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Study of weed parameters under plastic mulch, irrigation methods and levels in Junagadh, Gujarat

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Abstract
A field experiment was conducted in order to study the weed parameters under plastic mulch, irrigation methods and levels. The effect of three irrigation levels viz.; 1.0 ET_c (I_1), 0.8 ET_c (I_2) and 0.6 ET_c (I_3) in combination with four cultivation practices; silver black plastic mulch (M_1), no mulch (M_2), flat bed with drip irrigation (M_3) and border irrigation (M_4) were studied on crop growth and yield response. The experiment was laid out in large plot technique taking twelve treatment combinations replicated thrice. The treatment combination of 0.6 ET_c with silver black plastic mulch resulted in minimum weed intensity of 13.00 nos/m^2, 32.67 nos/m^2 and 35.67 nos/m^2 at 30 DAS, 60 DAS and at harvest respectively. Significantly maximum weed intensity of 216.67 nos/m^2, 390.00 nos/m^2 and 431.00 nos/m^2 were observed in 1.0 ET_c with border irrigation at 30 DAS, 60 DAS and at harvest respectively. The treatment combination of 0.6 ET_c with silver black plastic mulch resulted in minimum dry weight of weed 2.00 g/m^2, 11.67 g/m^2 and 16.10 g/m^2 at 30 DAS, 60 DAS and at harvest respectively. Significantly highest dry weight of weed 85.00 g/m^2, 219.03 g/m^2 and 202.33 g/m^2 were observed in 1.0 ET_c with border irrigation at 30 DAS, 60 DAS and at harvest respectively. Overall it could be concluded that 0.6 ET_c irrigation levels along with silver black plastic mulch was found most economical and obtained least number of weed.

Keywords: Sliver black plastic mulch, no mulch, drip irrigation, border irrigation, cucumber

1. Introduction
The cucumber (*Cucumis sativus* L.) is one of the most important fruit vegetables grown in the tropic and temperate regions of the world. It belongs to the gourd family Cucurbitaceae (Ajibola and Amujoyegbe, 2019) [4]. The cucumber responds like a thermopile crop which grows best under conditions of high temperature, humidity, and light intensity and with an uninterrupted supply of water and nutrients. The optimum daily average air temperature is 15-24 ºC.
Cucumber is one of the most profitable summer vegetables. For enhancing its production of in Gujarat, proper cultivation practice has to be brought into practice. During the summer season the temperature goes up to 45 ºC in Saurashtra region of Gujarat and the region is also facing water scarcity during summer, therefore judicious use of water is necessary. In order to meet these requirements, mulching technology can be adopted.
To be competitive in today's market place, plasticulture is a management tool that enables vegetable growers realize greater returns per unit land (Lamont, 1999a) [12], such as earliness of harvesting, higher yields per unit area (two to three times higher), cleaner and higher quality produce, more efficient use of water resources, reduced leaching of fertilizers especially on light sandy soils, more efficient use of fertilizer input through fertigation technology, reduced soil and wind erosion, potential decrease in the incidence of diseases, better management of certain insect pests, fewer weed problem, reduced soil compaction, and opportunity for extended production cycles (double or triple cropping) with maximum efficiency.

2. Materials and Methods
2.1 Location & Experimental Site
The experiment was conducted at the field of Renewable Energy Engineering Department, CAET, Junagadh Agricultural University, Junagadh, located at 21.5^o N latitude and 70.1^o E longitude with an altitude of 61.20 meters above MSL. The climate of the experimental area is typically subtropical and semi-arid type. The study area is having an average annual rainfall of 900 mm and average pan evaporation of 5.6 mm/d.

2.2 Field Experimental Details
The experiment was undertaken to evaluate the combined impact of two irrigation methods; drip irrigation and border irrigation, three irrigation levels; 1.0 ET_c, 0.8 ET_c, 0.6 ET_c, and silver black plastic mulch (20 µm), along with raised bed with no mulch treatment on summer cucumber. The details of the experimental design adopted were as described Table 1.

