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Effect of method of irrigation, plastic mulch and nitrogen on fruit and seed yields of chilli (*Capsicum annum L.*)

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Abstract

Two sets of field experiments were conducted on sandy loam soils at Anand, India during the *rabi* (winter) - summer seasons of two years 1994/95 – 1995/96 to study the effect of method of irrigation in association with plastic mulch and nitrogen on the growth, fruit (green and dry) and seed yields of chilli cv. Pusa Jwala. Scheduling irrigation through drip at 80% of the CPE increased plant height, branches, chlorophyll, fruit and seed yields as compared to surface irrigation method. Similar trend was also noted with plastic mulch. Increasing the nitrogen rates from 75 kg to 125 kg N/ha progressively increased the fruit and seed yields.

Key Words: Irrigation, mulching, chillies and nitrogen

Introduction

Chilli (*Capsicum annum L.*) popularly known as *Mirchi* or red pepper is one of the important vegetable cum spices crop. It is a house hold article of daily diet. Chillies are used in preparation of vegetables, spices, condiments, sauces and pickles. Irrigation, fertilizers and their efficient use by the crop play an important role in elevating crop productivity. The efficiency of surface irrigation method is less and also affects the availability of the nutrients to the plants by virtue of leaching below the active root-zone of the crop. Application of irrigation and nitrogen through drip irrigation system help in saving of both these to the tune of 25-75% and 25-50%, respectively with considerable increase in good quality yield, because the fertilizers are applied often repeatedly and directly where active roots are concentrated. Synthetic plastic mulch reduces water evaporation and nutrient loss through volatilization; ultimately increase the use efficiency of these valuable inputs. Increase fertilizer use efficiency and yield in sweet pepper was also noted by Cresporuiz *et al.* (1). Chilli being a long duration crop requires more irrigation and nutrients for their higher production and hence constant wetting of the soil under split application of fertilizers are necessary on account of crop profitability. Since, both inputs are costly and scarce and escalating the cultivation cost, their judicious use is important. Mulching and nitrogen fertigation play pivotal role in harnessing the higher water and fertilizer use efficiency as compared to conventional method. Keeping this information in view, experiments were planned to study the effect of method of irrigation, plastic mulch and nitrogen on fruit and seed yields of chilli.

Materials and methods

The field experiments following the same methodologies for both sets (green and dry red fruit/ seed purpose) were done at Department of Agronomy Farm, Gujarat Agricultural University, Anand, Gujarat, India during *rabi*-summer seasons of 1994/95 – 1995/96. The soil of the experiment site was sandy loam, low in total nitrogen (0.036%), medium in available P_2O_5 (42 kg/ha) and with an average availability of K_2O (243 kg/ha) at pH 7.8. The values for field capacity, permanent wilting point and bulk density at 0-60 cm depth were 16.7 and 4.9% and 1.52 g/cm^3, respectively. Two irrigation method consisting of drip irrigation with three rate (irrigation at 40, 60 and 80% replacement of cumulative pan evaporation) compared with surface irrigation based on the irrigation water : cumulative pan evaporation (IW/CPE) ratio 0.75 with 50 mm depth and two levels of mulch (no mulch and black plastic mulch) as main plots and three rates of nitrogen (75, 100 and 125 kg N/ha) as sub plots applied in split plot design with four replications. Chilli

(cv. Pusa Jwalla) seedlings one month old were planted in paired row system of 75 cm x 45 cm x 75 cm in last week of October during both the years. The P_2O_5 and K_2O each at 50 kg/ha as a common dose in form of single superphosphate and muriate of potash, respectively were applied as basal in all treatments and nitrogen was applied from third irrigation as per treatments with irrigation water in 10 equal splits at an interval of 12 days in drip irrigation treatment, while in surface irrigation, it was applied in four equal splits at 30 days interval. The linear low density polyethylene (LLDPE 50m) black plastic mulch was applied a week after transplanting the crop in respective treatments. Good quality well water was applied with the help of Parshall flume (7.5 cm throat section) installed near the field head when cumulative pan evaporation (CPE) value achieved 66.7 mm in surface irrigation method. Thus, surface irrigation method received total 11 irrigations (550 mm) barring two common irrigations one before transplanting and another at four days after transplanting of the crop. In drip irrigation treatments, irrigation water was applied as per CPE fraction in the respective treatments. Seven pickings in green chilli fruits and three pickings in dry red chilli fruits/seed purpose experiments were done. The crop was terminated at 210 days of transplanting. The green fruits, dry red fruits and seed yields are given in Tables 1-3. The results were submitted to analysis of variance. Statistical significance was taken to be at $P < 0.05$ where necessary, combined analysis of variance of multiple season were carried out after testing the homogeneity of error mean square from the individual analysis of variance.

