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INFLUENCE OF IRRIGATION METHODS AND MULCHES ON PEA (*PISUM SATIVUM* L.) IN BER (*ZIZIPHUS MAURITIANA*) BASED VEGETABLE PRODUCTION SYSTEM UNDER TROPICAL CLIMATE OF RAJASTHAN

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ABSTRACT

A field experiment was conducted during the rabi season of 2009-10 and 2010-11. The experiment consisted of two methods of irrigation *viz.* drip and furrow methods and four type of mulching material treatments *viz.* plastic mulch (black polyethylene-25micron), hessian cloth mulch (50% shade jute cloth), indigenous plant material (laptodoniaspps.@ 10t/ha) mulch and no mulch (control). Method of irrigation, mulching and their interaction had significant effects on growth, yield attributes and yield. Mean yield averaged across the mulching treatments was 18.3 % higher under drip irrigation than furrow method. Mulching improved the yield from 40 to 71.8 % over no mulch treatment. Among the tested mulching materials, the plastic mulch had the highest improvement in yield (71.8 %) followed by hessian cloth (54.1 %) and indigenous plant material mulch (40 %) over no mulch. Interaction effect between drip irrigation with plastic mulch resulted in significant response in growth, yield attributes and yield of pea as compared to all other treatment combinations. Number of branches per plant, canopy cover and survival percentage of ber was higher in ber + pea cropping system than sole ber.

Key words: Ber + pea cropping system, Drip irrigation, Furrow irrigation, Mulching, Yield.

INTRODUCTION

To sustain the rapidly growing world population, agricultural production needs to be increased in spite of decreasing availability of fresh water for use in agriculture (Cai and Rosegrant, 2003). The need of the hour therefore, is to maximize the production per unit of water. Hence, sustainable methods to increase crop water productivity are gaining importance in arid and semiarid regions (Debaeke and Aboudrare, 2004). The identification of suitable method of irrigation to minimize the unproductive losses of water is one of the important strategies to improve water productivity.

Besides this, further expansion of irrigation may depend upon the adoption of new irrigation systems such as pressurized irrigation methods. Amongst those pressurized irrigation methods, drip irrigation has proved its superiority over other methods of irrigation due to the direct application of water and nutrients in the vicinity of root zone.

In India, the potential for the drip irrigation system is estimated to be 21.27mha (Narayanamoorthy, 2008). Water saving from drip irrigation system varied from 12 to 84% for different crops besides increasing the production of crops. Water use efficiency is increased because plants can be supplied with water in precise amounts. Water is applied directly to the plant root zone results in better weed control and significant water savings.

In arid ecosystem water is lost mainly by the process of evaporation. Mulching reduces the rates of water loss from soil surface and facilitates moisture distribution, hence influencing irrigation schedule (Bhella, 1988). Organic (plant materials) and synthetic mulches (transparent, black and whiteplastics) are widely used in vegetable production for various reasons including conservation of soil moisture. Clear plastic mulches substantially promote growth, yield and quality of tomatoes (Liu and Hu, 2000) by readily warming the soil, conserving

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moisture and directing carbon dioxide from soil to the plant leaves. Organic mulches such as grass, sawdust, corncobs, rice husks, straws of wheat and rice are also beneficial to crops (Shrivastava *et al.*, 1994) and locally available. Birbal *et al* (2012) concluded that drip method of irrigation is better than furrow method of irrigation to achieve higher yields of vegetable crops and mulching improves the yield in hot arid environment. Therefore drip irrigation combined with mulching should be used to get better yields of vegetables in hot arid environment Ber (*Ziziphus mauritiana* L.) has been found to have an efficient and positive interaction with several crops and plant species like field crops, vegetables and fruit plants in a composite system under arid and semi-arid ecosystem of the country. Different ber based cropping system are proving their usefulness in improving the socio-economic status of the people in various ecosystems of the country (More *et al* .2012) Keeping aforesaid points in view, a study was conducted with the objective to investigate the influence of irrigation Methods, mulching materials and their interactions on the yield attributes and yield of pea (*Pisum sativum* L.) in ber based cropping system.

MATERIALS AND METHODS

The field experiment was conducted on pea (*Pisum sativum* L.) with newly established ber plantation during the years of 2009-10 and 2010-11at CAZRI, Regional Research Station, Bikaner (28º4' N; 74º3' E; 238.3 m above mean sea level). 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% geometric and volume by volume is 11.8 and permanent wilting point is 3.0%. The irrigation water was having the electrical conductivity 2.8 ds/m (moderately saline) and pH was 7.7.

