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Effect of Drip Irrigation, Fertigation and Mulching on Growth and Dry Matter Accumulation in Bitter Gourd

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ABSTRACT

The field experiments were carried out to evaluate the effect of irrigation, fertigation and plastic mulching in bitter gourd variety Preethi in randomised block design with factorial combination of treatments having 18 treatments and 3 replications. Effect of three levels of irrigation (60%, 80% and100% ET) applied through drip, two levels of mulching (no mulch and mulching with silver- black plastic mulch) and three levels of fertiliser (75%, 100% and 125% of NPK dose 210: 74: 225 kg/ ha) applied as fertigation using water soluble fertilisers were studied. The results indicated that the highest irrigation and fertigation levels (100%Ep and 125%NPK dose) along with plastic mulching significantly enhanced the length of main vine, number of primary branches, dry matter content of leaves and vine, fruit dry mater content, harvest index and N,P,K and iron content of fruits. However, higher doses of irrigation, fertigation and mulching lead to decrease in the ascorbic acid content of fruits. Plastic mulching resulted in early opening of male and female flowers on lower nodes and facilitated 8.64 days early harvest. While increasing the fertigation dose, from 75 to 100 per cent, increased dry matter content of fruits by 37.29 per cent, further increase from 100 to 125 per cent resulted in an increase of only 6.26 per cent. Drip fertigation using water soluble fertilisers along with silver-black plastic mulching can be effectively used for attaining higher production and early harvest in bitter gourd variety Preethi in Kerala.

Key Words: Bitter gourd, Drip irrigation, Dry matter, Fertigation, Plastic mulching.

INTRODUCTION

Bitter gourd is one of the leading cucurbitaceous vegetables grown in India. The crop is mainly cultivated for its fruits that are rich in vitamin C, beta carotene, iron, phosphorus and potassium (Trivedi *et al,* 2011). Bitter gourd is also known for its medicinal properties and presence of good amount of hypoglycemic chemicals such as steroidal saponins called charantins, insulin like peptides and alkaloids in the fruit (Anilakumar *et al,* 2015). It is widely cultivated during post south-west monsoon period (September-December) and summer in Kerala. The production and accumulation of dry matter and nutrients in a plant is influenced by the physico-chemical properties of soil, climatic conditions prevailing at various stages of growth, the variety used and the management practices adopted (Meenakshi *et al,* 2008). The role of irrigation at appropriate level and according to the crop growth stage has great significance in improving yield (Singh *et al,* 1990). Fertigation, the judicious application of fertilisers along with irrigation, proved to be the principal factor that enhance yield in many crops (Ningaraju and Joseph, 2014; Sathish *et al,* 2014).

Drip fertigation coupled with plastic mulching is gaining popularity in Kerala as tools for improving production, productivity and profitability of vegetable cultivation. Fertigation and plastic mulching proved to improve growth by providing optimum nutrient availability conditions for nutrient absorption. However, the effectiveness of any new irrigation fertiliser application strategy need to be evaluated and fine tuned in the prevailing agro

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climatic situation. Hence the present investigation was carried out to understand the influence of these practices on growth, accumulation of dry matter and the quality of produce in bitter gourd under open field cultivation, in the humid tropical condition of Kerala.

MATERIALS AND METHODS

Field experiments with Bitter gourd (Momordica charantia L.) cv. Preethi were carried out in the instructional farm of ICAR- Krishi Vigyan Kendra, CARD, Kolabhagom located at 90 22'44'' N latitude and 760 41'13''E longitude and at an average elevation of 17m above MSL in agro climatic zone humid forest loam, during the period September to December in 2014 and 2015. The soil texture was clay loam with pH (5.1) , electrical conductivity (0.05 dSm-1), available N (172.48 kg/ha), available P (90.94 kg/ha) and available K (236.54 kg/ha). The experiments were laid out in factorial randomised block design having 18 treatment combinations and 3 replications. The treatment factors were three levels of irrigation applied through drip viz., 60%, 80% and100% ET; two mulching levels viz., without mulch and mulching with silver- black plastic mulch of 30µ thickness; and three fertiliser levels viz., 75% , 100% and 125% of NPK dose 210: 74: 225 kg/ha.

The operation time of drip irrigation system for supply of required quantity of water for each treatment combinations were computed using the following equations.

