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Response of super absorbent polymer and mulching on morphophysiological parameter and yield of cucumber (*Cucumis sativus* L.)

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Abstract

The experiment was conducted at Naturally Ventilated Polyhouse (VRC) at Maharajpur, Department of Horticulture, JNKVV, Jabalpur during the years 2020–21. The experiment was laid out in a completely randomized design with three replications and a total of 18 treatment combinations. Data analysis statistically indicates that among the treatments, the highest vine length, maximum leaf area (cm^2) and chlorophyll index were observed with Mulch+10 g Hydrogel + 25% moisture depletion (T_{18}) 54.89 cm, 161.00 cm, 187.14 cm, 202.33 cm maximum leaf area occurred at 256.00, 385.78, 412.33, and 438.33 and maximum Chlorophyll index 38.80, 42.40, 50.80, 56.20, at 30, 45, 60 and 75 DAS respectively. However highest fruit yield vine-1 (5.44 kg) and fruit yield (725.20 qha^{-1}) was obtained in treatment (T_{18}) *i.e.*, Mulch+ 10 g Hydrogel + 25% moisture depletion.

Keywords: Cucumber, *Cucumis sativus* L, super absorbent polymer, hydrogel, irrigation scheduling, mulch and polyhouse

Introduction

Cucumber (*Cucumis sativus* L.) is one of the most important fruit vegetable crop from nutritional as well as economic point of view. It is grown in the tropical and temperate region of the world. It is a member of the gourd family Cucurbitaceae.it is a thermophile crop that needs a steady warm temperature for optimum marketable fruit yield. Due to its extensive use in salad dishes, sandwiches, and pizza, its demand is year-round. It is generally grown in India during the zaid and kharif seasons. However, because it is a high value, low volume crop, its commercial exploitation in greenhouses as an off-season crop can high income for the growers. In India cucumber is cultivated in Haryana, Madhya Pradesh, Karnataka, Andhra Pradesh, Uttar Pradesh, Punjab, Assam state. (Anonymous, 2018) [2]. In India total cucumber production 1259.94 thousand MT from 82.04 thousand ha area and 154.52 thousand MT production from 9.46 thousand Ha area under Madhya Pradesh (Anonymous, 2018) [2].

Cucumber yields have been observed to be extremely high even in naturally ventilated poly houses as compared to open fields. The medical benefits of vitamins and minerals including A, B6, C, K, potassium, dietary fibres, pantothenic acid, magnesium, phosphorus, copper, and manganese have made cucumber one of the most important vegetables (Vimala *et al*). Irrigation water stress is one of the major limiting factors that affect crop, fruit growth and productivity. In a greenhouse, the amount of water in the soil is most limiting factor. The main goal of protected cultivation is to improve productivity and efficient use of water consumption (Hasandokh 2006) [12]. Irrigation water stress is one of the major limiting factors that affect crop, fruit growth and productivity. The hydrogel is a soil conditioner able to absorbing and retaining large quantities of plant available water. Hydrogel releases water and nutrient to the plant, when surrounding soil near root zone of the plants starts to dry up. Plastic mulches are completely impermeable to water and make more favourable conditions for plant growth, development and efficient crop production. It therefore prevents direct evaporation of moisture from the soil and thus limits the water losses and soil erosion over the surface. In this manner it plays a positive role in water conservation. The suppression of evaporation also has a supplementary effect. Thus, it facilitates more retention of soil moisture and helps in control of temperature fluctuations, improves physical, chemical and biological properties of soil, as it adds nutrients to the soil and ultimately enhances the growth and yield of crops (Kumar *et al*., 1990) [15]. New innovations technique saving irrigation water and thereby increasing crop water use efficiency (WUE) is especially important in water-scarce regions (Gencoglan *et al*.,

2006) [9]. Keeping the above facts in mind the present investigation was carried out.