The treatment consisted of two methods 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 (50% shade jute cloth), M_3: indigenous plant material (laptodonia spp. @ 10t/ha) mulch and M_4: no mulch (control). The experiment was laid out in split plot design and replicated thrice. Plot size was 8x8 meter and one ber plant cv Gola was planted in between the every plot as part of system. No additional input was given to ber crop. Inputs were applied as per demand of pea crop. Sole ber plant were also planted on the spacing of 8x8 meter with recommended dose of inputs.

Irrigation treatments were assigned to main plot and mulching treatments were assigned to sub plots. Azad P-1 variety of pea was sown at 50 X 30 cm row to row and plant to plant spacing in winter season. After germination of seeds, the mulch was placed between the rows of pea. In drip irrigation water was applied daily while in furrow irrigation method, water was applied at weekly interval. 200 q/ha FYM at the time of field preparation and recommended uniform dose of 40kg P_2O_5/ ha through DAP and 40 kg K_2O /ha through MOP were applied in the soil at the time of sowing. However, the remaining dose of nitrogen was applied in five equal split at 10 days interval in the form of urea in drip irrigated area and one split dose furrow irrigated area. The observation on various yield attributes and yield were recorded as per standard procedures. Data were analysed using analysis of variance (ANOVA). Analysis of variance of the experimental data was carried out as per split-plot design (Gomez and Gomez, 1983). Data from each year were analysed separately. In case of significant F test in ANOVA with 5 % significance level ($P < 0.05$), the means were compared using the least significant difference (LSD) test at $\alpha = 0.05$.

RESULTS AND DISCUSSION

Growth attributes: A perusal of data (Table 1) indicated that plant height, number of branches and leaf area of pea was significantly improved by various treatments viz. irrigation methods, mulching and their interaction effect during both years of experiment. Regarding plant height, drip irrigation showed its superiority over furrow method, and registered 12.1 % and 14.9 % higher plat height over furrow method in 2009-10 and 2010-11, respectively. Mulching improved the plant height in both the years. Plastic mulch had 10.7-14.4 %, 26.9-28.2 % and 37.1 – 41.9 % higher plant height than HC, IM and NM, respectively. Drip irrigation method recorded the highest number of branches (3.46 and 4.20 during 2009-10 and 2010-11, respectively), which was significantly superior to furrow irrigation method. Mulching improve the number of branches

TABLE 1: Effect of irrigation methods and mulching on growth attributes of pea with ber.

Treatments	Plant height (cm)			Number of branches/ plant			Leaf area		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
Irrigation									
I_1 : Drip	52.00	58.50	55.23	3.46	4.20	3.83	279.58	316.96	298.27
I_2 : Furrow	46.40	50.90	48.67	2.85	3.49	3.17	244.96	281.27	263.12
LSD (5%)	4.29	7.17	5.72	0.59	0.63	0.58	34.10	30.47	18.65
Mulch									
M_1 :Plastic	57.70	65.00	61.34	3.78	4.75	4.27	331.19	369.03	350.11
M_2:Hesssian	52.10	56.80	54.45	3.57	4.19	3.88	315.07	328.31	321.69
M_3:Indigenous	45.00	51.20	48.08	2.78	3.43	3.10	215.89	269.27	242.58
M_4: No	42.10	45.80	43.92	2.49	3.01	2.75	186.94	229.85	208.39
LSD (5%)	2.75	2.73	2.22	0.41	0.32	0.31	18.90	18.92	14.65
Interaction									
$I_1 \times M_1$	62.30	72.70	67.52	3.97	4.95	4.46	361.35	391.21	376.28
$I_1 \times M_2$	56.40	61.00	58.70	3.54	4.72	4.13	350.98	363.68	357.33
$I_1 \times M_3$	45.20	52.90	49.05	3.35	3.94	3.65	224.99	269.65	247.32
$I_1 \times M_4$	44.10	47.20	45.65	2.99	3.17	3.08	181.00	243.31	212.15
$I_2 \times M_1$	53.00	57.30	55.16	3.60	4.56	4.08	301.02	346.85	323.94
$I_2 \times M_2$	47.90	52.50	50.20	3.60	3.65	3.63	279.17	292.94	286.05
$I_2 \times M_3$	44.80	49.40	47.11	2.20	2.91	2.56	206.78	268.88	237.83
$I_2 \times M_4$	40.00	44.40	42.19	1.98	2.85	2.41	192.88	216.39	204.63
LSD (5%)	3.89	3.87	3.13	0.58	0.45	0.43	26.72	26.76	20.72