Results and discussion

Method of irrigation

Weed biomass and broom rape

Dry weed biomass was significantly lower under drip irrigation than surface irrigation which further reduced with the reduction in quality of irrigation water while dry weight of broomrape was significantly lowest under surface irrigation and significantly highest under drip irrigation apply at 80 % CPE (Table- 1). In drip irrigation only a fraction of soil surface is wetted which might have resulted in less germination of weed seeds as well as growth of germinating weeds resulted into less dry weed biomass, while in surface irrigation entire surface area is wetted at each irrigation which provide congenial for germinating seeds and growth of weeds.

Low temperature and optimum soil moisture condition prevailed through out the crop season under drip irrigation at 80% CPE might have favoured germination and growth of broom rape resulting in the highest dry weight of broom rape. At Anand, India higher number of broom rape was observed under drip irrigation method in rustica tobacco (2).

Growth attributes of green chilli

Growth characters, such as plant height and number of secondary branches/plant (Table -1) were significantly influenced by irrigation method during both the years of study and also in the combined analysis. Application of water through drip irrigation produced taller plants with more number of secondary branches as compared to surface method of irrigation. Among the drip treatments, irrigation at 80% CPE gave highest values of plant height and secondary branches/ plant in both the years and in combined results. Similar trend was also observed in case of total chlorophyll content in leaf lamina at different growth stages of crop. The increase in plant height and number of secondary branches/plant might be due to improved soil moisture status around the root zone which retained at sufficient levels through out the growth at 80% CPE. In drip irrigation at 80% CPE, higher water potential provided through out the crop period might have helped in availing optimum soil moisture and nutrients resulted in higher values of chlorophyll. Higher uptake of N under drip irrigation at 80% CPE increased the chlorophyll content. Similar results were also noted by Hegde (3).

Yield attributes and yield of green chilli

Significant variation was observed in all the yield attributes such as green fruits/plant, length of fruit and green fruit yield/plant due to method of irrigation in 1994/95 and 1995/96 and in pooled analysis (Table 2). Scheduling irrigation through drip at higher CPE fractions (60 & 80%) significantly increased the number of green fruits/plant, length of fruit and weight of fruit/plant resulted in higher green fruit yield as compared to drip irrigation at 40% CPE and surface irrigation. More fruit number under optimum moisture condition through drip irrigation was also reported by Goldberg and Shmueli (4).

Maximum values of all these yield attributing characters under irrigation 80% CPE attributed due to maintenance of favourable soil moisture status in the root zone which in tern helped plants to maintain better turgor, thus utilized moisture as well as nutrients more efficiently from wetted area and

Table 1. Growth attributes of green chilli grown at Anand, India as influenced by irrigation, mulch and nitrogen (1994-95 and 1995-96)

