	MT_1	MT_2	MT_3	MT_4	Mean
IL_1	140.75	199.67	183.00	170.30	173.43
IL_2	155.80	203.20	192.50	181.80	183.33
IL_3	137.40	178.55	166.40	153.80	159.04
IL_4	126.45	153.90	143.00	136.85	140.05
Mean	140.10	183.83	171.23	160.69	

	Mulches	Irrigation levels	Two main plot at same subplot	Two subplot at same main
SE	0.05	0.08	0.15	0.16
CD at 5 %	0.16	0.23	0.43	0.46

Table 3. Effect of mulches and irrigation levels on number of leaves vine^{-1}

	MT_1	MT_2	MT_3	MT_4	Mean
IL_1	71.70	107.88	107.01	105.97	98.14
IL_2	89.20	115.29	107.42	97.90	102.45
IL_3	71.57	99.22	86.32	79.47	84.15
IL_4	59.66	79.57	68.15	56.47	65.96
Mean	73.03	100.49	92.23	84.96	

	Mulches	Irrigation levels	Two main plot at same subplot	Two subplot at same main
SE	0.09	0.15	0.27	0.30
CD at 5 %	0.28	0.42	0.78	0.85

Table 4. Effect of mulches and irrigation levels on number of branches vine^{-1}

	MT_1	MT_2	MT_3	MT_4	Mean
IL_1	8.15	9.55	9.10	8.55	8.84
IL_2	7.95	9.35	9.00	8.70	8.75
IL_3	7.75	8.75	8.40	8.00	8.23
IL_4	6.75	8.00	7.50	7.35	7.40
Mean	7.65	8.91	8.50	8.15	

	Mulches	Irrigation levels	Two main plot at same subplot	Two subplot at same main
SE	0.05	0.06	0.12	0.13
CD at 5 %	0.15	0.18	0.34	0.36

Table 5. Effect of mulches and irrigation levels on number of fruits vine^{-1}

	MT_1	MT_2	MT_3	MT_4	Mean
IL_1	16.21	28.79	24.10	14.50	20.90
IL_2	18.81	22.12	15.60	15.79	18.08
IL_3	12.10	22.06	19.30	17.07	17.63
IL_4	17.30	28.39	20.96	23.04	22.42
Mean	16.11	25.34	19.99	17.60	

	Mulches	Irrigation levels	Two main plot at same subplot	Two subplot at same main
SE	0.08	0.11	0.21	0.23
CD at 5 %	0.24	0.32	0.60	0.64

Table 6. Statistical analysis of average yield of fruits (q ha^{-1})as influenced by different treatments

	MT_1	MT_2	MT_3	MT_4	Mean
IL_1	160.3	252.2	224.0	193.0	207.38
IL_2	128.6	179.4	164.2	160.3	158.13
IL_3	193.0	270.0	233.9	205.9	225.70
IL_4	201.2	361.5	252.2	210.9	256.45
Mean	170.78	265.78	218.58	192.53	

	Mulches	Irrigation levels	Two main plot at same subplot	Two subplot at same main
SE	1.24	1.48	2.84	2.95
CD at 5 %	3.83	4.19	8.08	8.39

Table 7. Average yield of fruits as influenced by different treatment combinations

Sr. No.	Treatments	Yield (q ha^{-1})
1.	MT_1 IL_1	160.3
2	MT_1 IL_2	128.6
3.	MT_1 IL_3	193.0
4.	MT_1 IL_4	201.2
5.	MT_2 IL_1	252.2
6.	MT_2 IL_2	179.4
7.	MT_2 IL_3	270.0
8.	MT_2 IL_4	361.5
9.	MT_3 IL_1	224.0
10.	MT_3 IL_2	164.2
11.	MT_3 IL_3	233.9
12.	MT_3 IL_4	252.2
13.	MT_4 IL_1	193.0
14.	MT_4 IL_2	160.3
15.	MT_4 IL_3	205.9
16.	MT_4 IL_4	210.9
	SE	0.30
	CD at 5 %	0.84

Table 8. Water use efficiency as influenced by different treatments

	MT$_1$	MT$_2$	MT$_3$	MT$_4$	Mean
IL$_1$	4.01	6.31	5.60	4.83	5.18
IL$_2$	10.94	15.27	13.97	13.64	13.46
IL$_3$	10.99	15.38	13.32	11.73	12.85
IL$_4$	8.59	15.44	10.77	9.01	10.95
Mean	8.63	13.10	10.92	9.80	

	Mulches	Irrigation levels	Two main plot at same subplot	Two subplot at same main
SE	0.05	0.08	0.15	0.16
CD at 5 %	0.16	0.23	0.43	0.46

Table 9. Cost economics of cucumber

Sr. No.	Trea tments	Cost of production (Rs. ha^{-1})	Gross monetary returns (Rs.)	Net benefit (Rs.)	B:C ratio
1.	MT$_1$ IL$_1$	55,649	80,150	24,501	1.44
2	MT$_1$ IL$_2$	53,007	64,300	11,293	1.21
3.	MT$_1$ IL$_3$	58,374	96,500	38,126	1.65
4.	MT$_1$ IL$_4$	59,057	1,00,600	41,543	1.70
5.	MT$_2$ IL$_1$	85,946	1,26,300	40,354	1.46
6.	MT$_2$ IL$_2$	79,846	89,700	9,854	1.12
7.	MT$_2$ IL$_3$	87,396	1,35,000	47,604	1.54
8.	MT$_2$ IL$_4$	95,046	1,80,750	85,704	1.90
9.	MT$_3$ IL$_1$	76,490	1,12,000	35,510	1.46
10.	MT$_3$ IL$_2$	71,507	82,100	10,594	1.14
11.	MT$_3$ IL$_3$	77,315	1,16,950	39,635	1.51
12.	MT$_3$ IL$_4$	78,840	1,26,100	47,260	1.59
13.	MT$_4$ IL$_1$	59,403	96,500	37,097	1.62
14.	MT$_4$ IL$_2$	56,678	80,150	23,472	1.41
15.	MT$_4$ IL$_3$	60,476	1,02,950	42,474	1.70
16.	MT$_4$ IL$_4$	60,895	1,05,450	44,555	1.73

cent ET by drip (1.70) and the least was found in treatment combination of transparent polythene mulch with irrigation at 50 per cent ET by drip (1.12).

The treatment combination of transparent polythene mulch with irrigation at 100 per cent ET by drip gave the highest B:C ratio of 1.90, as it gave the highest gross monetary returns of Rs. 1,80,750/- at the cost of production of Rs. 95,046/-. This indicates the superiority of this treatment combination in giving the highest yield of crop. In case of straw mulch with irrigation at 100 per cent ET by drip the gross monetary returns were (Rs. 1,05,450/-) lower than the transparent polythene mulch with irrigation at 75 per cent ET by drip (Rs.1,35,000/-). The cost of production of the former combination (Rs. 60,895/-) was lower than that of later combination (Rs.87,396/-).

Hence, the treatment combination of transparent mulch with irrigation level of 100 per cent ET by drip may be recommended for obtaining higher monetary returns and higher B:C ratio for the cucumber crop.

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