significantly than no mulch. Pooled analysis across irrigation methods and years showed that plastic mulch, hessian cloth and indigenous mulch increased 55.3, 41.1 and 13.9 percent number of branches over no mulch, respectively. Leaf area of pea across the mulching treatment and years was 298.3 with drip and 263.12 with furrow method of irrigation (Table1). Across irrigation method and years, the plastic mulch had 141.7, 113.9 and 34.2 cm^3 more leaf area compared to no mulch, respectively. The irrigation method x mulching treatments interaction was significant for plant height, number of branches and leaf area in both the years. The drip irrigation with plastic mulch recorded the highest plant height, number of branches and leaf area in both the years, whereas the lowest values were recorded in furrow irrigation in combination with no mulch. The improvement in growth parameter was mainly due to proper moisture regimes in root zone and reduction in evaporation.

Yield attributes: Drip method of irrigation had significantly higher pods / plant compared to furrow method in both the years, and it improved the pods per plant by 17.0-21.1 % than furrow method. The plastic mulch recorded highest number of pods per plant in both the years. The pods per plant attained under plastic mulch were 16.0, 33.0 and 55.4 percent higher compared to HC, IM and NM, respectively. The drip method of irrigation had higher pod length in both the years; mean pod length of pea across the mulching treatment and year was 7.6 with drip and 6.4 with furrow. Mulching also increased the pod length in both years. Plastic mulch increased 15.09 %, 20.33 % and 38.64 % in 2009-10 and 19.89 %, 27.17 % and 45.70 % in 2010-11 over HC, IM and NM, respectively (Table 2).

A perusal of data presented in Table 2 indicated that pod weight per pod (g) of pea crop was significantly improved by various treatments *viz.* irrigation methods, mulching and their interaction effect during both years of experiment. Drip irrigation showed significant higher pod weight than furrow method. It increased 10.71 % and 22.48 % pod weight per pod over furrow method in 2009-10 and 2010-11, respectively. Mulching also improved the pod weight per pod in both years. Plastic mulch increased 7.27 %, 17.89 % and 34.67 % in 2009-10 and 24.64 %, 51.04 % and 70.59 % in 2010-11 over HC, IM and NM, respectively. Number of seeds per pod of pea crop was significantly affected by irrigation methods during both year and mulching treatments for second year only (Table 2). The drip irrigation method had higher number of seeds per pod in both the years, mean number of seeds per pod across the mulching treatment and years was 7.0 with drip and 6.3 with furrow method of irrigation.

TABLE 2: Effect of irrigation methods and mulching on yield attributes and yield of pea with ber.