Table 1: Treatments

Main factor: Irrigation levels	**Sub Factor:** Cultivation practices
(I_1) Irrigation with 1.0 ET_c	(M_1) Silver black plastic mulch+ Raised bed+ Drip
(I_2) Irrigation with 0.8 ET_c	(M_2) No mulch + Raised bed + drip
(I_3) Irrigation with 0.6 ET_c	(M_3) Drip irrigation on flat bed
	(M_4) Border irrigation

2.3 Plot Size:
a) Plot size of treatment: 3.0 m × 7.2 m
b) Plot size of replication: 3.0 m × 2.4 m
c) Plot size of experiment: 18.0 m × 18.3 m

The experimental layout of the field is shown in the figure 1 and the treatment details are shown in the table 2

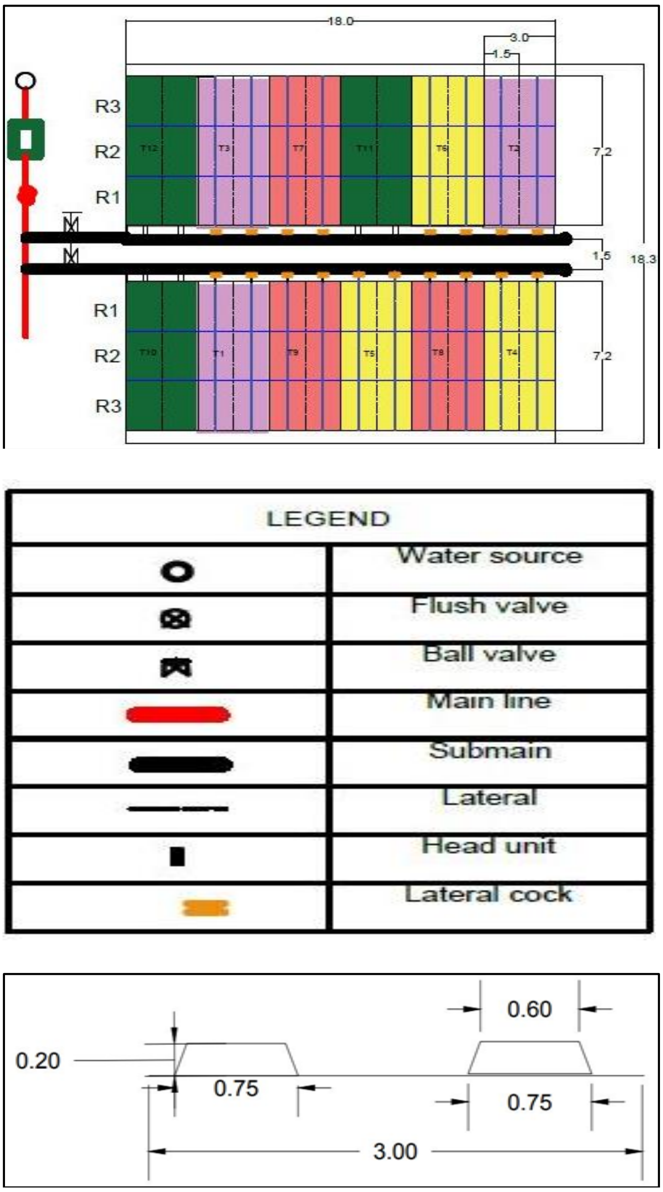

Fig 1: Experimental layout of the field

Table 2: Details of Treatments

Treatment	Cultivation practices	Irrigation level
I_1M_1 (T_1)	Silver black plastic mulch: 20 µm	1.0 ET_c
I_2M_1 (T_2)	Silver black plastic mulch: 20 µm	0.8 ET_c
I_3M_1 (T_3)	Silver black plastic mulch: 20 µm	0.6 ET_c
I_1M_2 (T_4)	No mulch (Raised bed with drip irrigation)	1.0 ET_c
I_2M_2 (T_5)	No mulch (Raised bed with drip irrigation)	0.8 ET_c
I_3M_2 (T_6)	No mulch (Raised bed with drip irrigation)	0.6 ET_c
I_1M_3 (T_7)	Flat bed with drip Irrigation	1.0 ET_c
I_2M_3 (T_8)	Flat bed with drip Irrigation	0.8 ET_c
I_3M_3 (T_9)	Flat bed with drip Irrigation	0.6 ET_c
I_1M_4 (T_{10})	Border irrigation	1.0 ET_c
I_2M_4 (T_{11})	Border Irrigation	0.8 ET_c
I_3M_4 (T_{12})	Border Irrigation	0.6 ET_c

2.4 Experimental Field Establishment
The practices adopted during the experiment are summarized in Table 3.

Table 3: Practices Adopted During the Experiment

Sr. No.	Particulars	Details
1	Crop	Cucumber (*Cucumis sativus* L.)
2	Variety	Arya GS22
3	Sowing method	Manual
4	Date of sowing	03/03/2018
5	Seed rate	1.10 kg/ha
6	Crop spacing (PP × RR)	0.30 m × 0.20 m
7	Fertilizer dose (N : P : K)	50 : 25 : 25 kg/ha
8	Weeding	Manual (three times in total)
9	Irrigation practices	Alternate days as per treatments
10	Plant protection (insecticides, pesticides)	Manually as per disease/pest indication
11	First picking	16/04/2018
12	Harvesting of cucumber (picking)	Manually in alternate days
13	Last picking	29/05/2018
14	Date of crop uprooting	11/06/2018

2.4 Irrigation Scheduling
2.4.1 Calculation of reference evapotranspiration, ET_0