Treatment	Plant height (cm) at harvest			Number of secondary branches/ plant at harvest			Total chlorophyll content in leaf lamina (mg/g)									Dry weight of weed bio mas (kg/ha)			Dry weight of broom rape (kg/ha)		
							60 Days after planting			120 Days after planting			150 Days after planting								
	1994-95	1995/96	Pooled	1994-95	1995-96	Pooled	1994-95	1995-96	Pooled	1994-95	1995-96	Pooled	1994-95	1995-96	Pooled	1994-95	1995-96	Pooled	1994-95	1995-96	Pooled
Method of irrigation																					
Drip at 40% CPE	53.0	55.1	54.1	18.4	19.2	18.8	8.86	9.07	8.97	9.01	8.98	9.00	7.28	7.48	7.38	119	150	134	32	33	33
Drip at 60% CPE	54.0	56.7	55.3	18.6	19.4	19.0	9.46	9.53	9.50	9.36	8.99	9.18	8.53	7.14	7.83	134	176	155	35	34	35
Drip at 80% CPE	55.3	59.6	57.5	19.3	19.7	19.5	9.94	9.68	9.81	9.98	9.73	9.86	9.31	8.74	9.02	150	212	181	40	42	41
Surface irrigation	52.9	55.0	53.9	17.8	18.1	18.0	8.36	8.93	8.64	8.02	8.75	8.39	7.28	7.03	7.16	537	544	540	22	28	25
S.E. (9 D.F.) (18 D.F. for pooled	0.56	0.38	0.39	0.20	0.14	0.12	0.06	0.20	0.10	0.20	0.17	0.14	0.12	0.12	0.09	3.62	8.98	3.94	1.0	1.5	0.9
Mulch																					
No mulch	53.1	55.5	54.3	18.1	18.6	18.4	8.82	8.90	8.86	8.66	8.68	8.67	7.68	7.05	7.37	396	456	426	43	47	45
Plastic mulch	54.5	59.7	56.1	19.0	19.6	19.3	9.48	9.71	9.60	9.53	9.53	9.54	8.53	8.14	8.33	74	84	79	22	22	22
S.E. (60 D.F.) (120 D.F. for pooled	0.23	0.22	0.15	0.10	0.07	0.06	0.05	0.08	0.05	0.10	0.10	0.07	0.07	0.06	0.05	1.33	2.44	1.34	0.9	0.9	0.7
Nitrogen (kg/ha)																					
75	53.2	55.6	54.5	18.0	18.7	18.4	7.71	8.77	8.24	7.58	7.87	7.72	7.23	6.75	6.99	221	256	238	31	33	32
100	53.7	56.7	55.2	18.5	19.2	18.8	9.14	9.30	9.22	9.13	9.27	9.20	8.37	7.74	8.05	238	271	255	32	34	33
125	54.5	57.3	55.9	19.0	19.5	19.2	10.61	9.84	10.23	10.58	10.20	10.39	8.70	8.31	8.51	245	284	265	33	37	35
S.E. (60 D.F.) (120 D.F. for pooled	0.28	0.27	0.19	0.12	0.09	0.07	0.06	0.10	0.06	0.12	0.12	0.08	0.09	0.07	0.06	1.63	2.999	1.64	1.1	1.1	0.8

Table 2. Yield attributes and yield of green chilli grown at Anand, India as influenced by irrigation, mulch and nitrogen (1994-95 and 1995-96)

Treatment	Number of green fruits/plant			Length of fruit (cm)			Weight of green fruit/plant (g)			Green fruit yield (t/ha)			Field WUE (g/kg)
	1994-95	1995-96	Pooled	1994-95	1995-96	Pooled	1994-95	1995-96	Pooled	1994-95	1995-96	Pooled	
Drip at 40% CPE	232	228	230	8.3	9.9	9.1	396	432	414	10.884	11.632	11.258	31.13
Drip at 60% CPE	264	276	270	8.5	10.2	9.3	464	552	508	12.560	14.946	13.753	26.32
Drip at 80% CPE	286	326	306	8.8	10.3	9.6	528	653	590	14.140	17.729	15.934	23.31
Surface irrigation	219	235	227	8.5	9.7	9.1	366	421	394	10.066	11.330	10.698	14.26
S.E. (9 D.F.) (18 D.F. for pooled	8.2	3.0	4.6	0.03	0.05	0.03	16.6	5.1	8.8	0.551	00.146	00.277	00.58
Mulch													
No mulch	238	243	240	8.4	9.9	9.1	406	469	438	11.040	12.647	11.844	21.78
Plastic mulch	263	289	276	8.6	10.1	9.4	471	560	515	12.785	15.171	13.978	25.73
S.E. (60 D.F.) (120 D.F. for pooled	2.0	2.4	3.5	0.04	0.04	0.02	3.1	4.1	2.5	00.095	00.119	00.071	00.14
Nitrogen (kg/ha)													
75	232	238	340	8.3	9.9	9.1	395	454	425	10.628	12.201	11.415	20.97
100	251	273	262	8.5	10.0	9.3	435	525	480	11.874	14.207	13.040	24.03
125	267	288	276	8.7	10.2	9.4	485	564	524	13.235	15.320	14.277	26.26
S.E. (60 D.F.) (120 D.F. for pooled	2.5	2.9	2.1	0.05	0.04	0.03	3.7	5.1	3.0	00.116	00.146	00.870	00.17

