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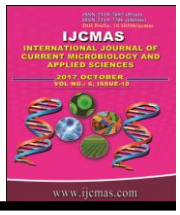

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Yield Performance and Profitability of Bitter Gourd Cultivation as Influenced by Drip Irrigation, Fertigation and Plastic Mulching

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A B S T R A C T

Assessing the impact of technologies on yield and profitability of cultivation is an essential step before dissemination of the technologies for wider adaptation. Investigations were carried out at ICAR-Krishi Vigyan Kendra, CARD, Pathanamthitta, Kerala during September- December period of 2014 and 2015 to evaluate the impact of irrigation, fertigation and plastic mulching in bitter gourd variety Preethi. The experiment was conducted in RBD factorial 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^{-1}) 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 produced maximum values of fruit length, fruit girth, fruit weight, number of fruits/plant, number of harvests and the marketable yield. Irrigation at 100%Ep and fertigation at 100% NPK dose along with mulching with silver-black plastic mulch gave the highest BCR of 2.32 due to the increase in unmarketable yield with the increase in fertiliser dose.

Introduction

Vegetable production plays a major role in the nutritional and financial security of small and marginal farmers in India. Achieving higher growth in productivity and profitability in vegetable cultivation is the need of the hour for sustaining these farmers. Dwindling sources and growing concern on the ecological impact of agricultural inputs like water and fertiliser, demand judicial use of these for boosting production and productivity in intensive agriculture. Application of apt technologies has a constructive impact on productivity of crops, quality of produce, economics of production and protection of the environment. Fertigation, the application of fertilisers along with irrigation, offer greater flexibility in fertiliser application and allow the grower to cater to the specific nutritional needs of the crop at different stages of its growth. Adoption of micro irrigation systems like drip saves 27 to 42 percent of water (Vivek *et al.*, 2011) and adoption of fertigation has shown favorable results globally in terms of fertiliser use efficiencies, quality of produce and environmental advantages (Anu *et al.*, 2014). Use of mulch along with fertigation is beneficial for conserving moisture, reducing weed

infestation and preventing leaching loss of nutrients.

Bitter gourd is one of the leading vegetable crops of India and farmers prefer this crop due to its higher yield and maximum returns (Naveen Kumar, *et al.*, 2012). Anti-diabetic properties of bitter gourd make it a favourite among Kerala consumers. The fruits are also rich in vit C, phosphorus and iron. The crop is widely cultivated during post south-west monsoon period and summer in Kerala. The crop enjoys a comparatively steady market price and market demand that makes it the most preferred vegetable crop among farmers. Rising labour and input costs demands the adoption of technologies that can improve the productivity and the profitability of bitter gourd cultivation in Kerala. New ways of advancing productivity and improving quality of produce are always in great demand in the farming community.

The full potential of any cultivar of a crop can be exploited only with judicious water and fertiliser management practices (Hari and Girija Devi, 2016). Vegetables being very sensitive to the availability of water and nutrients, the application rate of these inputs may affect their performance. Standardization of the application doses of these nutrients for each crop and each climatic condition need to be done before recommending it to the farmers. The present experiment was conducted to study the irrigation and fertigation requirement of bitter gourd under open field conditions in Kerala and to evaluate the effect of various levels of irrigation, fertigation and plastic mulching on yield performance and profitability of bitter gourd cultivation under drip-fertigation.

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 P.O, Pathanamthitta district, Kerala; located at 9^0 22''44'' N latitude and 76^0 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^{-1}), available P (90.94 kg ha^{-1}) and available K (236.54 kg ha^{-1}).

The experiment was conducted in Randomised Block Design with factorial combination of treatments 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^{-1}.

Irrigation scheduling for drip irrigation was done based on estimated maximum crop water requirement for the season using past five years pan evaporation data, crop coefficient for different crop growth stages and percent wetted area of plant root zone. The operation time of drip irrigation system for supply of required quantity of water for each treatment combinations were computed using the following equations

$V_d = (Ep \times Kp \times Kc \times Wp \times Sp)$

Where;

V_d – 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 ($K_{c\ ini}$ - 0.6, $K_{c\ mid}$ – 1.15, $K_{c\ end}$ – 0.75) (Allen, *et al.,* 1998)

Wp – Percent wetted area (0.7)

Sp- Plant area in m^2 (1.2)

$IW_d = (V_d - ER_d) / IE$

Where;

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

ER_d – Daily effective rainfall

IE- Application efficiency of drip irrigation system in decimal

$t = (V_d \times 60) / D$

Where;

t - Operation time of the drip system in minutes

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

D - Discharge capacity of dripper

In the case of plastic mulched treatments effective rainfall was considered as zero and in non-mulched treatments effective rainfall was considered as 70%

The drip irrigation system consisted of disk and screen filters, main and sub main pipes, control valves, pressure gauge, 16mm LDPE laterals and 12mm LDPE drip laterals having inline drippers of 2.4 lph delivery capacity at 60 cm spacing. Injection of the fertiliser solution to the drip system was carried out using dosmatic injection pump.