Allen *et al.* (1998) [6] published the FAO paper no. 56 and defined the Penman-Monteith ET_0. The FAO Penman-Monteith method to estimate ET_0 (Allen *et al.*, 1998) [6] using daily or monthly data is given by,

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \dfrac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

The information about the K_c of cucumber is drawn from FAO-56 (Allen *et al.*, 1998) [6], which is considered as the major document for guiding irrigation water management in crops grown in different agro-climatic regions. Therefore crop coefficient (K_c) values for cucumber are 0.60, 1.00, 0.90 to be used during initial growth stage, mid growth stage, and maturity stage of cucumber, to estimate the crop evapotranspiration ET_c. Plastic mulches substantially reduce the evaporation of water from the soil surface. The transpiration rates under mulch may increase by an average of 10-30% over the growing season as compared to using no mulch and the K_c values decrease by an average of 10-30% due to the 50-80% reduction in soil evaporation. The value for K_c ini under mulch is often as low as 0.10 (Allen *et al*., 1998) [6].

The crop evapotranspiration ET_c, is calculated by multiplying the reference crop evapotranspiration, ET_0, by a crop coefficient, K_c. i.e $ET_c = K_c \times ET_0$

Irrigation water requirement based on irrigation level can be calculated by using the equation below, $IW = L \times ET_c$

2.4.2 Observations Recorded

Weed parameters

1. Weed intensity
2. Weed dry weight

3. Results and Discussion

3.1 Crop Coefficient Values of Cucumber for No Mulch and Plastic Mulch Condition

The moisture loss is related to the evapotranspiration (ET_c) of a particular crop due to various factors such as solar radiation, crop stage and ground cover etc. In plastic mulched soils, the mulch provides a partial barrier to vapour flow between the soil and the atmosphere and causes a return flow of water after condensation under the mulch. The crop transpiration rates under plastic mulch may increase by an average of 10 - 30% over the season as compared to using no mulch, but K_c value decreases by an average of 10 - 30% due to 50 - 80% reduction in soil evaporation