Treatments	Number of pods			Pod length (cm)			Pod weight(g)			Pod yield/ plant (g)			Seeds/pod			Yield(q/ha)		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
Irrigation																		
I_1 : Drip	15.82	17.19	16.50	7.39	7.92	7.65	3.41	3.65	3.53	42.6	44.78	43.69	6.91	7.01	6.96	59.88	66.51	63.20
I_2 : Furrow	13.47	14.18	13.83	6.18	6.63	6.40	3.08	2.98	3.03	39.72	38.59	39.15	6.29	6.26	6.27	54.55	52.19	53.37
LSD (5%)	1.93	2.88	1.57	0.88	1.23	0.32	0.33	0.69	0.45	2.66	6.16	2.06	0.61	0.73	0.60	4.87	10.10	4.09
Mulch																		
M_1 : Plastic	17.65	19.93	18.79	7.93	8.8	8.37	3.69	4.35	4.02	48.91	52.83	50.87	6.84	7.21	7.02	67.61	73.90	70.76
M_2 : Hessian	15.09	17.04	16.06	6.89	7.34	7.11	3.44	3.49	3.47	41.83	43.68	42.76	6.67	7.05	6.86	62.45	64.56	63.51
M_3 : Indigenous	13.40	13.95	13.67	6.59	6.92	6.75	3.13	2.88	3.01	38.41	38.26	38.34	6.48	6.37	6.42	57.68	57.72	57.70
M_4 : No	12.45	11.81	12.13	5.72	6.04	5.88	2.74	2.55	2.65	35.48	31.97	33.73	6.41	5.91	6.16	41.13	41.22	41.18
LSD (5%)	1.03	0.88	0.82	0.52	0.4	0.29	0.09	0.24	0.11	1.23	2.14	1.34	NS	0.86	0.50	1.76	2.50	1.40
Interaction																		
$I_1 \times M_1$	19.35	21.36	20.35	8.71	9.9	9.30	3.89	4.82	4.35	51.36	57.87	54.62	7.1	8.2	7.65	70.81	82.22	76.51
$I_1 \times M_2$	16.85	18.82	17.83	7.22	7.76	7.49	3.65	3.94	3.80	43.45	46.51	44.98	6.96	7.25	7.11	63.75	72.47	68.11
$I_1 \times M_3$	14.22	15.99	15.10	6.9	7.29	7.09	3.3	3.1	3.20	39.05	40.47	39.76	6.85	6.59	6.72	59.91	65.20	62.56
$I_1 \times M_4$	12.86	12.58	12.72	6.71	6.74	6.73	2.82	2.74	2.78	36.54	34.29	35.42	6.72	6	6.36	45.06	46.16	45.61
$I_2 \times M_1$	15.96	18.50	17.23	7.16	7.71	7.43	3.49	3.88	3.68	46.46	47.8	47.13	6.57	6.21	6.39	64.41	65.59	65.00
$I_2 \times M_2$	13.33	15.26	14.30	6.56	6.92	6.74	3.24	3.03	3.13	40.22	40.85	40.53	6.38	6.85	6.62	61.15	56.65	58.90
$I_2 \times M_3$	12.57	11.92	12.24	6.27	6.56	6.41	2.95	2.65	2.80	37.78	36.06	36.92	6.11	6.14	6.13	55.45	50.24	52.85
$I_2 \times M_4$	12.03	11.05	11.54	4.72	5.33	5.03	2.66	2.35	2.51	34.42	29.66	32.04	6.1	5.81	5.96	37.21	36.28	36.74
LSD (5%)	1.46	1.25	1.16	0.74	0.56	0.41	0.12	0.33	0.16	1.75	3.02	1.89	NS	NS	NS	2.49	3.53	1.98

Irrigation method, mulching and their interaction effect significantly improve pod yield per plant of pea crop during both the year of experiment (Table 2). The highest pod yield per plant was obtained under drip irrigation as compare to furrow; it attained the 11.58 per cent higher mean pod yield per plant. Plastic mulch had significantly improved the pod yield per plant in both the year. It had 18.98, 32.70 and 50.84 percent increase in pod yield per plant as compare to HM, IM and NM, respectively.

The irrigation method x mulching treatments interaction was significant for pod yield per plant, pod weight per pod (g), pod length, pods/plant in both the years. The drip irrigation with plastic mulch recorded the highest pod yield per plant, pod weight per pod, pod length, pods/plant in both the years, whereas the lowest values were recorded in furrow irrigation in combination with no –mulch.

Yield: The irrigation method, mulching and their interactions had significant influence on yield of pea in both the years. The drip method had significantly higher yield compered to furrow method of irrigation. Mean yield averaged across the mulching treatments was 18.3 % higher under drip irrigation than furrow method (Figure 1 and Table 3). Malik and Kumar (1996) also observed similar findings. The mulching had significant effect on yield. Plastic mulch improved the yield from 40.0 to 71.8 % over other mulching treatment. From Among the tested mulching materials, the plastic mulch had the highest improvement in yield (71.8 % over no mulch) followed by hessian cloth (54.1 % over no mulch)

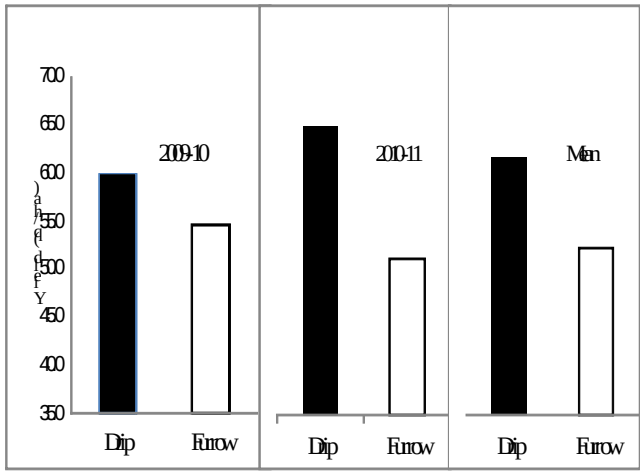

FIG.1: Effect of irrigation methods on pod yield of pea in pea+ ber cropping system.

TABLE 3: Growth attributes of ber with or without vegetable crops.

