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Yield and Water use Efficiency of Cucumber under Plastic Mulch and Micro Irrigation

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A B S T R A C T

A field experiment was conducted in order to study the cucumber (*Cucumis sativus* L.) yield response to 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 0.8 ET_c with silver black plastic mulch resulted in maximum crop yield (22543.33 kg/ha) and water use efficiency (78.62 kg/ha-mm). Overall it could be concluded that 0.8 ET_c irrigation levels along with silver black plastic mulch was found most economical and obtained highest crop yield of summer cucumber with best water use efficiency.

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). 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.

Mulches are used for several purposes in agricultural crop production, out of those soil moisture conservation and erosion control are the major objectives, specifically in arid and semi-arid regions like Gujarat. The useful response of crops to mulch includes earlier production, increased yield and superior quality.

The use of different types of mulches has been found to be helpful in conserving moisture, controlling weeds, moderating soil temperature, and also increasing the yield of different vegetable crops.

Materials and Methods

Location & experimental site

The experiment was conducted at the field of Renewable Energy Engineering Department, CAET, Junagadh Agricultural University, Junagadh, located at 21.5° N latitude and 70.1° 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.

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.

Plot size

Plot size of treatment: 3.0 m × 7.2 m
Plot size of replication: 3.0 m × 2.4 m
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.

Experimental field establishment

The practices adopted during the experiment are summarized in Table 3.

Irrigation scheduling

Calculation of reference evapotranspiration, ET_0

Allen *et al.,* (1998) 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) using daily or monthly data is given by,

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

The information about the K_c of cucumber is drawn from FAO-56 (Allen *et al*., 1998), 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). 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, $IW = L \times ET_c$

Results and Discussion

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

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.

Effect of irrigation levels and cultivation practices on crop yield (kg/ha)

The statistical analysis of the effect of different irrigation levels and cultivation practices on cucumber crop yield was carried out and the analysed data accounted in Table 7and Figure 2with C.D. and S.Em. influenced by all the variables are explained in the present study.

Effect of cultivation practices

The data presented in Table 5 reveals that the cucumber crop yield was influenced significantly by different cultivation practices. Crop yield observed in M_1 (silver black plastic mulch) treatment (20654.00 kg/ha) was found highest and it was found significantly higher than the rest of treatments. Lowest crop yield of 4623.99 kg/ha was observed in M_4 (border irrigation) treatment and it was observed significantly lower than the rest of the treatments.

The crop yield obtained in M_1 (silver black plastic mulch) treatment was observed to be 446.67 % higher than M_4 (border irrigation). These results are closely related to the results obtained by Tyagi and Sharma (2013) in watermelon.

Effect of irrigation levels

A significant difference in crop yield was observed due to different levels of irrigation (Table 4.17). The crop yield of 11411.83 kg/ha recorded with I_2 (0.8 ET_c) irrigation level was found significantly higher than the rest of irrigation treatments. Lowest crop yield of 9734.50 kg/ha was observed in I_3 (0.6 ET_c) irrigation level and it was found significantly lower than the rest of irrigation treatments.

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

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

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

Table.4 Observations Recorded

Weed parameters	Crop parameters
1. Weed intensity (no./m^2): **2. Dry weight of weed (g/ m^2)**	Plant height Vine length Height of plant (in cm) at harvesting stage Number of nodes per plant Dimensions of the fruit Number of fruits per plant Weight of fruits per plant Crop yield Water use efficiency

Table.5 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

Table.6 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**

Table.7 Effect of irrigation levels and plastic mulch on crop yield (kg/ha)

Irrigation	Cultivation practices				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**
I_1	20960.67	6881.00	12985.00	4819.66	11411.83
I_2	22543.33	8891.33	15181.00	5191.33	12951.74
I_3	15828.00	5631.00	10988.00	3861.00	9734.50
Mean	20654.00	7134.44	13051.33	4623.99	
	Mulching	**Irrigation**	**Interaction**		
S.Em. ±	71.65	62.05	124.11		
C.D. at (5 %)	209.15	181.13	362.26		
C.V. (%)	-	-	1.89		