Material and Methods

The experiment was carried out in the Naturally Ventilated Polyhouse at Vegetable Research Centre (VRC), Maharajpur, Department of Horticulture, JNKVV, Jabalpur. It is situated in the "Kymore plateau" agro-climatic region of Madhya Pradesh at 23.10°N latitude and 79.58°E longitude, having an altitude of 412.08 metres above the mean sea level. The soil in the trial field was laterite soil, which is typically thought to have originated in hot, humid subtropical regions and has good drainage, a homogeneous texture, and a rock type rich in iron and aluminium. The experiment was laid out in a Complete Randomized Block Design and three replications with 18 treatments each. Moisture depletion was 100%, 50%, and 25% water depletion in combination with zero, 5 g, and 10 g SAP along with mulch and without mulch. In each treatment, the transplanting of 14-day old seedlings was done with a spacing of 60 cm within plants and 100 cm between rows in a paired row system. The vegetative and yield parameters were recorded from a randomly selected five tagged plants of each treatment and averaged for further analysis. To determine the main effects of mulching, hydrogel, and irrigation scheduling on cucumber morpho phenological and yield parameters, all data were subjected to analysis of variance. The obtained data was tabulated and analysed using analysis of variance (ANOVA) as per a fisher (1935) [8].

Result and Discussion

Vine length (cm) (30 DAS)

The information presented in Table 1 indicates that SAP (Super Absorbent Polymer), mulch and irrigation scheduling significantly promote the increment in vine length by 30 DAS. In general, a steady increase in vine length was seen as crop growth advanced. Maximum vine length(54.89 cm) was observed with the treatment T_{18} followed by treatment T_{17} (54.04 cm) and minimum vine length (38.66) was observed in treatment T_1.The increasing vine length may be attributed to support hydrogels and mulch positive effects on promoting vine length and minimizing the negative effects of water stress. The plants were grown with hydrogel and mulch subjected to controlled water stress. Which have been widely reported; Ashrafuzzaman *et al*, (2011) [4].

Vine length (cm) (45 DAS)

The information presented in Table 1 indicates that SAP, mulch and irrigation scheduling significantly promote the increment in vine length by 45 DAS. In general, a steady increase in vine length was seen as crop growth advanced. Maximum vine length (161.00 cm) observed with the treatment T_{18} followed by treatment T_{17} (160.05 cm) and minimum vine length (128.20 cm) was treatment T_1 (No Mulch). Water stress generally has a negative impact on a plants growth and development, and it can cause a plants height to decrease by reducing cell enlargement and division (Manivannan *et al.,* 2007; Yazdani *et al.*, 2007) [20, 29]. The enhanced plant height in mulched plants could have been spurred due to the mulch better availability of soil moisture and improved soil temperature. Mulches have been used to observe changes in the height of the chilli plants and plastic mulch increased the plant height more than no mulch Shinde *et al.*, 1999) [26].

Vine length (cm) (60 DAS)

The information presented in Table 1 indicates that SAP, mulch and irrigation scheduling significantly promote the increment in vine length by 60 DAS. Maximum vine length (187.14 cm) observed with the treatment (T_{18}) followed by treatment T_{17} (186.96 cm) and minimum vine length (163.46 cm) was with treatment (T_1).The increasing level of hydrogel and mulch significantly increased the vine length. The positive impact of superabsorbent on the height of various plants has been confirmed by some investigations (Esfandiari *et al.*, 2009) [7]. Under all treatments, the plants treated with the superabsorbent showed the maximum plant height.

Vine length (cm) (75 DAS)

The data presented in Table 1 indicates that SAP, mulch and irrigation scheduling significantly promote the increase in vine length by 75 DAS. In general, a steady increase in vine length was seen as crop growth advanced. The maximum vine length (202.33 cm) was found with treatment T_{18} (Mulch + 10 g hydrogel + 25% moisture depletion), followed by 202.0 cm with treatment (T_{17}) *i.e.* Mulch + 10 g hydrogel + 50% moisture deletion (202.00 cm). The minimum increase in vine length 183.14 cm was noted with no mulch, no hydrogel, and 100% moisture depletion (T_1). The increasing level of SAP and mulch significantly increased the vine length. Due to increased moisture retention, plant height was more and indirectly through the hydrophilic polymers supply of nutrients, where it could have helped in increasing the activity of cell division, expansion and elongation, ultimately leading to increased plant height. Anupama *et al*. (2007) [3] found similar results in chrysanthemum.