Table 4: K_c Values for Cucumber under Mulch and No Mulch Conditions

Plant growth stage	DAS	K_c value	
		No mulch	Mulch
Initial	1 to 15	0.6	0.1
Development	16 to 40	0.6-1.0	0.1-0.8
Mid-season	41 to 80	1.0	0.8
Late season	81 to 90	1.0-0.9	0.8-0.72

3.2 Stage Wise Irrigation Water Requirement of Cucumber

The reference evapotranspiration (ET_0) was calculated using FAO Penman-Monteith equation. Multiplication of ET_0 and adjusted K_c gives the crop evapotranspiration. The depth of water applied for different levels of irrigation under no mulch and mulch conditions during different crop growth stage is presented in Table 5.

Table 5: Depth of water applied in cucumber, mm

Plant growth stages	Border			Drip			Mulch		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
Pre Sowing	50	50	50	50	50	50	50	50	50
Initial	55.1	44.0	33.0	42.8	34.2	25.7	7.1	5.7	4.2
Development	120.7	96.5	72.4	93.9	75.1	56.3	70.4	56.3	42.2
Mid-season	351.9	281.5	211.1	273.7	218.9	164.2	216.8	173.4	130.0
Late season	89.6	71.7	53.8	69.7	55.8	41.8	64.0	51.2	38.4
Total	667.4	543.9	420.4	530.2	434.1	338.1	408.4	336.7	265.0
Water saving (%)	-	-	-	20.55	20.18	19.58	38.80	38.10	36.97

3.3 Weed Parameters

3.3.1 Weed intensity (weed count/m^2)

Weed intensity at 30 DAS, 60 DAS and harvest was observed and interpreted. The interpreted data are presented in Table 3, 4 and 5 and depicted in Fig. 6, 7 and 8 respectively. Statistical analysis was carried out to find the effect of different cultivation practices and irrigation levels on weed intensity (weed count/m^2) and C.D. and S.Em. influenced by all variables are taken into account in the present study.

3.3.1.1 Effect of cultivation practices and irrigation levels on weed intensity at 30 DAS

Interaction effect

Data of interaction between cultivation practices and irrigation levels on weed intensity at 30 DAS is presented in figure 2. The results indicated that the treatment combinations of cultivation practices and irrigation levels had significantly influenced the weed intensity at 30 DAS. The treatment combination I_3M_1 (0.6 ET_c with silver black plastic mulch) resulted in minimum weed intensity of 13.00 nos/m^2 and was at par with treatment combinations I_2M_1 (0.8 ET_c with silver black plastic mulch), I_1M_1 (1.0 ET_c with silver black plastic mulch). Maximum weed intensity of 216.67 nos/m^2 was observed in treatment combination I_1M_4 (1.0 ET_c with border irrigation) and it was at par with I_2M_4 (0.8 ET_c with border irrigation).

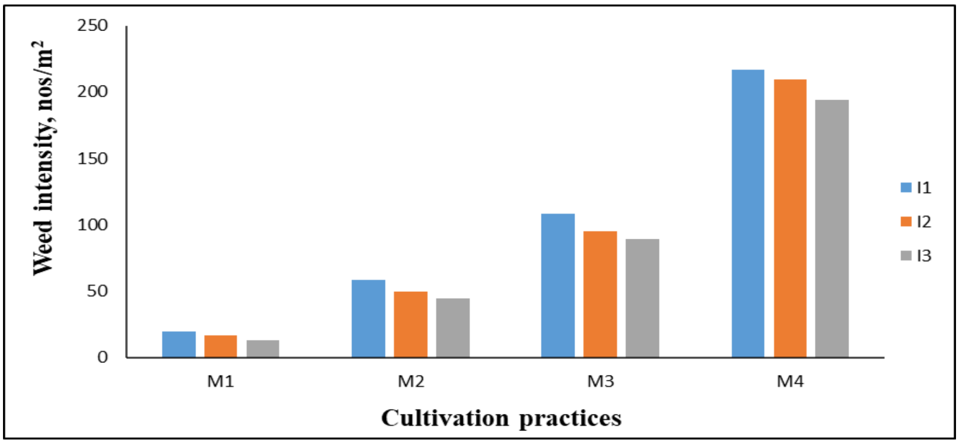

Fig 2: Effect of irrigation level and cultivation practices on weed intensity at 30 DAS