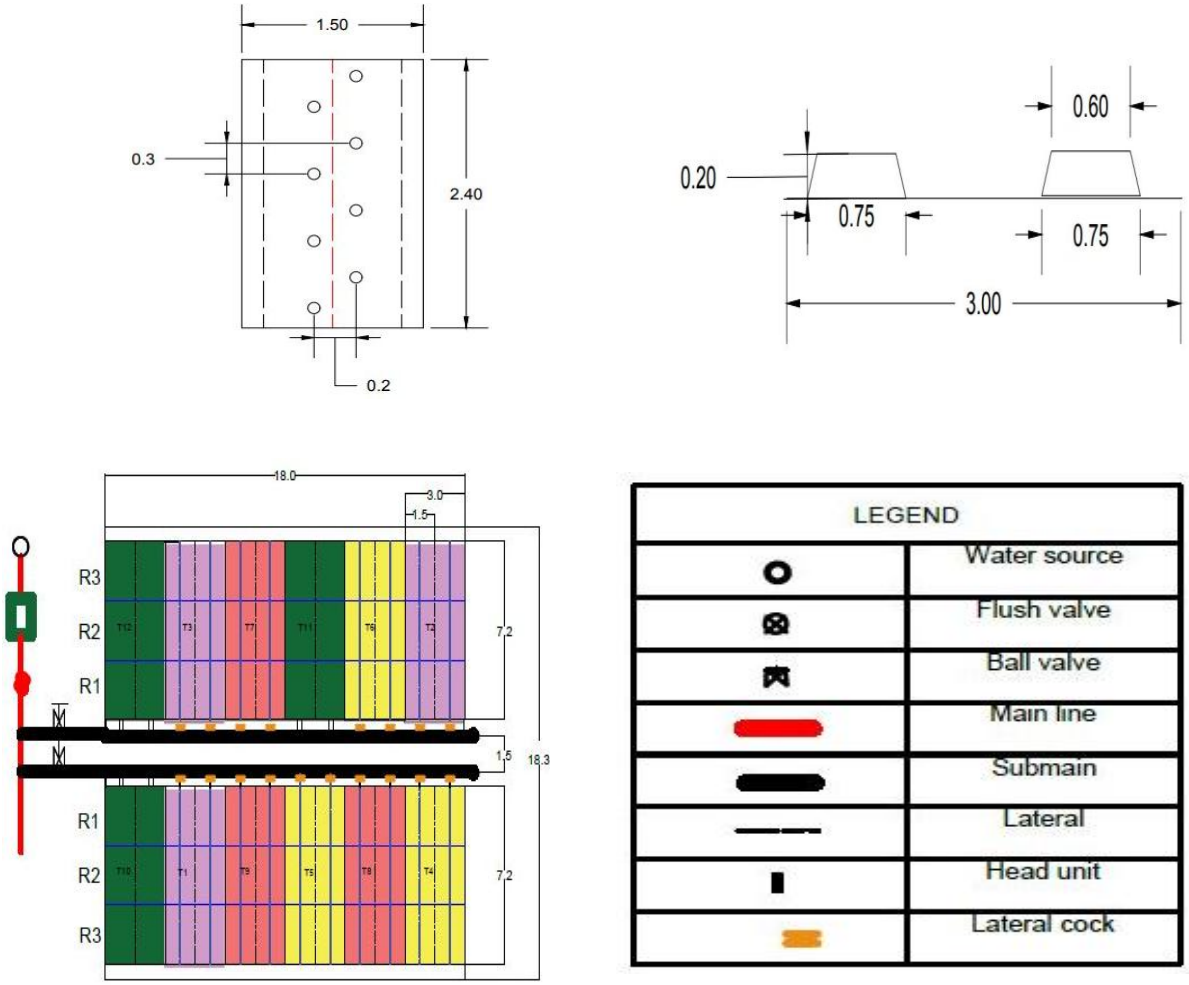

Fig.1 Experimental layout of the field

Table.8 Effect of irrigation levels and cultivation practices on water use efficiency

Treatment	Mean yield (kg/ha)	Irrigation depth (mm)	WUE (kg/ha-mm)
I_1M_1	20,960.67	358.43	58.48
I_2M_1	22,543.33	286.72	78.62
I_3M_1	15,828.00	215.04	73.60
I_1M_2	6,881.00	480.24	14.32
I_2M_2	8,891.33	384.19	23.14
I_3M_2	5,631.00	288.14	19.54
I_1M_3	12,985.00	480.24	27.03
I_2M_3	15,181.00	384.19	39.51
I_3M_3	10,988.00	288.14	38.13
I_1M_4	4,819.67	617.44	7.80
I_2M_4	5,191.33	493.96	10.50
I_3M_4	3,861.00	370.47	9.97