Leaf area (cm^2) 30 days

The findings in Table 1 showed that the leaf area increased significantly with SAP, mulch and irrigation scheduling. The treatment 18-Mulch + 10 g Hydrogel + 25% Moisture depletion resulted in the highest leaf area of 256.00 cm^2 followed by treatment T $_{15}$-Mulch+ 5 g Hydrogel + 25% Moisture depletion had the next-highest leaf area of 246.67 cm2. The lowest leaf area 205.00 cm^2 was noted with control T -No Mulch + No Hydrogel + 100% Moisture depletion. Due to greater growth and light availability, the increased air and soil temperatures under plastic mulch cause an increase in leaf area. Similar results were obtained by Gimenez *et al*. (2002) [10] in cabbage, Alabi *et al*. (2014) [1] in bell pepper and Ahmad (2020) [32].

Leaf area (cm^2) 45 days

The findings in Table 1 showed that the leaf area increased significantly with hydrogel, mulch and irrigation scheduling. The treatmentT_{18}-Mulch + 10 g Hydrogel + 25% Moisture depletion resulted in the highest leaf area of 385.78 cm^2 followed by treatment T_{15}-Mulch+ 5 g Hydrogel + 25% Moisture depletion had the next-highest leaf area of 383.33 cm^2. The lowest leaf area 313.44 cm^2 was noted with treatment T_1-No Mulch+ No Hydrogel + 100% Moisture depletion. Similar findings were observed by Yazdani *et al*. (2007) [29]. Plants had increased availability of moisture, which led to turgidity in the cells and subsequently enhanced meristematic activity. This resulted in more photosynthetic activity, more foliage growth, and consequently higher growth and development. Ravisankar *et al*. (2014) [22] and Jakhar *et al*. (2018) [13].

Leaf area (cm^2) 60 days

The findings in Table 1 showed that the leaf area increased significantly with super absorbent polymer (Hydrogel), mulch and irrigation scheduling. The treatment T_{18}-Mulch + 10 g Hydrogel + 25% Moisture depletion resulted in the highest leaf area of 412.33 cm^2. Treatment T_{15}- Mulch+ 5 g Hydrogel + 25% Moisture depletion had the next-highest leaf area of 410.00 cm2. The lowest leaf area 340.00 cm2 was noted with control (T_1) i.e. No Mulch+ No Hydrogel + 100% Moisture depletion. Similar results were obtained by Brevedan and Egli (2003) [5] showed that leaf area decreased more quickly under constant stress than it would under normal stress.

Leaf area (cm^2) 75 days

The findings in Table 2 showed that the leaf area increased significantly with super absorbent polymer (Hydrogel), mulch and irrigation scheduling. The treatment T_{18}-Mulch + 10 g Hydrogel + 25% Moisture depletion resulted in the highest leaf area of 438.33 cm. Treatment T_{17}- Mulch+ 10 g Hydrogel + 50% Moisture depletion had the next-highest leaf area of 431.67 cm^2. The lowest leaf area 356.33 cm^2 was noted with control (T_1) *i.e.* No Mulch+ No Hydrogel + 100% Moisture depletion. Plants had increased availability of moisture, which led to turgidity in the cells and subsequently enhanced meristematic activity. This resulted in more photosynthetic activity, more foliage growth, and ultimately higher growth and development. Ravisankar *et al.* (2014) [22] and Jakhar *et al.* (2018) [13].

Chlorophyll Index (30 days)

The information shown in Table 2 indicates that the chlorophyll index of leaves was significantly increased by SAP, mulch and irrigation scheduling. It was noticeable that all of the treatments considerably varied from one another, and that the amount of chlorophyll in the leaves increased as the level of SAP, mulch and irrigation scheduling increased. Mulch+ 10 g Hydrogel + 25% moisture depletion (T_{18}) resulted in a maximum chlorophyll index of 38.80, followed by treatment T_{15} (Mulch+ 5 g Hydrogel + 25% moisture depletion) for a 37.40 SPAD value. The minimum chlorophyll index of 23.62 SPAD value was noted with control (T_1) *i.e.* No Mulch + No Hydrogel + 100% moisture depletion. Due to stomatal factors (Stomatal closure) and non-stomatal factors (defect in metabolic processes), the amount of photosynthesis is limited in response to drought stress, and generally, the chlorophyll index is decreased. Mafakheri *et al*. (2010) [18].

