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RESPONSE OF OKRA (*ABELMOSECHUS ESCULENTUS* (L.) MOENCH.) TO IRRIGATION METHODS AND MULCHING UNDER HOT ARID CONDITIONS

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Abstract

Different irrigation methods and mulching materials were tested at CAZRI, RRS, Bikaner during 2009 and 2010 on okra crop under hot arid conditions. Irrigation methods *viz*., drip (I_1) and furrow (I_2) and mulching materials *viz*., plastic (M_1), hessian cloth (M_2), indigenous materials (M_3) and no mulch (M_4) were evaluated in Split plot design with three replications using the okra cv. Varsha Uphar. Among the various treatments drip irrigation and plastic mulch alone and their interaction resulted in maximum plant height, number of branches, number of fruits per plant, fruit weight, fruit yield per plant and yield per hectare. Drip irrigation increased 13.5 percent and 12.9 percent fruit yield/ha over furrow method in 2009 and 2010, respectively. Plastic mulch recorded the highest fruit yield/ha in both the year which was 10.2, 17.7 and 32.7 percent higher compared to hessian cloth, indigenous material and no mulch, respectively.

Key words : Okra, Irrigation methods, Mulching, Yield.

1. Introduction

Water scarcity poses serious threats to nutritional and livelihood security in the hot arid region of Rajasthan. The requirement of water to cater the food requirement is projected to increase with increasing population, but the availability of fresh water for agriculture production has been decreasing with depletion of ground water reservoirs coupled with urbanization and industrialization. This warrants finding suitable management practices to maximize the yield of crops with lesser use of water. In this context, improvement in irrigation practices is needed to increase crop production and water productivity.

Furrow method of irrigation is common in vegetable production. Many researchers have reported higher application efficiency of drip method compared to conventional methods. Use of mulches has been found to conserve moisture, control weeds and increase in yield of vegetables. Drip method of irrigation is better than furrow method of irrigation to achieve higher yields of vegetable crops and mulching improves the yield [Birbal *et al*. (2012)]. The

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high evaporative demand and deep percolation losses in the tropics require adequate irrigation and agronomic management practices that will improve water use efficiency in okra [Adekalua *et al*. (2008)]. The response of okra to the combined effect of drip with different types of mulch is not well known under agro-ecological conditions of Bikaner, Rajasthan. Hence, the present study was conducted to study growth and yield response of irrigation methods with mulching in okra under hot arid conditions of Rajasthan.

2. Materials and Methods

The experiment was conducted at Central Arid Zone Research Institute, Regional Research Station, Bikaner, Rajasthan (28º4' N; 74º3' E; 238.3 m above mean sea level) during *Kharif* season of 2009 and 2010. The soil of the field was loamy sand, low in organic carbon and high in available potassium and had pH 8.1, electrical conductivity 0.2ds/m with field capacity of 7.8% grametric and volume by volume is 11.8 and permanent wilting point is 3.0%. The irrigation water having the electrical conductivity 2.8 ds/m (moderately saline) and pH was 7.7.

The treatment consisted two method of irrigation *i.e.* I_1: drip and I_2: furrow and four mulching treatments *i.e.* M_1: plastic mulch (black polyethylene-25micron), M_2: hessian cloth mulch (0% shade jute cloth), M_3: indigenous plant material (laptodoniaspps @ 10t/ha) mulch and M_4: no mulch (control). Irrigation treatments were assigned to main–plot and mulching treatments were assigned to sub–plots. The experiment was laid out in Split plot and replicated thrice. The cultivar Varsha Uphar of okra was used and sown at 30 cm × 50 cm spacing in 4.0 m × 8.0 m sized plots. Growth and yield attributes were measured from ten randomly selected plants from each plot excluding border rows.

Analysis of variance of the experimental data was carried out as suggested by Gomez and Gomez (1983). When the *F*-test was significant ($P<0.05$), the means were compared using the least significant difference (LSD) test at $\alpha = 0.05$. The interactions irrigation methods × mulching treatments were also calculated and significant differences were analyzed at $P<0.05$.

