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Mulching and fertigation in okra (*Abelmoschus esculentus*)

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ABSTRACT

Experiment was conducted in okra (*Abelmoschus esculentus* L.) (var. Arka Anamika) to study the effect of drip irrigation with and without mulch along with fertigation at Agricultural Research Station, Mannuthy during 2012-13 and 2013-14. Treatments comprised two levels of irrigation, viz. I_1: drip irrigation at 0.60 ET, I_2: drip irrigation at 0.80 ET, two mulching treatments, viz. M_1: mulching with 30 µ silver black polythene sheet, M_2: without mulching and three fertigation treatments, viz. F_1: 75% RDF (Recommended Dose of Fertilizer), F_2: 100 % RDF and F_3: 125% RDF. Drip irrigation, fertigation and mulching treatments induced earliness and significantly enhanced the number of fruits and yield/plant. Treatment $I_2F_3M_1$ recorded significantly highest yield of 1.46 kg/plant and number of fruits (53.88). Mulching had positive significant impact on yield and the results were significant even when irrigation is given at 0.60 ET. All the treatments with mulch irrespective of irrigation and fertiliser levels recorded higher water use efficiency when compared to corresponding treatments without mulch. At the highest dose of fertilizer(125 % of RDF), the significant influence of mulch was evident at 0.60 as well as 0.80 ET. From the study conducted it can be recommended that if water is a limiting factor, irrigation at 0.60 ET along with mulching and 75% of recommended dose of fertilizer is sufficient to achieve a yield of 23.87 tonnes/ha. If there is sufficient water availability, a higher level of irrigation at 0.80 ET along with mulching and 125% of recommended dose of fertiliser can be adopted for achieving a significantly higher yield of 32.44 tonnes/ha.

Key words: Drip irrigation, Fertigation, Mulching, Precision farming, Water use efficiency

Okra (*Abelmoschus esculentus* L.) is an important vegetable cultivated in humid, arid and semi arid regions of India. Total area under okra cultivation in India is around 5.04 lakh ha which is about 5.7% of the total area under vegetable cultivation. Production from this area is nearly 57.09 lakh tonnes and productivity is 11.30 tonnes per ha (NHB 2015). In Kerala, area under okra cultivation is 1264 ha with a production of 10 744 tonnes recording a productivity of 8.5 tonnes/ha (FIB 2016). Okra is in great demand throughout the year in Kerala. Although year round cultivation is possible, majority of the area under okra cultivation is rainfed in Kerala. But the cultivable land area during rainy season is limited when compared to summer season. Due to shortage of irrigation water extensive cultivation is not possible during summer. The traditional method of okra cultivation is highly labour intensive as frequent inter culture, viz. weeding, fertilizer application and earthing up is needed for raising a successful crop. With the introduction of precision farming in vegetables there has been a renewed interest in vegetable cultivation in the state as many young entrepreneurs are coming forward to take up vegetable cultivation on a commercial scale. As a result, cultivation in garden lands is also coming up during the summer season. Water is not a limiting factor during rainy season but luxuriant weed growth, leaching of nutrients and soil compaction create problems for vegetable growers leading to increased requirement of labour and other inputs. Since the labour cost is very high in Kerala, suitable technologies are to be introduced to reduce input cost like labour, water and fertilizers for encouraging commercial vegetable cultivation. Precision farming techniques which optimise the use of inputs and resources become relevant in this context.

MATERIALS AND METHODS

Experiment was conducted on fertigation and mulching in okra (var. Arka Anamika) at Agricultural Research Station, Mannuthy for two consecutive summer seasons during 2012-13 and 2013-14.The experiment was laid out in factorial RBD with two levels of irrigation, viz. I_1: drip irrigation at 0.60 ET, I_2: drip irrigation at 0.80 ET, two levels of mulching, viz. M_1: mulching with 30 µ silver black polythene sheet, M_2: without mulching and three levels of fertigation, viz. F_1: 75% RDF (Recommended Dose of Fertilizer), F_2: 100 % RDF and F_3: 125% RDF. The recommended dose of fertilizer is 110: 35: 70 kg NPK/ha (KAU 2016). Drip irrigation was given daily while fertigation was given

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at three days interval starting from two leaf stage. The fertigation schedule followed in the experiment is given in Table 1. Conventional practice of surface irrigation with 100% RDF without mulching was treated as control and this was practised at three days interval. Plot size of each treatment was 20.16 m^2 with 56 plants in each plot. Each treatment was replicated four times. Irrigation requirement was worked out from daily evaporation data collected from a US Class A Pan Evaporimeter installed near the experimental site. Observations were recorded on important quantitative characters like plant height at 30 and 45 days after sowing (DAS), days to flowering, number of fruits/ plant, fruit length (cm), fruit weight (g), and yield/plant (kg).Water use efficiency for the treatments was calculated from yield/ha and total water use. Pooled data of two years was compiled for important growth attributes and yield parameters of okra. Statistical analysis was carried out using MSTAT – C software.