50% P of each treatment combination was applied as basal dose using rock phosphate and the rest 50% P along with 100% 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 (Table 1). 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.

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 lbh, mulched as per treatment. Data from the two experimental years were pooled and analyzed using statistical software SPSS ver.16.

Results and Discussion

Yield and yield attributing factors

Irrigation at 100% Ep resulted in maximum values for fruit length (25.78 cm), Fruit girth (23.9 cm), fruit weight (253.23g), number of fruits/plant (24.47), number of harvests (10.89) and Marketable yield (22.73t/ha). Similar results of higher fruit length, fruit girth, fruit weight, number of fruits/plant and yield per hectare was reported by Devaranavadgi, *et al.,* (2011) in bitter gourd, drip irrigated at 100% Ep, during rabi and summer seasons in the semi-arid conditions of Raichur. Increasing the irrigation level from 60% Ep to 100% Ep also increased the quantity of pest infested and deformed fruits that are unmarketable (Table 2). Increasing levels of irrigation might have lead to maintenance of moisture at field capacity and facilitated better absorption of water by the plants and better photosynthetic activity.

Application of plastic mulching resulted in significantly superior values in all yield attributing factors as shown in table 3. The

treatment resulted in 12.77% increase in fruit length, 11.52% increase in fruit girth, 15.67% increase in single fruit weight, 14.47% increase in number of fruits per plant and 16.4% increase in marketable fruit yield of bitter gourd. Mulching the plant basins with silver-black plastic mulching effectively controlled the weed competition.

It also might have prevented the leaching of nutrients due to rain and helped in maintaining ideal soil conditions for plant growth. It was also noted that in mulched plots, after the crop covered the bower, the lower leaves received better light radiation through reflectance from the silver surface of the mulching sheet where as in no mulch plots the leaves were completely under shade. This also might have lead to higher photosynthetic activity and better translocation of assimilates from source to sink. Significant variation was observed between the various fertigation treatments in all yield attributing factors with 75% level producing the lowest and 125% level producing the highest values. However the percentage increase observed in the values obtained from 75% to 100% level was more pronounced than the increase observed in values obtained due to rising in the level of fertiliser form 100% to 125%. The marketable yields obtained in 100% and 125 % treatments were statistically at par. It was also observed that increasing the fertiliser level form 75% NPK dose to 125% NPK dose almost doubled the quantity of unmarketable fruits (Table 4). Higher doses of NPK supply might have resulted in better nutrient availability and facilitated higher uptake of nutrients and lead to better growth and total yield. However, supply of nutrients at higher rates also found to facilitate attack of plants and fruits by pests which might be due to the presence of higher quantity of nutrients in the plant system

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

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

Table.2 Effect of drip irrigation levels on yield and yield attributing factors in bitter gourd

Treat-ments	Fruit Length(cm)	Fruit Girth (cm)	Fruit Weight (g)	Number of fruits/plant	Number of harvests	Marketable yield (t/ha)	Unmarketable yield (t/ha)
I_1	22.52	21.50	215.69	20.93	10.06	18.88	1.42
I_2	25.14	23.42	246.88	23.94	10.39	22.10	1.69
I_3	25.78	23.90	253.23	24.47	10.89	22.73	1.79
CD (5%)	0.24	0.23	6.13	0.38	0.26	0.24	0.021

I_1- irrigation at 60% ET, I_2- irrigation at 80% ET and I_3- irrigation at 100% ET

Table.3 Effect of mulching levels on yield and yield attributing factors in bitter gourd

Treat-ments	Fruit Length(cm)	Fruit Girth (cm)	Fruit Weight (g)	Number of fruits/plant	Number of harvests	Marketable yield (t ha^{-1})	Unmarketable yield (t ha^{-1})
M_1	23.01	21.69	221.26	21.56	10.15	19.63	1.49
M_2	25.95	24.19	255.94	24.68	10.74	22.85	1.77
CD (5%)	0.2	0.19	5.01	0.31	0.21	0.20	0.017

M_1- without mulch, M_2 – Mulching with Silver- Black plastic mulch of 30µ thickness

Table.4 Effect of fertigation levels on yield and yield attributing factors in bitter gourd

Treat-ments	Fruit Length(cm)	Fruit Girth (cm)	Fruit Weight (g)	Number of fruits/plant	Number of harvests	Marketable yield (t ha^{-1})	Unmarketable yield (t ha^{-1})
F_1	22.22	21.4	211.54	20.68	9.39	18.66	1.06
F_2	25.15	23.5	248.06	23.74	10.56	22.32	1.73
F_3	26.06	23.92	256.19	24.93	11.39	22.54	2.11
CD (5%)	0.24	0.23	6.13	0.38	0.26	0.24	0.02

F_1 – 75% NPK dose, F_2 – 100% NPK dose and F_3 – 125% NPK dose.