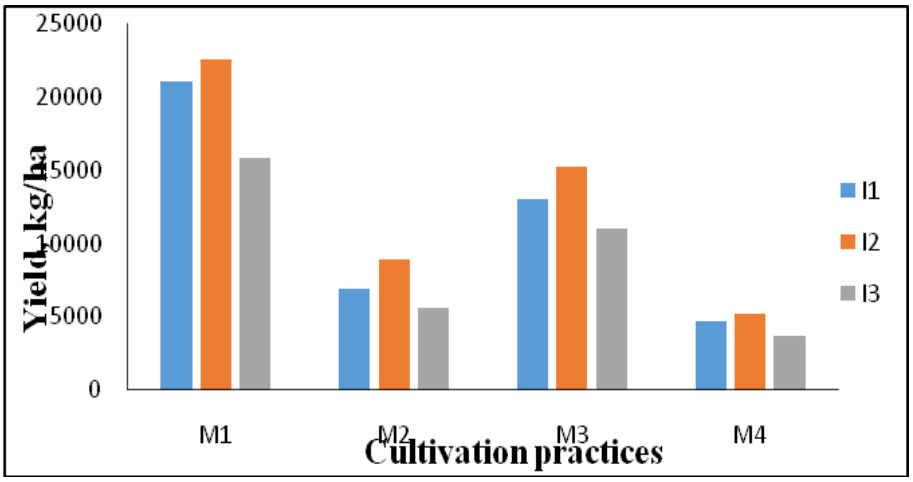

Fig.2 Effect of Irrigation Levels and Cultivation Practices on Crop Yield (kg/ha)

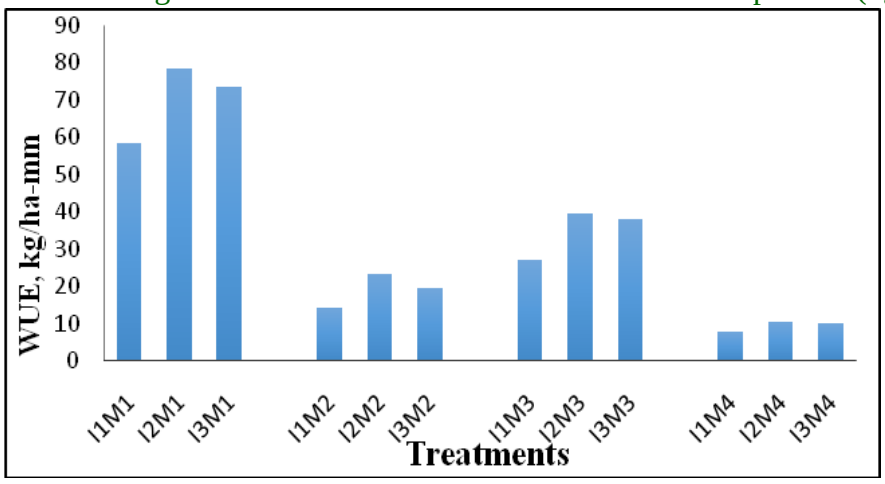

Fig.3 Effect of irrigation levels and cultivation practices on water use efficiency

Crop yield under I_2 (0.8 ET_c) was observed to be 117.23 % higher than that with I_4 (0.6 ET_c). These results are found similar to the ones obtained by Agrawal and Agrawal (2005) in banana, Harmanto *et al.,* (2005) in tomato and Abubaker *et al.,* (2014) in okra.

Interaction effect

Data regarding interaction between irrigation levels and cultivation practices on crop yield are tabulated in Table 6. The result revealed that the highest crop yield was observed in treatment combination of I_2M_1 (0.8 ET_c with silver black plastic mulch) (22543.33 kg/ha) and it was found significantly higher than the rest of treatment combinations. The findings obtained were in close agreement to those of Singh (2007), Singh *et al.,* (2009) and Zhang *et al.,* (2017) in tomato. The lowest crop yield of 3861.00 kg/ha was recorded in treatment combination of I_3M_4 (0.6 ET_c with border irrigation) and it was observed to be at par with I_3M_2 (0.6 ET_c with no mulch). The higher yield production under 0.80 ET may be due to proper balance of moisture in plants, which creates favorable conditions for nutrients uptake, photosynthesis and metabolites translocation.

Other possibility was increasing available water and nutrients uptake which ultimately accelerated the rate of vegetative growth and yield (Saleh and Ozawa, 2006).Crop yield under silver black plastic mulch was observed to be higher than border irrigation treatment by 446.67 %. These data are in close relation with data obtained by Wien and Menotti (1987) in tomatoes. The higher soil moisture content maintained under plastic mulched treatments and better control of weed than in the bare soil plots had positively reflected on the vegetative and yield parameters. Consequently, use of silver black plastic mulch as soil cover increased the yield of cucumber.

Water use efficiency

Crop water use efficiency is the yield of crop produce per unit of crop water use. It is the degree to which a crop is capable of switching water into yield of crop. The data on water use efficiency of cucumber is given in Table 4.6 and it is graphically represented in Fig. 3.