Chlorophyll Index (45 days)

The information shown in Table 2 indicates that the chlorophyll index of leaves was significantly increased by SAP, mulch and irrigation scheduling. It was noticeable that all of the treatments considerably varied from one another, and that the amount of chlorophyll in the leaves increased as the level of SAP, mulch and irrigation scheduling increased. Mulch+ 10 g Hydrogel + 25% moisture depletion (T_{18}) resulted in a maximum chlorophyll index of 42.40, followed by treatment T_{17} (Mulch+ 5 g Hydrogel + 50% moisture depletion) for a 42.20 SPAD value. The minimum chlorophyll index of 33.62 SPAD value was noted with control (T_1) No Mulch + No Hydrogel + 100% moisture depletion. Reduced synthesis of the primary pigment complexes may be responsible for the decrease in photosynthetic pigment concentration under stress conditions. Nikolaeva *et al*. (2010) [21].

Chlorophyll index (60 days)

The information shown in Table 2 indicates that the chlorophyll index of leaves was significantly increased by SAP, mulch and irrigation scheduling. It was noticeable that all of the treatments considerably varied from one another, and that the amount of chlorophyll in the leaves increased as the level of SAP, mulch and irrigation scheduling increased. Mulch+ 10 g Hydrogel + 25% moisture depletion (T_{18}) resulted in a maximum chlorophyll index of 50.80, followed by treatment T_{15} (Mulch+ 5 g Hydrogel + 25% moisture depletion) for a 47.80 SPAD value. The minimum chlorophyll index of 39.29 SPAD value was noted with control (T_1) No Mulch + No Hydrogel + 100% moisture depletion. The increase in the cell's production of free oxygen radicals is connected to the decrease in chlorophyll caused by drought stress. Sayyari and Ghanbari (2012) [23]

Chlorophyll index (75 days)

The information shown in Table 2 indicates that the chlorophyll index of leaves was significantly increased by SAP, mulch and irrigation scheduling. It was noticeable that all of the treatments considerably varied from one another, and that the amount of chlorophyll in the leaves increased as the level of SAP, mulch and irrigation scheduling increased. Mulch+ 10 g Hydrogel + 25% moisture depletion (T_{18}) resulted in a maximum chlorophyll index of 56.20, followed by treatment T_{15} (Mulch+ 5 g Hydrogel + 25% moisture depletion) for a 52.80 SPAD value. The minimum chlorophyll index of 41.95 SPAD value was noted with control (T_1) No Mulch + No Hydrogel + 100% moisture depletion. Based on the theory of Schutz and Fangmir (2001) [24], the increase in the cell's production of free oxygen radicals is connected to the decrease in chlorophyll caused by drought stress.

Number of flower per plant

The findings in Table 2 showed that the number of flower increased significantly with SAP, mulch and irrigation scheduling. The treatment T_{18}- Mulch+ 10 g Hydrogel + 25% Moisture depletion resulted in the highest number of flower of 75.33.00 followed by treatment T_{15} (Mulch+ 5 g Hydrogel + 25% Moisture depletion) had the next-highest number of flower 74.00. The lowest number of flower 52.00 was noted with treatment T_1- No Mulch+ No Hydrogel + 100% Moisture depletion. The closure of stomata to prevent transpirational water loss is the preliminary plant response to water stress that results in the decline of photosynthesis rate Mahajan and Tuteja *et al* (2005) [19].

Fruit yield (Kg/Vine)

According to the data on fruit yield per vine contained in Table 1, SAP, mulch and irrigation schedule enhanced fruit yield per vine. All of the treatments were found to be significantly different from one another, treatment T_{18}-Mulch+ 10 g Hydrogel + 25% Moisture depletion produced highest fruit yield (5.44 kg/vine) followed by treatment T_15-Mulch+ 5 g Hydrogel + 25% Moisture depletion 5.41 kg/vine. The lowest fruit yield of 2.87 kg/vine was obtained wit control (T_1): no mulch + no hydrogel + 100% moisture depletion. An increase in yield related attributes could be because of sufficient availability of water and indirectly nutrients supplied by the SAP to the plants under water stress condition, which in turn lead to better translocation of water, nutrients and photosynthates and finally better plant stand and yield (El Hardy *et al.*, 2009) [31]. However plastic mulches produce more fruit due to less competition among the plant for abiotic factors resulting in more number of branches, a higher leaf number, improving the leaf photosynthetic capacity of the plant, and more number of flowers per vine. The results of the present study are in agreement with the findings of Siborlabane (2000) [27] in tomato and Locher *et al.* (2005) [17] in sweet paper.