3.3.1.2 Effect of irrigation levels and cultivation practices on weed intensity at 60 DAS

Interaction effect

Data of interaction between cultivation practices and irrigation levels on weed intensity at 60 DAS is shown in figure 3. The results revealed that the treatment combinations of different cultivation practices and irrigation levels had significantly influenced the weed intensity at 60 DAS. The treatment combination I_3M_1 (0.6 ET_c with silver black plastic mulch) resulted in minimum weed intensity of 32.67 nos/m^2 and was at par with treatment combinations I_1M_1 (1.0 ET_c with silver black plastic mulch), I_2M_1 (0.8 ET_c with silver black plastic mulch). Maximum weed intensity of 390.00 nos/m^2 was found significantly higher than the rest of treatment combinations observed in treatment combination of I_1M_4 (1.0 ET_c with border irrigation) and was found significantly higher than rest of the treatment combinations.

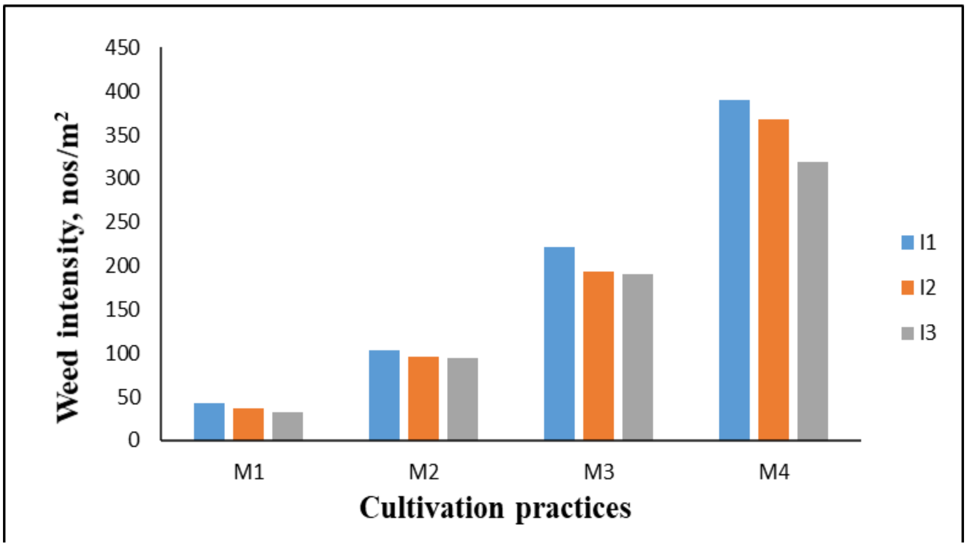

Fig 3: Effect of irrigation levels and cultivation practices on weed intensity at 60 DAS

3.3.1.3 Effect of irrigation levels and cultivation practices on weed intensity at harvest stage

Interaction effect

Data of interaction between cultivation practices and irrigation levels on weed intensity at harvest stage is depicted in figure 4. The results indicated that the treatment combinations of cultivation practices and irrigation levels had influenced the weed intensity at harvest stage. The treatment combination I_3M_1 (0.6 ET_c with silver black plastic mulch) resulted in minimum weed intensity of 35.67 nos/m^2 and was at par with treatment combinations I_1M_1 (1.0 ET_c with silver black plastic mulch), I_2M_1 (0.8 ET_c with silver black plastic mulch). Maximum weed intensity of 431.00 nos/m^2 was observed in treatment combination of I_1M_4 (1.0 ET_c with border irrigation) and it was at par with I_2M_4 (0.8 ET_c with border irrigation).