1. Vd = (Ep x Kp x Kc x Wp x Sp) where; (Vermeiren and Jobling, 1980)

   Vd – Daily water requirement of plants in L/ day/plant

   Ep – Maximum pan evaporation for the season (4.5mm/day)

   Kp- Pan coefficient for USWB Class-A pan evaporimeter (0.7)

   Kc- Stage wise crop coefficient values for cucurbitaceous crops (Kc ini - 0.6, Kc mid – 1.15, Kc end – 0.75) (Allen, *et al*., 1998)

   Wp – Percent wetted area (0.7)

   Sp- Plant area in m2 (1.2)

2. IWd = (Vd- ERd) / IE where; (Kumari, *et al*., 2014)

   IWd – Net irrigation water requirement in L/ day /plant

   ERd – Daily effective rainfall (70% in no-mulch treatments, Zero in mulched treatments)

   IE- Application efficiency of drip irrigation system in decimal (0.90)

3. t = (Vd x 60) / D where; (Pawar, 2001)

   t - Operation time of the drip system in minutes

   IWd - Net irrigation water requirement in L/ day /plant

   D - Discharge capacity of dripper (2.4lph)

Fifty per cent of P of each treatment combination was applied as basal dose using rock phosphate and the rest 50 per cent P along with 100 per cent N and K were applied as fertigation; split in to 40 doses, applied once in 3 days starting from third day after sowing as per the schedule recommended by Kerala Agricultural University for fertigation. 19:19:19, Urea, Potassium Nitrate (13:0:45) and Mono Ammonium Phosphate (12:61:0) were used as fertiliser sources for supplying the nutrients.

The sprouted seeds of bitter gourd variety Preethi were sown at a spacing of 2 x 0.6 m on raised beds of size 3x1x0.45m (lxbxh) mulched as per treatment. The data on parameters, length of vine and number of primary branches, were collected on the day of last harvest. Plant leaf and vine dry matter content was determined using the five observation plants from each plot, sampled on the day of last harvest. Per plant dry weights obtained were used for calculating the per hectare plant dry weight expressed in kg /ha. Fruit dry matter production in kg/ha was calculated using data on average number

Table 1. Total quantity of water soluble fertilisers used and quantity of nutrients supplied through fertigation during each crop growth stage in kg/ha.

Sr. No.	Crop growth stage	No of splits	Total fertilisers applied				Total nutrients supplied		
			19:19:19	13:0:45	Urea	12:61:0	N	P	K
1.	Stage I (1-20 d)	6	29.2	62.7	38.6	0	31.5	5.5	33.7
2.	Stage II (21-54 d)	12	29.2	137.7	83.5	9.1	63.0	11.1	67.5
3.	Stage III (55-120 d)	22	53.6	252.4	153.3	16.7	115.5	20.4	123.8

of fruits/plant and average dry weight of single fruit. Harvest index was determined using the equation

HI= (FDM x100) ÷ TDM where;

HI- Harvest Index; FDM – Fruit Dry Matter in kg/ha and TDM- Total Dry Matter in kg/ha

Methodologies suggested by Jackson (1973) (total N, P & K content), Sadasivam and Manikam (1996) (ascorbic acid content) and Lindsay and Norvel (1978) (iron content) was employed to assess the quality of fruits. Data from the two experimental years were pooled and analyzed using statistical software SPSS ver.16.

RESULTS AND DISCUSSION

Growth, flower anthesis, node number of flowers and first fruit harvest

Increasing irrigation levels form 60 % Ep to 100% Ep enhanced the length of main vine and number of primary branches and resulted in early opening of male and female flowers on lower nodes. Irrigation at 80% Ep and 100% Ep resulted in at par values in days taken for anthesis of female flowers and the node position of first female flower (Table 2).

Mulching with silver–black plastic mulching sheet resulted in 6.85, 8.72 and 8.64 days of reduction respectively in the anthesis of first male flower, first female flower and number of days taken for first harvest when compared to non-mulched plots (Table 2). Bed mulching practice was found to be very useful in controlling weeds and conserving soil moisture and this might have helped in increasing plant growth. NPK Fertigation at higher doses significantly increased the length of vines and lead to production of more number of primary branches. It also resulted in early male and female flower anthesis on lower nodes and early harvest.

Canopy of the plants is greatly influenced by the length of vines and number of branches which in turn contributes to the production of dry matter through photosynthesis. Maintenance of moisture at field capacity, higher availability of nutrients due to higher rates of supply and improvement in soil properties due to plastic mulching must have resulted in higher vine length, more number of branches in I3, M2 and F3 treatments and lead to early development and opening of flowers and facilitated early harvest in these treatments.