Table 3. Yield attributes and yields of dry red chilli grown at Anand, India as influenced by irrigation, mulch and nitrogen (1994-95 and 1995-96)

Treatment	Number of dry red fruits/plant			Weight of dry red fruit/plant (g)			Number of seeds/ fruit			Dry red fruit yield (t/ha)			Seed yield (kg/ha)			Field WUE (g/kg)
	1994-95	1995-96	Pooled	1994-95	1995-96	Pooled	1994-95	1995-96	Pooled	1994-95	1995-96	Pooled	1994-95	1995-96	Pooled	
Method of Irrigation																
Drip at 40% CPE	132	141	137	64	71	70	34	33	33	17.51	18.30	17.91	510	515	512	4.95
Drip at 60% CPE	141	161	151	71	85	81	35	35	35	19.31	21.95	20.63	564	628	596	3.95
Drip at 80% CPE	145	167	156	75	91	86	36	37	36	20.72	23.55	22.14	615	681	648	3.24
Surface irrigation	118	135	126	56	70	65	32	32	32	15.43	17.81	16.62	448	508	478	2.22
S.E. (9 D.F.) (18 D.F. for pooled	4.1	1.8	2.6	1.7	0.8	1.2	0.3	0.3	0.2	0.60	0.18	00.36	14.9	4.0	8.9	0.07
Mulch																
No mulch	126	139	133	61	73	70	33	34	34	16.81	18.78	17.80	489	536	513	3.31
Plastic mulch	142	163	152	71	85	81	35	35	35	19.37	22.02	20.85	579	630	605	3.87
S.E. (60 D.F.) (120 D.F. for pooled	1.1	1.8	1.0	0.5	0.7	0.4	0.3	0.3	0.2	0.14	00.20	00.11	4.0	5.5	3.1	0.02
Nitrogen (kg/ha)																
75	121	137	129	60	72	68	33	33	33	16.37	18.41	17.39	481	528	505	3.24
100	136	152	143	66	80	76	34	34	34	18.12	20.72	19.42	533	591	562	3.60
125	148	163	156	73	86	82	36	36	36	20.23	22.07	21.15	588	630	609	3.93
S.E. (60 D.F.) (120 D.F. for pooled	1.3	2.2	1.3	0.6	0.8	0.5	0.3	0.4	0.3	0.17	00.24	00.14	4.9	6.8	3.8	0.03

ultimately enhanced vegetative as well as reproductive growth more over, higher chlorophyll content in leaf lamina under drip irrigation at 80% CPE (Table 1) which might have helped for high rate of photosynthesis during the reproductive phase and channelization of accumulated photosynthesis during vegetative phase from source to sink.

Yield attributes and yield of red chilli

Method of irrigation had significant influence on number of red fruit, weight of dry red fruit, number of seeds/fruit, dry red fruit yield and seed yield of chilli in both the years of study and also in combined analysis (Table-3). Application of water through drip gave higher values for these characters as compared to surface irrigation. Among the drip treatments, irrigation at 80 % CPE gave maximum value for the same. The field WUE was also higher in drip irrigation system than surface method of irrigation. Drip irrigation at 40% CPE gave the highest WUE. It was obviously due to appreciable increase in yields per unit volume of water was higher under drip irrigation at lower level as compared to higher level of drip and surface irrigation method. More over large quantity of irrigation water (750 mm) in shorter time applied in entire surface area in surface irrigation is likely to be lost through deep percolation and surface evaporation resulted in poor utilization by plants which may affect the growth and reproduction processes. In drip irrigation treatment, maximum utilization of applied water in term of plant growth and yields took place, which ultimately results in higher yield with less water as the water is applied in limited quantity at frequent interval in the effective root zone. Thus, in drip irrigation bilateral advantages i. e. saving of water and optimum availability of moisture helped in increasing nutrient availability in the soil solution, increased nutrient up take, increased growth and development and ultimately the yield. WUE is proportionally related with the amount of water applied for used. These results are accordance with the results of Goyal *et al.* (5).