Fruit Yield (q/ha)

Fruit yield was lower under the water-stressed treatment than in the moisture-maintained plants (Table 2). Treatment T_{18}-Mulch+ 10 g Hydrogel + 25% moisture depletion produced the highest fruit yield (725.20 q/ha), followed by treatment T_{15}-Mulch+ 5 g Hydrogel + 25% Moisture Depletion *i.e.*, 721.33 q/ha. The lowest fruit yield 382.67 q/ha was obtained with treatment T1-No mulch + No hydrogel + 100% moisture depletion. An increase in yield and yield related attributes could be because of sufficient availability of water. It may be due to super absorbing properties of the hydrogel which absorbs the water and releases it slowly to the growing plants as per the crop needs. The positive effect of superabsorbent polymers in increasing the yields was reported by Khadem *et al.*, (2011) [14], Gunes *et al.* (2011) [11] and Kumari *et al.*, (2017) [16] in maize crop.

Table 1: Morphological characters influenced by SAP Mulch and irrigation scheduling of parthenocarpic cucumber

Treatments	Vine length (cm)	Vine length (cm)	Vine length (cm)	Vine length (cm)	Leaf area (cm^2)	Leaf area (cm^2)	Leaf area (cm^2)
	30 DAS	45 DAS	60 DAS	75 DAS	30 DAS	45DAS	60 DAS
T_1 (No Mulch+ No Hydrogel + 100% Moisture depletion)	38.66	128.20	163.46	183.14	205.00	313.44	340.00
T_2 (No Mulch+ No Hydrogel + 50% Moisture depletion)	39.26	131.60	169.82	190.16	210.00	315.00	344.33
T_3 (No Mulch+ No Hydrogel + 25% Moisture depletion)	44.11	136.88	170.46	191.29	219.00	323.67	352.00
T_4 (No Mulch+ 5 g Hydrogel +100% moisture depletion)	38.85	129.74	164.47	184.99	215.00	343.78	350.33
T_5 (No Mulch+ 5 g Hydrogel + 50% Moisture depletion)	40.66	131.89	170.13	190.16	220.00	347.33	350.67
T_6 (No Mulch+ 5 g Hydrogel + 25% Moisture depletion)	46.07	137.11	172.36	192.00	227.00	348.11	355.00
T_7 (No Mulch+ 10 g Hydrogel +100% Moisture depletion)	39.82	131.48	169.25	185.80	227.33	331.44	349.67
T_8 (No Mulch+ 10 g Hydrogel + 50% Moisture depletion)	46.22	136.05	170.94	192.49	229.33	335.00	349.33
T_9 (No Mulch+ 10 g Hydrogel + 25% Moisture depletion)	46.89	142.45	173.74	194.95	234.00	339.33	352.67
T_{10} (Mulch+ No Hydrogel + 100% Moisture depletion)	48.22	150.70	176.25	195.85	220.00	323.89	336.67
T_{11} (Mulch+ No Hydrogel + 50% Moisture depletion)	49.71	154.55	181.24	196.00	221.67	352.89	360.00
T_{12} (Mulch+ No Hydrogel + 25% Moisture depletion)	50.12	155.55	181.85	197.00	235.67	376.56	388.00
T_{13} (Mulch+ 5 g Hydrogel + 100% Moisture depletion)	51.59	156.55	182.89	199.52	230.33	321.22	390.00
T_{14} (Mulch+ 5 g Hydrogel + 50% Moisture depletion)	53.72	157.58	183.12	199.67	230.33	361.11	400.00
T_{15} (Mulch+ 5 g Hydrogel + 25% Moisture depletion)	53.34	159.97	185.67	201.33	246.67	383.33	410.00
T_16 (Mulch+ 10 g Hydrogel + 100% Moisture depletion)	47.58	150.07	176.15	199.18	241.00	323.11	396.00
T_{17} (Mulch+ 10 g Hydrogel + 50% Moisture depletion)	54.04	160.05	186.96	202.00	236.00	367.33	400.00
T_{18} (Mulch+ 10 g Hydrogel + 25% Moisture depletion)	54.89	161.00	187.14	202.33	256.00	385.78	412.33
C.D. at 5%	2.92	3.27	3.10	1.67	8.67	18.27	13.42
S Em ±	1.01	1.14	1.08	4.80	3.01	6.34	4.66