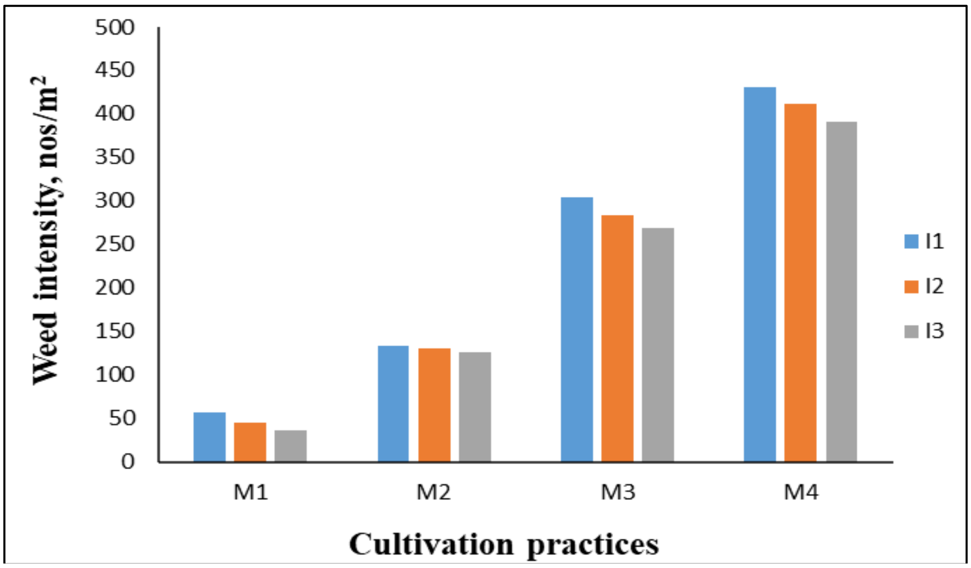

Fig 4: Effect of irrigation levels and cultivation practices on weed intensity at harvest stage

3.3.2 Dry weight of weed (g/m^2)

Dry weight of weed at 30 DAS, 60 DAS and harvest stage was observed and interpreted. The data of dry weight of weed at 30 DAS, 60 DAS and harvest stage are depicted in Fig. 5, 6 and 7. Statistical analysis was carried out to find the effect of irrigation levels and cultivation practices on dry weight of weed (g/m^2) and C.D. and S.Em. influenced by all variables are taken into account in the present study.

3.3.2.1 Effect of irrigation levels and cultivation practices on dry weight of weed at 30 DAS

Interaction effect

Data regarding interaction between irrigation and cultivation practices on dry weight of weed at 30 DAS are presented in figure 5. The result revealed that the lowest dry weight of weed was observed in treatment combination I_3M_1 (0.6 ETc with silver black plastic mulch) (2.00 g/m^2) which was at par with treatment combinations I_2M_1 (0.8 ET_c with silver black plastic mulch) and I_1M_1 (1.0 ET_c with silver black plastic mulch). The highest dry weight of weed was recorded in treatment combination of I_1M_4 (1.0 ET_c with border irrigation) (85.00 g/m^2) and it was significantly higher than rest of the treatments.