3. Results and Discussion

Irrigation method, mulching and their interaction had significant effect on plant growth attributes during both the years (Table 1). Plant height showed significant response to irrigation (I), mulching (M) and their interaction (I × M) measured at 30, 60 and 90 days after sowing (DAS) in both the years. Drip irrigation (I_1) recorded the highest plant height as compared to furrow irrigation (I_2). Mulching improved the plant height significantly than no-mulch. The I × M interaction was significant for plant height at all the stages in both the years. Averaged across both the years, the highest plant height at all stages of plant height was attained by plastic mulch coupled with drip irrigation.

Averaged across the mulching treatments and years the number of branches/plant with drip (I_1) was 13.2, 16.2 and 13.3% higher at 30, 60 and 90 DAS, respectively as compared to Furrow (I_2). Plastic mulch recorded the highest improvement in number of branches

(Table 1). Plastic mulch recorded 23.1, 50.8 and 41.9% more branches at 30, 60 and 90 DAS, respectively over no mulch. The increase in growth attributes might be due to conservation of soil moisture, reduced rate of evaporation and less crop-weed competition [Panigrahi *et al.* (2011)].

Numbers of fruits per plant of okra crop were significantly influenced by I, M and I × M during both years of experiment. The drip (I_1) had higher number of fruit per plant in both the years with mean number of fruit per plant across the mulching treatments and years was 15.0 (Table 2). Mulching increased the number of fruit per plant significantly in both the years. Among different mulching materials, plastic mulch showed the highest fruits per plant followed by hessian cloth and indigenous material mulch. Averaged across irrigation methods and years, the plastic mulch had 4.1, 1.9 and 1.0 more fruits per plant compared to no-mulch. The interaction effect of I × M was significant for number of fruit per plant and the highest number was recorded with plastic mulch with drip (I_1) followed by hessian mulch with I_1 in both the years. Fruit weight showed significant response to method of I, M and their interaction (Table 2). Drip (I_1) had significantly higher fruit weight compared to furrow irrigation (I_2) during the study period and recorded 12.5-14.2% higher fruit weight. Mulch improved the weight of fruit. Among the different mulching materials, the plastic mulch gave the highest fruit weight in both the years. The fruit weight with plastic mulch attained 5.3, 17.7 and 39.3% higher compared to hessian cloth, indigenous material mulch and no-mulch, respectively. The effectiveness of mulch with respect to fruit weight varied with method of irrigation. The different combinations of irrigation and mulching had 11.6-18.8 g fruit weight, being highest under drip irrigation with plastic mulch and lowest for no-mulch with furrow irrigation. The importance of plastic mulch and its effect on yield attributes were also observed by Panigrahi *et al.* (2011) in okra.

Fruit yield per plant of okra was significantly increased by various treatments *viz.*, I, M and I × M during both the years of experimentation. Drip (I_1) showed its superiority over furrow (I_2) with respect to fruit yield per plant and drip had 15.1% and 10.8% higher fruit yield over furrow in 2009 and 2010, respectively (Table 2). Mulching improved the fruit yield per plant in both the years. Plastic mulch had 6.2-7.1%, 16.7-17.9% and 33.7-43.7% higher fruit yield than hessian cloth, indigenous material mulch and no-mulch, respectively. The I × M interaction was significant for fruit yield per plant in both the years. The fruit yield per plant under different combinations of irrigation method and mulching varied from 149.4-270.4 g in 2009 and 185.6-276.6 g in 2010. The drip irrigation with plastic mulch recorded the highest fruit yield in both the years, whereas the lowest yield was observed in furrow irrigation in combination with no mulch. Tiwari *et al.* (1998) also indicated that drip irrigation along with black plastic mulch gave the highest okra yield (14.51 t/ha) with 72% increase in yield as compared to furrow irrigation.