Table 2: Morphological characters influenced by SAP mulch and irrigation scheduling of parthenocarpic cucumber

Treatments	Leaf area (cm2) 75 DAS	Chlorophyll index 30 DAS	Chlorophyll index 45 DAS	Chlorophyll index 60 DAS	Chlorophyll index 75 DAS	Number of flower per plant	Fruit yield per vine (Kg)	Fruit yield (q/ha)
T_1 (No Mulch+ No Hydrogel + 100% Moisture depletion)	356.33	23.62	33.62	39.29	41.95	52.00	2.87	382.67
T_2 (No Mulch+ No Hydrogel + 50% Moisture depletion)	359.00	24.02	35.02	40.00	42.00	60.27	3.14	418.22
T_3 (No Mulch+ No Hydrogel + 25% Moisture depletion)	365.67	24.44	36.00	41.33	43.00	68.00	3.44	458.67
T_4 (No Mulch+ 5 g Hydrogel +100% moisture depletion)	365.33	25.78	35.29	40.95	42.95	52.67	3.19	425.33
T_5 (No Mulch+ 5 g Hydrogel + 50% Moisture depletion)	368.33	27.11	37.45	41.33	43.00	62.93	3.53	470.67
T_6 (No Mulch+ 5 g Hydrogel + 25% Moisture depletion)	372.00	28.58	38.51	43.30	45.00	72.33	3.71	495.11
T_7 (No Mulch+ 10 g Hydrogel +100% Moisture depletion)	368.00	29.12	38.62	42.62	43.95	55.67	3.52	469.33
T_8 (No Mulch+ 10 g Hydrogel + 50% Moisture depletion)	371.33	30.00	40.00	43.33	45.00	65.60	3.98	530.67
T_9 (No Mulch+ 10 g Hydrogel + 25% Moisture depletion)	374.67	31.22	41.78	44.63	46.00	74.33	4.33	576.89
T_{10} (Mulch+ No Hydrogel + 100% Moisture depletion)	394.00	29.58	39.25	43.25	45.58	55.00	3.43	457.33
T_{11} (Mulch+ No Hydrogel + 50% Moisture depletion)	413.00	31.00	39.78	44.78	47.45	59.27	3.83	510.67
T_{12} (Mulch+ No Hydrogel + 25% Moisture depletion)	418.00	33.00	41.78	45.11	48.11	69.33	4.00	533.33
T_{13} (Mulch+ 5 g Hydrogel + 100% Moisture depletion)	413.33	31.60	35.60	43.20	44.20	53.67	4.66	621.33
T_{14} (Mulch+ 5 g Hydrogel + 50% Moisture depletion)	430.00	35.60	38.30	45.20	49.00	64.33	4.96	661.33
T_{15} (Mulch+ 5 g Hydrogel + 25% Moisture depletion)	429.00	37.40	39.60	47.80	52.80	74.00	5.41	721.33
T_{16} (Mulch+ 10 g Hydrogel + 100% Moisture depletion)	423.33	32.40	38.40	44.80	50.00	56.67	5.30	706.67
T_{17} (Mulch+ 10 g Hydrogel + 50% Moisture depletion)	431.67	34.20	40.20	46.20	52.30	66.60	5.40	720.00
T_{18} (Mulch+ 10 g Hydrogel + 25% Moisture depletion)	438.33	38.80	42.40	50.80	56.20	75.33	5.44	725.20
C.D. at 5%	14.78	2.32	2.76	4.01	3.28	5.18	0.78	103.66
S Em ±	5.13	0.81	0.96	1.39	1.14	1.80	0.27	35.99

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