Table.5 Interaction effect of Irrigation, mulching and fertigation levels on yield and yield attributing factors in bitter gourd

Treat-ments	Fruit Length (cm)	Fruit Girth (cm)	Fruit Weight (g)	Number of fruits/plant	Number of harvests	Marketable yield (t ha^{-1})	Unmarketable yield (t ha^{-1})
$I_1M_1F_1$	19.27	19.29	185.66	17.93	8.67	15.00	0.83
$I_1M_1F_2$	21.58	20.88	204.64	20.15	9.67	17.74	1.34
$I_1M_1F_3$	22.52	20.98	211.42	20.9	10.67	18.39	1.65
$I_1M_2F_1$	21.72	21.29	205.52	19.95	9.33	18.52	1.04
$I_1M_2F_2$	24.71	23.20	240.07	22.78	10.33	21.33	1.63
$I_1M_2F_3$	25.31	23.34	246.82	23.88	11.67	22.27	2.01
$I_2M_1F_1$	21.38	20.49	201.34	19.88	8.67	17.94	1.00
$I_2M_1F_2$	24.02	22.70	237.50	22.78	10.33	21.48	1.64
$I_2M_1F_3$	25.19	23.02	245.42	24.07	11.00	22.12	2.02
$I_2M_2F_1$	24.30	23.15	230.94	22.70	9.67	20.65	1.19
$I_2M_2F_2$	27.60	25.36	277.90	26.47	11.00	25.29	1.99
$I_2M_2F_3$	28.33	25.81	288.16	27.74	11.67	25.11	2.31
$I_3M_1F_1$	21.98	20.89	208.91	20.31	9.67	18.64	1.06
$I_3M_1F_2$	24.93	23.16	245.51	23.20	11.00	22.29	1.74
$I_3M_1F_3$	26.21	23.80	250.89	24.77	11.67	23.04	2.15
$I_3M_2F_1$	24.71	23.27	236.90	23.28	10.33	21.19	1.23
$I_3M_2F_2$	28.06	25.72	282.73	27.05	11.00	25.77	2.06
$I_3M_2F_3$	28.81	26.59	294.42	28.23	11.67	25.47	2.49
CD (5%)	NS	NS	NS	NS	NS	0.32	0.05

I_1- irrigation at 60% ET, I_2- irrigation at 80% ET and I_3- irrigation at 100% ET
M_1- without mulch, M_2 – Mulching with Silver- Black plastic mulch of 30µ thickness
F_1 – 75% NPK dose, F_2 – 100% NPK dose and F_3 – 125% NPK dose

Table.6 Benefit cost ratio of bitter gourd crop under drip irrigation, fertigation and plastic mulching as influenced by treatment factors and their interactions

Treatments	Marketable yield t/ha	Gross Cost (Rs/ha)	Gross return* (Rs/ha)	Net return (Rs/ha)	BCR
Irrigation Levels					
I_1	18.88	324770.64	566400	241629.36	1.74
I_2	22.1	326440.18	663000	336559.82	2.03
I_3	22.73	328468.21	681900	353431.79	2.08
Mulching levels					
M_1	19.63	320926.43	588900	267973.57	1.84
M_2	22.85	331800.58	685500	353699.42	2.07
Fertiliser levels					
F_1	18.66	307076.25	559800	252723.75	1.82
F_2	22.32	326315.79	669600	343284.21	2.05
F_3	22.54	342206.48	676200	333993.52	1.98
Interaction effect of irrigation and mulching levels					
I_1M_1	17.05	319687.50	511500	191812.50	1.60
I_1M_2	20.71	330478.72	621300	290821.28	1.88
I_2M_1	20.52	320625.00	615600	294975.00	1.92
I_2M_2	23.68	331962.62	710400	378437.38	2.14
I_3M_1	21.32	323030.30	639600	316569.70	1.98
I_3M_2	24.14	333732.72	724200	390467.28	2.17
Interaction effect of irrigation and fertilizer levels					
I_1F_1	16.76	304727.27	502800	198072.73	1.65
I_1F_2	19.54	323867.40	586200	262332.60	1.81
I_1F_3	20.33	342640.45	609900	267259.55	1.78
I_2F_1	19.3	306349.21	579000	272650.79	1.89
I_2F_2	23.39	326372.09	701700	375327.91	2.15
I_2F_3	23.62	345658.54	708600	362941.46	2.05
I_3F_1	19.92	308041.24	597600	289558.76	1.94
I_3F_2	24.03	327681.82	720900	393218.18	2.20
I_3F_3	24.26	346571.43	727800	381228.57	2.10
Interaction effect of mulching and fertiliser levels					
M_1F_1	17.19	301578.95	515700	214121.05	1.71
M_1F_2	20.51	320468.75	615300	294831.25	1.92
M_1F_3	21.19	339946.52	635700	295753.48	1.87
M_2F_1	20.12	312746.11	603600	290853.89	1.93
M_2F_2	24.13	332064.22	723900	391835.78	2.18
M_2F_3	24.28	350192.31	728400	378207.69	2.08
Interaction effect of irrigation, mulching and fertiliser levels					
$I_1\ M_1\ F_1$	15.00	299444.51	450000	150555.49	1.50
$I_1\ M_1\ F_2$	17.74	318519.43	532200	213680.57	1.67
$I_1\ M_1\ F_3$	18.39	337599.51	551700	214100.49	1.63
$I_1\ M_2\ F_1$	18.52	310494.51	555600	245105.49	1.79
$I_1\ M_2\ F_2$	21.33	329569.43	639900	310330.57	1.94
$I_1\ M_2\ F_3$	22.27	348649.51	668100	319450.49	1.92