RESULTS AND DISCUSSION

The effect of drip irrigation, fertigation and mulching in okra were explored. Results of analysis of the pooled data for two years for important vegetative characters and yield attributes showed that the mean squares were highly significant for all the characters observed (Table 2).

Vegetative growth

Plant height at 30 DAS was maximum for $I_1F_1M_1$ (51.35 cm) which was on par with $I_2F_3M_1$ (50. 68 cm) followed by $I_1F_2M_1$ (47.49 cm). Plant height was the lowest (33.64 cm) for control. At each irrigation and fertilizer level mulching significantly increased the plant height. Almost the same trend was observed at 45 DAS. Plant height was significantly higher in $I_2F_3M_1$ (112.20 cm) followed by $I_2F_1M_1$ and $I_2F_2M_1$ both with a height of 100.38 cm. Increased vegetative growth under mulching is attributed to better moisture retention capacity of soil as reported by Jayapiratha *et al.* (2010). At 45 DAS lowest height was recorded for $I_1F_3M_2$ (76.73) and it was even significantly lower than that of control. This might be due to that plants without mulch fed with a high dose of fertilizer and low dose of irrigation were subjected to severe competition from weeds for water and nutrients.

Table 1 Fertigation treatments applied in the experiment

Number of fertigations at 3 days intervals	Fertilizer	Quantity of fertilizer applied/ plot (20.16 m^2)/fertigation (g)		
		F_1 (75% RDF)	F_2 (100% RDF)	F_3 (125% RDF)
Establishment 6 doses	19:19:19	6.00	8.00	10.00
	13:0:45	6.32	8.43	10.53
	12:61:0	4.65	6.21	7.76
	Urea	7.00	9.34	11.67
Vegetative 12 doses	19:19:19	3.02	4.03	5.03
	13:0:45	5.96	7.95	9.93
	12:61:0	2.33	3.11	3.88
	Urea	8.74	11.66	14.57
Fruiting 12 doses	19:19:19	3.02	4.03	5.03
	13:0:45	7.35	9.81	12.26
	12:61:0	2.50	0.34	4.25
	Urea	8.80	11.85	14.81

Flowering and yield attributes

Plants under $I_2F_1M_1$ were the earliest to flower and it took 35.6 days to reach the flowering stage. This was followed by $I_1F_1M_2$ (36.80) and $I_1F_1M_1$ (37.03). Control treatment was the last to flower and it took 41.50 days for the first flower to appear. In general it could be inferred that plants took more days to flower when fertilizer dose was increased. This might be due to that when nutrient availability is more vegetative phase gets prolonged. It could also be seen that plants under mulching flowered earlier when compared to their corresponding treatments without mulch even though the difference was not significant. Earlier flowering under drip irrigation along with mulch may be attributed to less water stress in the plant canopy (Jayapiratha *et al.* 2010).

Yield/plant was significantly high in $I_2F_3M_1$ (1.46 kg/ plant). This was followed by $I_2F_3M_2$ (1.16 kg/plant), $I_1F_3M_1$ (1.15 kg), $I_1F_2M_1$ (1.14 kg), $I_2F_2M_1$ (1.14 kg), $I_2F_2M_2$ (1.07 kg), $I_1F_1M_1$ (1.08 kg), $I_2F_1M_1$ (1.05 kg) and $I_2F_1M_2$ (1.04 kg) and all these treatments were on par with regard to yield/plant. In general it could be observed that yield was more in treatments with mulch. But the influence of mulch becomes significant at lower dose of irrigation when compared to corresponding higher dose of irrigation. However, at the highest fertilizer dose (125% RDF) tried, yield was influenced by both irrigation level and mulch. Lowest yield/plant was observed for control (0.44 kg). Another yield parameter, viz. number of fruits were also significantly higher in $I_2F_3M_1$ (53.88). This was followed by on par performance in several treatments like $I_2F_1M_1$ (41.5), $I_1F_2M_1$ (41.38), $I_1F_3M_1$ (41.38), $I_2F_2M_1$ (41.13), $I_2F_3M_2$ (40.50), $I_2F_2M_2$ (40.13), $I_1F_1M_1$ (38.13) and $I_2F_1M_2$ (37.63). Similar to the yield/plant, number of fruits was also the lowest (16.13) in control. Fruit length was significantly higher in two treatments, viz. $I_1F_1M_1$ (24.34 cm) and $I_2F_1M_1$ (22.09 cm), followed by $I_2F_2M_2$ (21.81 cm), $I_2F_2M_1$ (21.61 cm), $I_1F_3M_1$ (21.29 cm), $I_2F_3M_1$ (21.00 cm), $I_1F_2M_2$ (20.74 cm) and $I_2F_3M_2$ (20.54 cm). The lowest fruit length was recorded in control (17.88 cm). It is revealed from the Table 2 that this parameter significantly responded to mulching only at the lowest level of irrigation and fertilizer. With regard to fruit weight, no specific pattern was observed among the treatments and control. In general fruit weight was low with lowest dose of irrigation and fertilizer levels. Beneficial effect of mulching and drip irrigation on vegetative characters and yield of okra has been reported by Sunikumar and Jaikumaran (2002), Suresh and Misra (2004), Rekha *et al.* (2005), Jayapiratha *et al.* (2010), Varughese *et al.* (2014), Haris *et al.* (2014), Imamsaheb *et*