The drip irrigation method had significantly higher fruit yield per hectare as compared to furrow method of irrigation (Table 2). The mean fruit yield averaged across the mulching treatments was 13.6 and 12.8% higher under I_1 compared to I_2 in 2009 and 2010, respectively. The mulching also had significant effect on yield and increased the yield from 21.7 to 43.3%.

Table 1 : Effect of irrigation methods and mulching on plant height (cm) and number of branch/ plant of okra.

Treatments	Plant height (cm)									Number of branch/ plant								
	2009			2010			Mean			2009			2010			Mean		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Irrigation (I)																		
I_1 : Drip	20.7	68.5	98.5	18.3	62.2	90.7	19.52	65.33	94.61	1.33	2.14	2.30	1.41	1.88	2.39	1.37	2.01	2.35
I_2 : Furrow	18.5	59.6	85.5	15.9	53.9	77.4	17.20	56.75	81.44	1.16	1.79	2.02	1.25	1.67	2.12	1.21	1.73	1.57
LSD (5%)	1.8	7.7	10.16	2.4	8.1	12.1				NS	0.28	0.16	1.16	0.19	0.27			
Mulch (M)																		
M_1: Plastic	22.5	73.4	108.4	19.5	67.7	100.2	20.99	70.57	104.30	1.43	2.42	2.55	1.44	2.18	2.67	1.44	2.30	2.61
M_2: Hesssian	20.2	66.2	93.7	18.0	62.5	85.7	19.12	64.34	89.69	1.27	2.00	2.31	1.34	1.89	2.32	1.31	1.95	2.32
M_3: Indigenous	19.4	62.5	87.8	16.5	53.4	79.8	17.96	57.97	83.80	1.16	1.86	2.04	1.30	1.56	2.09	1.23	1.71	2.07
M_4: No	16.3	54.1	78.3	14.5	48.5	70.5	15.38	51.29	74.39	1.12	1.58	1.74	1.22	1.47	1.94	1.17	1.53	1.84
LSD (5%)	0.6	3.2	4.41	0.7	3.3	4.3				0.13	0.20	0.14	0.06	0.12	0.10			
Interaction (IXM)																		
$I_1 \times M_1$	23.6	77.2	117.1	21.0	69.9	108.8	22.32	73.54	112.95	1.54	2.77	2.83	1.53	2.38	2.83	1.54	2.58	2.83
$I_1 \times M_2$	21.2	70.4	97.4	18.7	69.4	89.4	19.96	69.90	93.40	1.34	2.06	2.41	1.44	2.03	2.55	1.39	2.05	2.48
$I_1 \times M_3$	20.2	65.0	92.0	18.0	57.6	84.0	19.10	61.30	88.01	1.18	1.93	2.14	1.37	1.60	2.16	1.28	1.77	2.15
$I_1 \times M_4$	18.0	61.3	87.6	15.6	51.7	80.6	16.81	56.52	84.11	1.23	1.83	1.82	1.28	1.52	2.03	1.26	1.68	1.93
$I_2 \times M_1$	21.5	69.5	99.6	17.9	65.6	91.6	19.71	67.55	95.60	1.32	2.07	2.26	1.35	1.98	2.51	1.34	2.03	2.39
$I_2 \times M_2$	19.2	62.0	90.0	17.4	55.5	81.9	18.29	58.77	85.99	1.20	1.94	2.20	1.25	1.75	2.10	1.23	1.85	2.15
$I_2 \times M_3$	18.6	60.0	83.6	15.0	49.3	75.6	16.81	54.64	79.59	1.14	1.79	1.94	1.22	1.52	2.02	1.18	1.66	1.98
$I_2 \times M_4$	14.5	46.9	69.0	13.3	45.2	60.3	13.90	46.05	64.66	1.00	1.34	1.66	1.16	1.42	1.84	1.08	1.38	1.75
LSD (5%)	0.8	4.5	6.24	0.9	4.7	6.1				NS	0.29	0.19	0.08	0.17	0.15			

Table 2 : Effect of irrigation methods and mulching on yield attributes and yield of okra.