Maximum seed yield was registered under drip irrigation at 80% CPE due to more values recorded in this treatment in respect of number of mature seeds per fruit, weight of seeds/fruit and seed yield/plant (Table-3). These results are akin to those reported by Payero *et al.* (6).

Mulch

Weed biomass and broom rape

Mulching with black plastic remarkably reduced the dry weight of weed biomass and broom rape over no mulch (Table-1). This may be due to reduction in germination of weeds because of covering of soil surface with mulch, any weed seeds germinated below mulch is subjected to death due to high soil temperature and lack of aeration and light. Gollifer (7) also noted that mulching 7 days after transplanting of Indian chilli enhanced the plant growth due to reduction in the weed competition.

Growth attributes of green chilli

Mulching with black plastic increased the growth parameters i. e. plant height and secondary branches/ plant during both the years and also in the pooled analysis. Higher plant height and secondary branches/ plant under mulching might be due to reduction in evaporation ultimately increased water retention in soil which helped in maintaining the turgidity of plant cell, promoting the division and expansion of plant cell component resulting in to increased in plant height and branches/plant. Similar results have also been reported by Geneve (8). Total chlorophyll content in leaf lamina at different growth periods was also significantly higher under mulching treatment. Mulching by the virtue of reduction in evaporation and control of weed decreased the weed competition for nutrient with the chilli plant thereby increased the up take of N under black plastic mulch. N being constituent of protein, enzymes and chlorophyll (9) there is very likelihood for increase in treatment of mulching.

Yield attributes and green fruit yield

Mulching with black plastic significantly increased number of green chilli fruits, fruit length, fruit weight and green chilli yield per plant than no mulching treatment. The increased in above characters might be due to the beneficial effect of mulch on growth and physiological parameters resulted in higher values of yield attributes. The increase in fruit length and weight might be due to increased chlorophyll content in leaf lamina resulted in higher photosynthetic activity and channelization of accumulated photosynthesis from source to sink. Gosselin & Trudel (10) reported beneficial effect of increased soil temperature on fruit weight under mulching. Mulching also significantly increased the green fruit yield as compared to no mulching due to increased in attributes. Joseph & Lee (11) reported positive effect of black plastic mulch on bell pepper yield under sandy loam soil of River hood.

Yield attributes and yield of red chilli

Mulching had significant positive influence on yield

attributing character for dry red chilli yield i. e. number of dry red fruits, yield of red dry fruits per plant and seed weight/fruit. These findings are in conformity with the results of those reported by Varade (12). Mulch with black plastic significantly increased the seed yield of chilli over no mulch and the increase was to the tune of 17.9 %. This was due to the fact that it increased number of dry red fruits/plant, yield of dry red fruit/plant, number of matured seeds/fruit and weight of seed/fruit.

Nitrogen

Weed biomass and broom rape

Dry weight of weeds increased progressively as the levels of N increased. Lower level of N recorded significantly lower dry weight of weed as compared to 100 and 125 kg N/ha (Table-1). This could be due to crop weed competition for N requirement. The dry weight of broom rape however did not influence significantly by the rates of nitrogen in both the years of study and in pooled results also.

Growth attributes of green chilli

Nitrogen rates have significant influence on growth characters such as plant height, secondary branches and chlorophyll content. Plant height and secondary branches were increased with increasing rates of N. Higher growth attributes under 125 kg N/ha could be attributed to favorable effect of N in increasing cell wall material resulted in increased size of cell which in turn expressed morphologically as increased plant growth and number of branches/plant. These results are in line with the results of those reported by Singh *et al.* (13). Similarly the total chlorophyll content in leaf lamina also increased significantly with increase in N rates. Higher chlorophyll content in leaf lamina under higher rates of N (125 kg/ha) could be due to increased N uptake in this treatment which is likely to increase chlorophyll content.

Yield attributes and yields of green chilli

Significant variation was noted in yield attributes such as number of green fruits/plant, fruit length and green fruit yield/plant due to N rates. Increasing the rates N from 75 to 125 kg/ha progressively increased all these yield attributes which intern resulted highest yield of green chilli fruits/ha. The results are in akin to these reported by Singh & Srivastava (14).