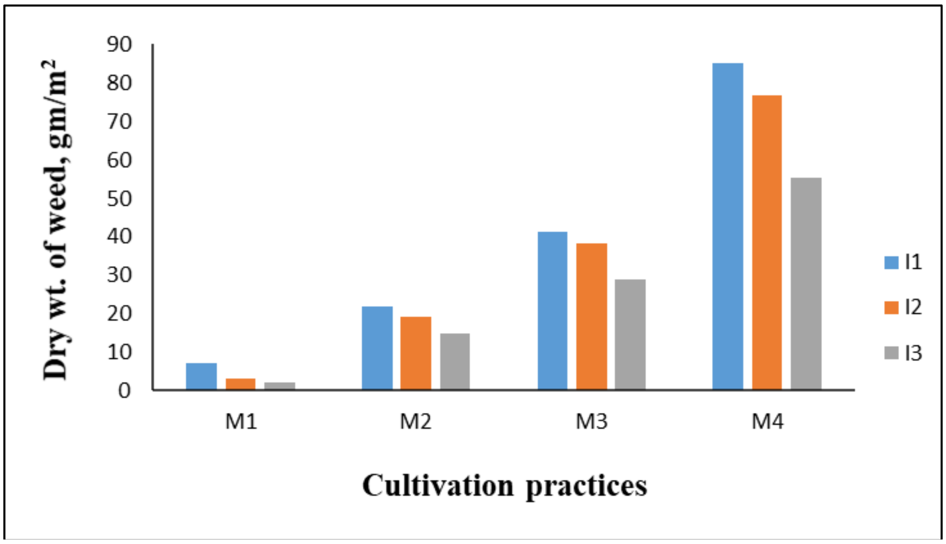

Fig 5: Effect of irrigation levels and cultivation practices on dry weight of weed at 30 DAS

3.3.2.2 Effect of irrigation levels and cultivation practices on dry weight of weed at 60 DAS

Interaction effect

Data regarding interaction between irrigation and cultivation practices on dry weight of weed at 60 DAS are depicted in figure 6. The result indicated that the lowest dry weight of weed was observed in treatment combination I_3M_1 (0.6 ET_c with silver black plastic mulch) (11.67 g/m^2) which was at par with treatment combinations I_2M_1 (0.8 ET_c with silver black plastic mulch), I_1M_1 (1.0 ET_c with silver black plastic mulch). The highest dry weight of weed was recorded in treatment combination of I_1M_4 (1.0 ET_c with border irrigation) (219.03 g/m^2) and it was significantly higher than the rest of treatment combinations.

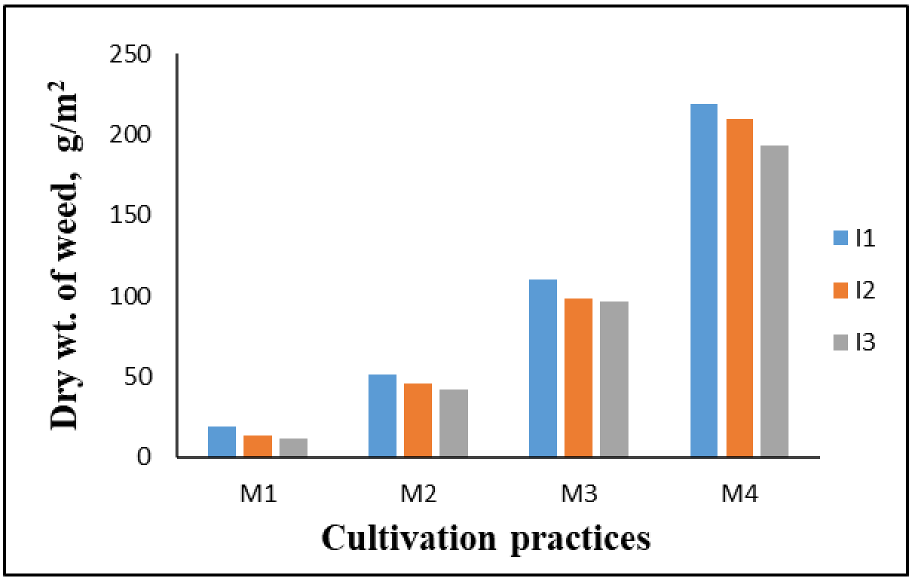

Fig 6: Effect of irrigation levels and cultivation practices on dry weight of weed at 60 DAS

3.3.2.3 Effect of irrigation levels and cultivation practices on dry weight of weed at harvest

Interaction effect

Data regarding interaction between irrigation levels and cultivation practices on dry weight of weed at harvest stage are presented in figure 7. The result revealed that the lowest dry weight of weed was observed in treatment combination I_3M_1 (0.6 ET_c with silver black plastic mulch) (16.10 g/m^2) which was at par with treatment combinations I_2M_1 (0.8 ET_c with silver black plastic mulch), I_1M_1 (1.0 ET_c with silver black plastic mulch). The silver black plastic mulch suppressed the maximum amount of weed. The highest dry weight of weed of 202.33 g/m^2 was observed in treatment combination of I_1M_4 (1.0 ET_c with border irrigation) and it was at par with treatment combination I_2M_4 (0.8 ET_c with border irrigation).