Treatments	Fruits / plant			Weight / fruit (g)			Fruit yield (g/ plant)			Yield (q/ha)		
	2009	2010	Mean	2009	2010	Mean	2009	2010	Mean	2009	2010	Mean
Irrigation (I)												
I_1 : Drip	14.92	15.05	15.0	16.30	18.18	17.2	241.36	251.86	246.6	78.78	82.47	80.63
I_2 : Furrow	13.21	13.32	13.3	14.28	16.16	15.2	209.64	227.33	218.5	69.35	73.10	71.23
LSD (5%)	1.69	1.62		1.89	1.54		18.90	23.40		7.23	8.19	
Mulch (M)												
M_1 : Plastic	15.91	15.90	15.9	17.45	19.45	18.5	258.73	270.80	264.8	86.29	89.50	87.90
M_2: Hesssian	14.88	14.83	14.9	16.53	18.53	17.5	243.70	252.93	248.3	77.88	81.71	79.80
M_3: Indigenous	13.93	13.97	14.0	14.68	16.68	15.7	219.51	232.03	225.8	72.58	76.75	74.67
M_4: No	11.52	12.04	11.8	12.50	14.00	13.3	180.06	202.60	191.3	59.50	63.19	61.35
LSD (5%)	1.26	0.56		0.88	0.84		11.39	6.83		3.12	3.29	
Interaction (IXM)												
$I_1 \times M_1$	16.77	16.65	16.7	17.81	19.81	18.8	270.40	276.60	273.5	91.07	94.85	92.96
$I_1 \times M_2$	15.40	15.60	15.5	17.27	19.27	18.3	256.80	265.60	261.2	79.46	83.13	81.30
$I_1 \times M_3$	14.07	14.51	14.3	15.95	17.95	17.0	227.54	245.67	236.6	75.40	79.73	77.57
$I_1 \times M_4$	13.43	13.44	13.4	14.18	15.68	14.9	210.70	219.57	215.1	69.17	72.17	70.67
$I_2 \times M_1$	15.06	15.15	15.1	17.10	19.10	18.1	247.07	265.00	256.0	81.51	84.15	82.83
$I_2 \times M_2$	14.37	14.06	14.2	15.80	17.80	16.8	230.60	240.27	235.4	76.29	80.29	78.29
$I_2 \times M_3$	13.80	13.43	13.6	13.41	15.41	14.4	211.47	218.40	214.9	69.77	73.77	71.77
$I_2 \times M_4$	9.61	10.65	10.1	10.82	12.32	11.6	149.43	185.63	167.5	49.83	54.20	52.02
LSD (5%)	1.78	0.79		1.25	1.19		16.11	9.66		4.41	4.66	

Among the tested mulching materials, the plastic mulch had the highest increment in yield (43.3% over no mulch) followed by hessian cloth (30.1% over no mulch) and indigenous material mulch (21.7% over no mulch). The better growth parameters and yield attributes were recorded in irrigation and mulching treatment resulted from better metabolic activity of the plant probably caused by consistent supply of soil moisture in root zone which ultimately resulted in increased yield [Panigrahi *et al.* (2011) and Wien *et al.* (1993)]. Adekalua *et al.* (2008) also found higher plant height and dry matter from mulched plots due to saving of soil water in okra crop.

Irrespective of method of irrigation an overall improvement in the yield and yield attributes of okra crop with mulching was resorted to. Mulching has been found instrumental to enhance yield in several crops through several factors [Bhella (1988) and Goyal *et al.* (1987)]. Mulching insulated the plant from soil moisture stress as well as other physico-chemical competitive factors in the soil and helped in the maintaining good internal water balance in the plant body [Bogle *et al.* (1989)]. When crops were mulched weed growth was checked and soil moisture losses through evaporation were arrested [Liu *et al.* (1989)]. These factors altogether might have contributed for higher yield attributes such as number of branches, number of flowers, number of fruits, fruit set, weight of fruits and ultimately the final fruit yield.

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