Dry matter content and harvest index

Dry matter content of leaves and vine, fruit dry mater content and harvest index showed significant variation among the different irrigation, mulching and fertigation levels. While dry matter content of plants leaves and vines showed an increase of only 5.8%, the fruit dry matter increased by 37.57% when irrigation was increased from 60% Ep (I1) to100% Ep (I3). Similarly, mulching with silver-black polythene mulch resulted in only 6.76% increase of dry matter content of plant vines and leaves against 49.23% increase in the dry matter

Table 2. Effect of drip irrigation, mulching and fertigation levels on growth, flower anthesis, node number of flowers and first harvest in bitter gourd.

Sr. No	Treatment	Vine length (cm)	Number of primary branches	Days to first male flower anthesis	Days to first female flower anthesis	Node number of first male flower	Node number of first female flower	Days to first harvest
1.	I1	434.68	19.20	31.91	35.85	14.45	20.46	51.43
2.	I2	480.15	21.70	31.67	35.35	13.02	18.87	51.26
3.	I3	498.11	22.06	31.85	35.20	12.72	18.56	51.20
	CD (0.05)	13.01	0.18	NS	0.3	0.14	0.51	NS
4.	M1	455.8	19.22	35.23	39.83	14.11	20.22	55.62
5.	M2	486.17	22.75	28.38	31.11	12.68	18.37	46.98
	CD (0.05)	10.62	0.15	0.26	0.25	0.11	0.42	0.29
6.	F1	434.05	19.28	34.33	38.15	14.78	20.41	53.91
7.	F2	479.49	21.67	31.19	34.94	12.85	18.91	50.58
8.	F3	499.40	22.02	29.91	33.32	12.59	18.58	49.41
	CD (0.05)	13.01	0.18	0.32	0.3	0.14	0.51	0.35

I1- irrigation at 60% Ep, I2- irrigation at 80% Ep and I3- irrigation at 100% Ep

content of fruits. While increasing the fertigation dose from 75% (F1) to 100% (F2) resulted in an increase of fruit dry matter content by 37.29 %, further increase from 100% (F2) to 125% (F3) resulted in an increase of only 6.26 % (Table 3). The interaction M2F3 resulted in maximum fruit dry matter content (3110 kg/ha) and harvest index (41.43) (Table 6) followed by I3M2 interaction (3054 kg/ha) and (41.39) respectively (Table 4).

N, P, K, iron and ascorbic acid content

Increasing levels of irrigation and mulching resulted in significant increase in the N, P, K and Iron content of fruits. However, raising fertigation level from 75 to 125 per cent resulted in less marked increase in the N, P, K content of fruits compared to the increase in iron content which showed an increase of 24.3 per cent. In all treatments higher levels of application lead to a significant reduction in the ascorbic acid content (Table 3) and Interaction of the highest levels of irrigation and fertigation (I3F2) resulted in the lowest ascorbic acid content in fruits (Table 5).

Growth and accumulation of dry matter is positively correlated with the availability of moisture and nutrients. Hebbar *et al*(2004) reported that fertigation using water soluble fertilisers contribute to the increased availability of N, P, and K in the 0-30 cm soil depth and reduce leaching of NO_3^- N and K. Plastic mulching aids in better weed control and reduce completion for moisture and nutrients. All these might have lead to the increased availability of nutrients in the soil solution ensuing in the increased uptake of these nutrients by plants and better translocation of assimilates from source to sink, resulting in higher dry matter accumulation by fruits. The decrease in the ascorbic acid content may be due to a relative dilution effect occurred in the plant tissues due to enhanced growth. The higher vine growth and branch number in the treatments supplied with higher doses of irrigation, fertiliser and mulching also must have resulted in reduced light intensity and shading of fruits in the pandal and might have lead to lesser synthesis of ascorbic acid by these fruits.

Table 3. Effect of drip irrigation, mulching and fertigation levels on dry matter, harvest index, total N, P ,K, iron and ascorbic acid content of fruits in bitter gourd.

Sr. No.	Treatment	PDM (kg/ha)	FDM (kg/ha)	Harvest Index	N (%)	P (%)	K (%)	Vit. C in (mg/100g)	Fe (mg/100g)
1.	I1	3891	1834	31.63	1.69	0.70	4.33	109.28	3.21
2.	I2	4065	2424	36.61	1.74	0.71	4.39	106.06	3.28
3.	I3	4118	2523	37.23	1.75	0.72	4.46	102.78	3.35
	CD (0.05)	14.95	88.17	0.67	0.03	0.003	0.004	0.44	0.009
4.	M1	3893	1814	31.47	1.68	0.68	4.26	107.56	3.15
5.	M2	4156	2707	38.85	1.77	0.74	4.53	104.52	3.41
	CD (0.05)	12.21	71.99	0.52	0.025	0.002	0.003	0.36	0.008
6.	F1	3765	1770	31.55	1.63	0.66	4.11	112.04	2.92
7.	F2	4103	2430	36.54	1.73	0.72	4.41	105.67	3.29
8.	F3	4205	2582	37.39	1.82	0.75	4.67	100.41	3.63
	CD (0.05)	14.95	88.17	0.67	0.03	0.003	0.004	0.44	0.009

I1- irrigation at 60% Ep, I2- irrigation at 80% Ep and I3- irrigation at 100% Ep, M1- without mulch, M2 – Mulching with Silver- Black plastic mulch of 30µ thickness, F1 – 75% NPK dose, F2 – 100% NPK dose and F3 – 125% NPK dose.