Parameter	Tree height (cm)		No. Of branches		Canopy spread (cm)				Stem girth (cm)		Survival %
					E-W	N-S	E-W	N-S			
	2009	2010	2009	2010	2009		2010		2009	2010	
Ber + crop + drip	180	255	4.6	6.4	195	239	256	20.5	16.8	20.5	82
Ber + crop + furrow	217	304	5.4	7.2	235	304	298	17.5	14.2	17.5	76
Sole ber	265	342	3.8	5.2	150	241	205	15.2	11.5	15.2	61

and indigenous plant material mulch (40 % over no mulch). The irrigation method x mulching treatments interaction was significant for yield in both the years. The yield per hectare under different combinations of irrigation method and mulching varied from 37.21-70.81 q/ha in 2009-10 and 36.28-88.22 q/ha in 2010-11, respectively.

An overall improvement in the yield and yield attributes of vegetable crops when mulching was resorted to, irrespective of method of irrigation. Mulching has been instrumental for enhancing yield in several crops through improvement in several factors viz. Moisture conservation, favourable microclimate etc.(Bhella, 1988; 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 fruiting branches, number of flowers, number of fruits, fruit set, weight of fruits per plant and ultimately the final fruit yield.

Performance of ber: The survival of ber in initial year was higher in the treatment where ber was grown in association with vegetable crops than sole ber. In the irrigation methods, the survival was higher with drip irrigation compared to furrow method of irrigation. Growth of ber was influenced by associated component. The plant height was the highest in sole ber than grown in association with vegetable crops, whereas number of branches and canopy cover was higher in ber grown with vegetable crops than sole ber. The height of fruit plant was 35.34 % higher in sole ber as compared to integrated with pea. Number of branches per plant, canopy cover and survival percentage was higher in Ber + pea system than sole ber. More number of branches, better canopy covers and higher survival percents in ber+ pea system might be due to favourable moisture conditions and microclimate. More *et al* .2012 also reported favorable effect of ber+ legume vegetable intercrop on ber and vice-versa.

The results of present experiment suggest that drip method of irrigation is better than furrow method of irrigation to achieve higher yields of pea and mulching improves the yield. Therefore drip

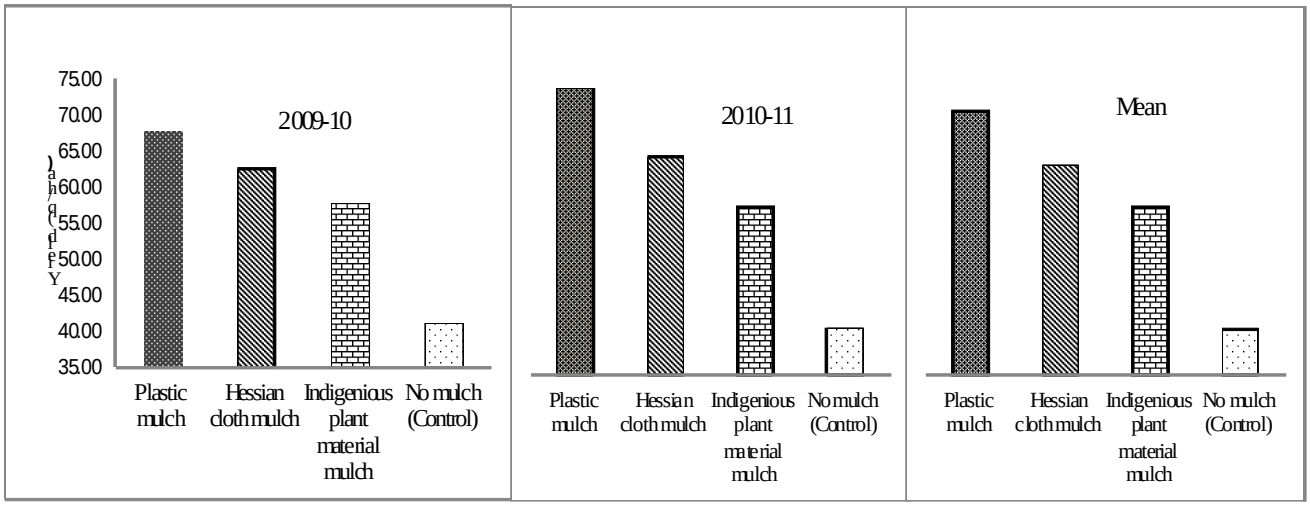

FIG.2: Effect of Mulching materials on pod yield of pea in pea + ber cropping system.

irrigation combined with mulching should be used to get better yields of pea and survival of ber plant and their growth in ber based system in tropical environment.

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