Interaction effect

The water use efficiency of different combinations of irrigation levels and cultivation practices are represented in Table 4.18 and Fig. 4.21. Maximum water use efficiency was obtained in treatment combination I_2M_1 (0.8 ET_c with silver black plastic mulch) (78.62 kg/ha-mm). Similar finding was given by Zhang *et al.,* (2017) which gave higher WUE under 0.8 ET_c and this result was sustained by Alenazi *et al.,* (2015).

Minimum water use efficiency of 7.80 kg/ha-mm was obtained in treatment combination I_1M_4 (1.0 ET_c with border irrigation) and the data are in close relation with Battikhi and Ghawi (1997), and Diaz-Perez and Batal (2000). Therefore silver black plastic mulch along with 80 % ET_c irrigation level treatment could be considered as more appropriate for optimizing water use efficiency.

The use of drip irrigation in combination with plastic mulch was found significantly superior for increasing the crop yield of cucumber. From the experiment results, it could be concluded that 0.8 ET_c irrigation level along with silver black plastic mulch was most economical and obtained highest crop yield with best water use efficiency.

Therefore drip irrigation scheduled at 0.8 ET_c in combination with silver black plastic mulch can be adopted in water scant situation in agricultural regions of Gujarat state.

References

Abubaker, B. M. A., Alhadi, M., Shuang-En, Y. and Guang-Cheng, S. 2014. Different irrigation methods for okra crop production under semi-arid conditions. *International Journal of Engineering Research and Technology*,3(4): 787-794.

Agrawal, N. and Agrawal, S. 2005. Effect of drip irrigation and mulches on the growth and yield of banana. *Indian Journal of Horticulture*, 62(3): 238-240.

Ajibola, O. V. and Amujoyegbe, B. J. 2019.Effect of seasons, mulching materials and fruit quality on a cucumber (*Cucumis sativus* L.) variety. *Asian Journal of Agricultural and Horticultural Research*, 3(2): 1-11.

Alenazi, M., Abdel-Razzak, H., Ibrahim, A., Wahb-Allah, M. and Alsadon, A. 2015. Response of muskmelon cultivars to plastic mulch and irrigation regimes under greenhouse conditions. *The Journal of Animal & Plant Sciences*, 25(5): 1398-1410.

Allen, R. G., Pereira, L. S., Raes, D. and Smith, M. 1998. Crop Evapotranspiration. Guidelines for computing crop water requirements. *FAO Irrigation and Drainage paper 56. FAO*, Rome, pp-300.

Battikhi, A. and Ghawi, I. 1987. Squash (Cucurbita people) production under mulch and trickle irrigation in the Jordan Valley, University of Jordan. *Dirasat*, 14(11): 59–72.

Diaz-Perez, J.C. and Batal, K.D. 2002. Colored plastic film mulches affect tomato growthand yield via changes in root-zone temperature. *Journal of the American Society for Horticultural Science*,127(1): 127–136.

Harmanto, Salokhe, V. M., Babel, M. S. and Tantau, H. J. 2005. Water requirement of drip irrigated tomatoes grown in greenhouse in tropical environment. *Agricultural Water Management*,71(3): 225-242.

Saleh, M. I. and Ozawa, K. 2006. Improvement of crop yield, soil moisture distribution and water use efficiency in sandy soils by clay Application. In: *Proceedings of the 10thInternational Water Technology Conference, Alexandria, Egypt*, 797-811.

Singh, A. 2007. Economic feasibility of drip irrigated tomato crop under rain-fed condition. *Agricultural Engineering Today*, 31(3): 1-5.

Singh, R., Kumar, S., Nangare, D. D. and Meena, M. S. 2009. Drip irrigation and black polyethylene mulch influence on growth, yield and water-use efficiency of tomato. *African Journal of Agricultural Research*, 4(12): 1427-1430.

Tyagi, S. K. and Sharma, M. L. 2013. Effect of plastic mulch on growth, yield and economics of watermelon (*Citrullus lanatus* (Thumb.) Matsum and Nakai) under Nimar plains conditions of Madhya Pradesh. *Hort. Flora ResearchSpectrum*, 2(3): 215-219.

Wien, H. C. and Menotti, P. L. 1987. Growth, yield, and nutrient uptake of transplantedfresh-market tomatoes as affected by plastic mulch and initialnitrogen rate. *Journal of the American Society for Horticultural Science*,112: 759–763.

Zhang, H., Xiong, Y., Huang, G., Xu, X. and Huang, Q. 2017. Effects of water stress on processing tomatoes yield, quality and water use efficiency with plastic mulched drip irrigation in sandy soil of the Hetao Irrigation District. *Agricultural Water Management*, 179: 205-214.

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