Table 4. Interaction effect of Irrigation and mulching levels on dry matter, harvest index, total N, P, K, iron and ascorbic acid content in bitter gourd.

Sr. No.	Treatment	PDM (kg/ha)	FDM (kg/ha)	Harvest Index	N (%)	P (%)	K (%)	Vit. C in (mg/100g)	Fe (mg/100g)
1.	I1M1	3766	1539	28.89	1.63	0.67	4.20	110.56	3.05
2.	I1 M2	4016	2129	34.38	1.74	0.72	4.46	108.00	3.37
3.	I2 M1	3930	1911	32.45	1.7	0.68	4.26	108.04	3.15
4.	I2 M2	4199	2938	40.78	1.78	0.73	4.53	104.07	3.41
5.	I3 M1	3984	1992	33.08	1.71	0.70	4.32	104.07	3.24
6.	I3 M2	4252	3054	41.39	1.79	0.75	4.60	101.48	3.46
	CD (0.05)	NS	124.69	0.9	NS	0.004	0.006	0.62	0.014

CONCLUSION

Irrigation at 100 per cent Ep and fertigation at 125 per cent NPK dose along with application of silver-black plastic mulching significantly enhanced the dry matter content and facilitated early harvest of fruits in bitter gourd variety preethi, cultivated under open field conditions in the humid tropical region of Kerala. It also improved the N, P, K and iron content of fruits. However, increasing the fertigation level form 100 per cent NPK recommendation to125 per cent level lead to less pronounced increase in dry matter content than increasing the level from 75 to 100 per cent and the lowest ascorbic acid content of fruits.

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Table 5. Interaction effect of Irrigation and fertigation levels on dry matter, harvest index, total N, P, K, iron and ascorbic acid content in bitter gourd.

Sr. No.	Treatment	PDM (kg/ha)	FDM (kg/ha)	Harvest Index	N (%)	P (%)	K (%)	Vit. C in (mg/100g)	Fe (mg/100g)
1.	I1 F1	3639	1496	28.97	1.57	0.64	4.04	114.72	2.86
2.	I1 F2	3911	1959	33.05	1.70	0.71	4.34	109.45	3.21
3.	I1 F3	4122	2048	32.88	1.80	0.74	4.62	103.67	3.56
4.	I2 F1	3812	1877	32.57	1.67	0.66	4.10	112.17	2.91
5.	I2 F2	4168	2620	38.04	1.73	0.72	4.41	105.72	3.29
6.	I2 F3	4214	2777	39.24	1.82	0.75	4.67	100.28	3.64
7.	I3 F1	3844	1937	33.11	1.65	0.68	4.18	109.22	2.98
8.	I3 F2	4231	2711	38.55	1.76	0.73	4.48	101.83	3.37
9.	I3 F3	4279	2922	40.04	1.85	0.76	4.73	97.28	3.70
	CD (0.05)	25.9	152.71	1.1	NS	0.005	0.007	0.76	0.017

Table 6. Interaction effect of mulching and fertigation levels on dry matter, harvest index, total N, P, K, iron and ascorbic acid content in bitter gourd.

Sr. No.	Treatment	PDM (kg/ha)	FDM (kg/ha)	Harvest Index	N (%)	P (%)	K (%)	Vit. C in (mg/100g)	Fe (mg/100g)
1.	M1F1	3637	1447	28.39	1.6	0.63	3.98	113.78	2.79
2.	M1F2	3969	1941	32.68	1.68	0.69	4.27	107.26	3.16
3.	M1F3	4075	2054	33.35	1.77	0.73	4.53	101.63	3.50
4.	M2F1	3894	2093	34.71	1.66	0.69	4.24	110.30	3.05
5.	M2F2	4238	2918	40.41	1.78	0.75	4.54	104.08	3.42
6.	M2F3	4335	3110	41.43	1.88	0.77	4.81	99.18	3.77
	CD (0.05)	NS	124.69	0.9	NS	0.004	0.006	NS	NS

Pathanamthitta by providing the land and drip-fertigation facilities essential for the conduct of the experiment.

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