Yield attributes and yield of red chilli

Higher rates of N had significant effect on red chilli yield attributes such as number of red fruit, weight of dry red fruit, number of seed and seed weight/fruit during individual years of study as well as on pooled basis. Increasing the rates of N significantly increased the values of these characters and linear trend was also observed in dry red fruit yield and seed yield wherein the maximum values were noted with 125 kg N/ha. The results are in accordance with Sonatakke *et al.* (15). They reported increased yield attributes and yield of chilli with increasing rates of N. The beneficial effect of N application on yield attributes and yield of dry red chilli and seed yield were also reported by Thiagarajan (16).

The field WUE for green chilli, dry red chilli and seed yield was significantly higher under 125 kg N/ha and this was only due to favourable effect of N on crop growth and higher production of yields, which in turn resulted substantially higher field WUE.

References

1. **Cresporuiz, M., Goyal, M.R., Baez, C.C. De and Rivera, L.E.**1988. Nutrient uptake and growth characteristics of nitrogen fertigated sweet peppers under drip irrigation and plastic mulch. *Journal of Agriculture of University of Puerto Rico.* **72** : 575-584.

2. **Anonymous.**1997. *Research accomplishments and recommendations.* Directorate of Research, Gujarat Agricultural University. Shahibaug, Dafnala, Ahmedabad. pp. 18-19.

3. **Hegde, D.M.** 1989. Effect of soil moisture and nitrogen on plant water relations mineral composition and productivity of bell pepper (*Capsicum annum* L.). *Indian Journal of Agronomy.* **34** : 30-34.

4. **Goldberg, D. and Shmueli, M.** 1971. Sprinkler and trickle irrigation of green pepper in an arid zone. *Horticulture Scence.* **6** : 559-563.

5. **Goyal, M.R., Cresporuiz, M. and Rivera, L.E.** 1987. Root distribution of nitrogen fertigated sweet pepper under drip irrigation. *Journal of Agricultural University Puerto Rico.* **72** : 51-55.

6. **Payero, J.O., Bhangoo, M.S. & Steiner, J.J.** 1990. Nitrogen fertilizer management practices to enhance seed production by 'Anaheim chilli' peppers. *Journal of American. Society for Horticulture Science.* **115** : 245-251.

7. **Gollifer, D.E.** 1993. Effects of applications of mulch and potassium on (*Capsicum annum* L.) Pupa New Guinea *Journal of Agriculture.* **36** : 22-29.

8. **Geneve, R.L.**1982. Selecting mulch for vegetable garden. *Minnesota Horticulturist.* **109** : 72-75.

9. **Lehninzer, A. L.** 1992. *Principles of biochemistry*, Kalyani Publisher, New Delhi.

10. **Gosselin, A. and Trudel, M.J.** 1986. Root-zone temperature effects on pepper. *Journal American Society of Horticulture Science.* **111 :** 220-224.

11. **Joseph, E.V. and Lee, D.W.** 1988. Influence of plastic mulch and type and frequency of irrigation on growth and yield of bell pepper. *Horticuture Scence.* **23 :** 985-988.

12. **Varade, S.B.** 1998. Role of irrigation in higher crop productivity. *Fertilizer News.* **43** : 59-63.

13. **Singh, M.; Pandey, S.K. and Yadav, H.S.** 1988. Efficiency of split doses of nitrogen and insecticides on the growth and yield of chillies. *Indian Agriculturist.* **32**, 271-274.

14. **Singh, K. & Srivastav, B.K.** 1988. Effect of various levels of nitrogen and phosphorus on growth of chilli. *Indian Journal of Horticulture.* **45** : 391-324.

15. **Sonatakke, M.B. Shinde, S.B., Mandge, A.S. and Shinde, N. N.** 1996. Studies on fruit harvesting at various levels of nitrogen in chilli during *kharif* season. *Journal of Maharashtra agricultural University.* **21** : 70-72.

16. **Thiagarajan, C. P.** 1990.Influence of NPK on the yield and quality of chilli seed. *South Indian Horticulture.* **38** :159-160.