Table 2 Growth and yield parameters of okra (Arka Anamika) under drip irrigation and mulching

Treatment	Plant height at 30 DAS	Plant height at 45 DAS	Days to flowering	Number of fruits/plant	Fruit length (cm)	Fruit weight (g)	Yield/plant (kg)
$I_1F_1M_1$	51.35	96.63	37.03	38.13	24.34	24.90	1.07
$I_1F_1M_2$	44.83	83.88	36.80	34.50	18.21	26.36	0.92
$I_2F_1M_1$	46.36	100.38	35.60	41.50	22.09	28.84	1.05
$I_2F_1M_2$	38.84	76.74	38.20	37.63	20.28	27.15	1.04
$I_1F_2M_1$	47.49	95.45	38.58	41.38	19.38	26.73	1.14
$I_1F_2M_2$	39.09	80.65	37.81	36.63	20.74	25.51	0.96
$I_2F_2M_1$	45.05	100.38	37.18	41.13	21.61	27.63	1.14
$I_2F_2M_2$	38.31	81.13	38.04	40.13	21.81	27.39	1.07
$I_1F_3M_1$	43.38	97.15	38.48	41.38	21.29	27.46	1.15
$I_1F_3M_2$	34.75	76.73	38.50	35.13	19.44	26.23	0.91
$I_2F_3M_1$	50.68	112.20	38.54	53.88	21.00	27.47	1.46
$I_2F_3M_2$	37.74	81.25	38.53	40.50	20.54	28.26	1.16
Control	33.64	82.85	41.50	16.13	17.88	27.66	0.44
CD (P=0.01)	3.18	4.79	0.98	3.97	2.45	2.06	0.12

al. (2014), Mahadeen (2014). Enhanced vegetative growth and yield might be due to better water use efficiency, better uptake of nutrients, reduced nutrient loss through leaching, less competition from weeds and reduced soil compaction. Enhanced growth and yield under mulched condition might also be due to improved plant microclimate especially in the root zone which in turn might have favoured enhanced photosynthesis and metabolic activities as reported by Bhatt *et al.* (2011) and Parmar *et al.* (2013).

Water use efficiency

Water use efficiency of the treatments was also calculated and the results are given in Table 3.

Table 3 Effect of drip irrigation and mulching on water use efficiency of okra (Arka Anamika)

Treatment	Total water use (ha mm)	Yield (kg/ha)	Water use efficiency (kg/ha mm)
$I_1F_1M_1$	93	23780	212.18
$I_1F_1M_2$	93	20440	185.16
$I_2F_1M_1$	124	23330	156.86
$I_2F_1M_2$	124	23110	155.51
$I_1F_2M_1$	93	25330	225.14
$I_1F_2M_2$	93	21330	190.44
$I_2F_2M_1$	124	25330	170.96
$I_2F_2M_2$	124	23780	161.10
$I_1F_3M_1$	93	25560	226.32
$I_1F_3M_2$	93	20220	180.50
$I_2F_3M_1$	124	32440	218.49
$I_2F_3M_2$	124	25780	174.03
Control	853	9780	11.21
CD (P=0.01)			20.87

It is clear from the Table 3 that higher water use efficiency was recorded for treatments, viz. $I_1F_3M_1$, $I_1F_2M_1$, $I_2F_3M_1$ and $I_1F_1M_1$and all these were on par. This further emphasises the beneficial effect of mulch in crop performance because all these treatments had mulch as the common factor. Enhanced yield and high water use efficiency for okra under drip irrigation with mulch has been reported by Spehia *et al*. (2010) and Kumar *et al*. (2013).Water use efficiency of conventional system of irrigation (control) is very low (11.21 kg/ha mm) when compared to drip irrigation treatments. It is also clear from the Table 3 that all the treatments with mulch irrespective of irrigation and fertiliser levels recorded higher water use efficiency when compared to corresponding treatments without mulch. But the effect of mulch is significant only when irrigation is given at 0.60 ET. This might be due to the reason that at higher irrigation level, available soil moisture does not become a critical factor when compared to the lower irrigation level. However, at the highest level of fertiliser, a higher level of irrigation at 0.80 ET and mulching is needed for maximum performance of the crop as evidenced from the study.

From the above study it can be concluded that drip irrigation, fertigation and mulching induced earliness, significantly increased the number of fruits, fruit yield and water use efficiency in okra. Application of fertilisers @ 125% RDF along with mulching and irrigation at 0.8 ET produced the highest number of fruits and yield/plant. Even at lower levels of irrigation (0.6 ET) and fertiliser (75% RDF) the effect of mulching was significant in enhancing the crop yield.

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