$I_2 M_1 F_1$	17.94	301064.91	538200	237135.09	1.79
$I_2 M_1 F_2$	21.48	320139.83	644400	324260.17	2.01
$I_2 M_1 F_3$	22.12	339219.91	663600	324380.09	1.96
$I_2 M_2 F_1$	20.65	312114.91	619500	307385.09	1.98
$I_2 M_2 F_2$	25.29	331189.83	758700	427510.17	2.29
$I_2 M_2 F_3$	25.11	350269.91	753300	403030.09	2.15
$I_3 M_1 F_1$	18.64	303185.31	559200	256014.69	1.84
$I_3 M_1 F_2$	22.29	322260.23	668700	346439.77	2.08
$I_3 M_1 F_3$	23.04	341340.31	691200	349859.69	2.02
$I_3 M_2 F_1$	21.19	314235.31	635700	321464.69	2.02
$I_3 M_2 F_2$	25.77	333310.23	773100	439789.77	2.32
$I_3 M_2 F_3$	25.47	352390.31	764100	411709.69	2.17

*The market price for bitter gourd was taken as Rs 30000/t

The interaction effect of irrigation, mulching and fertigation levels was statistically significant in the case of marketable yield and unmarketable yield. The application of irrigation at 100%Ep, fertiliser at 100% NPK dose along with plastic mulching resulted in highest quantity of marketable yield (Table 5).

Economic analysis

To determine the economic feasibility of the treatments benefic cost ratio (BCR) was used. BCR gives the ratio between the present value of benefits and the present value of costs. According to Jain *et al.,* (2007) BCR greater than 1.5 can be considered as acceptable for an experiment. The economic analysis given in Table 6 shows the effect of different levels of irrigation, mulching and fertiliser on economics of bitter gourd cultivation. The average market price Rs 30/kg was taken as the price of bitter guard for computation of economics.

Among the various irrigation levels, the maximum BCR of 2.08 was observed in the highest irrigation level of 100%Ep. Mulching with silver-black plastic mulch was more profitable as it gave BCR of 2.07 against BCR of 1.84 in treatments with no mulch application. Among the various levels of fertiliser, fertigation with 100% NPK dose gave the maximum BCR of 2.05. The interaction of irrigation and mulching treatments produced maximum BCR in the highest level combination I_3M_2. However, in the interaction of irrigation levels with fertiliser levels and mulching with fertiliser levels, the maximum BCR of 2.20 and 2.18 was observed in the combinations I_3F_2 and M_2F_2 respectively. In the three way interaction of irrigation, mulching and fertiliser the maximum BCR of 2.32 was obtained in the combination $I_3 M_2 F_2$, in which the plants were irrigated at 100%Ep level and given fertiliser at 100% NPK dose level along with silver-black plastic mulching. This may be due to the higher quantity of unmarketable fruits observed in treatments with NPK dose of 125% level.

The profitability of bitter gourd cultivation can be improved significantly by the adoption of drip irrigation, fertigation and plastic mulching. Application of irrigation at 100 % Ep, fertigation of 100%N, 50%P and 100% K of NPK dose 210: 74: 225 kg/ha along with silver-black plastic mulching can be recommended for bitter gourd cultivation in the humid tropical region of Kerala.

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