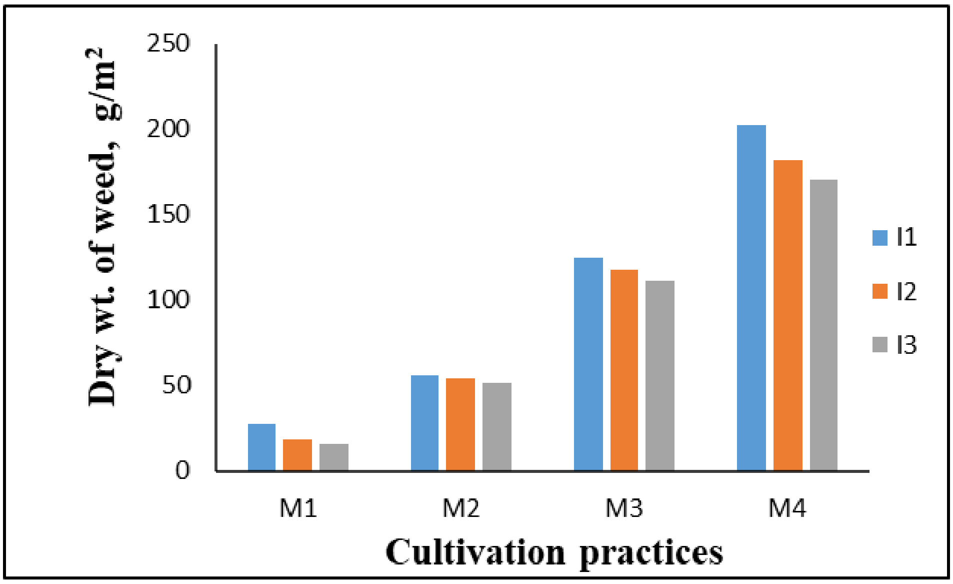

Fig 7: Effect of irrigation levels and cultivation practices on dry weight of weed at harvest stage

Above results indicated that the different irrigation levels and cultivation practices had a significant effect on weed intensity and dry weight of weed. The weed intensity and dry weight of weed were observed lowest in silver black plastic mulch. The silver black plastic mulch suppressed weed growth due to less exposure of weed seeds to sunlight. The results obtained were in harmony with those of Shrivastava *et al.* (1994), Prasad (1996) [15], Lamont (1999) [12], Rajablariani *et al.* (2012) [16], Aminu-Taiwo *et al*. (2014) [7], Naik *et al.* (2015) [14], and Bobby *et al*. (2017) [9]. They revealed that the silver black plastic mulch suppressed the weed growth to a maximum extent as compared to no mulch condition. Weed intensity and dry weight of weed was found lowest in the treatment combination I_3M_1 (0.6 ET_c with silver black plastic mulch). The weed intensity as well as dry weight of weed increased as the amount of irrigation increased and thus more weed intensity and dry weight of weed was observed in I_1 (1.0 ET_c) irrigation treatment.

4. Summary and Conclusions

The use of drip irrigation in combination with plastic mulch was found significantly superior for reducing the weed growth. From the experiment results, it could be concluded that 0.6 ET_c irrigation level along with silver black plastic mulch was most economical and obtained least weed intensity as. Therefore drip irrigation scheduled at 0.6 ET_c in combination with silver black plastic mulch can be adopted so as to minimize weed intensity in agricultural regions of Gujarat state.

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