Water productivity and profitability of melon based cropping system under drip fertigation and polyethylene mulching

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Received: September 4, 2017 Accepted: September 30, 2017 Published: December 27, 2017

ABSTRACT

Farmers participatory research were conducted melon based cropping system with water melon and muskmelon in 20 hectare area during 2011-12 with an objective to study the water productivity and profitability of growing three melon crops under drip fertigation with polyethylene mulching. Field experiments were conducted at farmers field in Nolambur (Olakkur block and Vadanerkunam (Marakkanam block) Villupuram district of TamilNadu state. The results indicated that yield and quality characters of melons were significantly higher under drip fertigation coupled with mulching practice as compared to drip fertigation alone and or conventional irrigation method. In the first crop (watermelon) recorded highest fruit yield of 38.6 t ha^{-1} under drip fertigation coupled with polyethylene mulching (T_3) as compared to either drip fertigation alone (T_2) (31.1 t ha^{-1}) and or farmer practice of furrow irrigation (T_1) (21.8t ha^{-1}). Similar trend was followed in second crop (Muskmelon) and third crop (Watermelon Ice box).In three-crop sequence, recorded highest cumulative fruit yield of 136t ha^{-1}, which was 56 per cent yield advantage over the drip fertigation alone. In comparison with the conventional irrigation the yield advantage is more that 247per cent. The cumulative annual crop field analysis indicated that among the treatments drip fertigation combined with polyethylene mulching has increased the annual cost of production that increased the net profit to the maximum level of Rs. 7.59 lakhs ha^{-1}.For the three crops 401 mm of water used under drip fertigation coupled with mulching, the saving was around 88.5 per cent over control and 34.8 per cent over drip fertigation alone.

Key words: Irrigation methods, drip fertigation, mulching, watermelon, muskmelon, cropping system.

Water is a one of the key resource that influences the choice of crops by the farmers. Early maturing and drought escaping or tolerant cultivars were previously used as strategies for crop production in the arid and semi-arid regions. These strategies are now threatened by the variation in monsoon pattern in the tropics, which are caused by global warming as a result of climate change. Water scarcity is the major problem in these areas that are irrigated by wells and hence, introduction of short duration crops with high profitable in nature is essential. In general, melon crops are to respond favorably to supplemental irrigation. Watermelon (*Citrullus lanatus*) and Muskmelon crop that provides a high return and relatively consumed less water as compared to other crops (Wang *et al*., 2004). The climate requirement of crop is a hot, dry climate with mean daily temperatures of 22 and 30°C. Maximum and minimum temperatures for growth are about 35 and 18°C respectively that makes the crop most suitable under semi-arid regions. In recent years, water melons are grown extensively in India and in tropical and sub-tropical countries of the world (Parmar *et al*., 2013).

Watermelon has typical growth periods when irrigation is a necessity for optimal yield and quality (Hartz, 1997). Water deficit during the establishment period delays growth and produces a less vigorous plant. Therefore, water deficit occurs during the early vegetative period that leads to less leaf area responsible for fruit yield reduction. In the case of late vegetative period or vine development stage,

flowering stage and also fruit formation stage (fruit filling) are the most sensitive periods to water deficit. However, in the case of ripening stage, a reduced water supply improves fruit quality. Yields are little affected by water deficits immediately prior to harvest. Within certain water deficit limits, irrigation practices do not greatly affect the number of fruits per plant but affect the fruit size, shape, weight and quality. It is recommended that supply of irrigation based on the rate of evaporation and soil that depleted around 50 to 70 per cent of plant available water.

Past projects of agricultural water management in many semi-arid areas have focused primarily on maximizing rainfall infiltration through soil and water conservation activities. Unreliability of rainfall remains a major challenge to crop production because of water stress during the crucial stages of crops. Hence, supplemental irrigation using appropriate methods is adapted to arid and semi-arid climate can provide a suitable strategy for the small holder farmers to manage water stress and increase crop production, thereby improving the rural livelihood and economic development. To address the issues related water scarcity, Government of Tamil Nadu has introduced farming demonstration through "Irrigated Agriculture Modernization and Water Bodies Restoration and Management" project, which are funded by World Bank in a convergence mode in collaborations with various departments. The main aim of this study was to use drip fertigation along with polyethylene mulching practices to enhance crop yield, water productivity and profitability in cropping system approaches. In addition, quantify the resource conservation and economic benefits of melon based cropping system also studied.

MATERIALS AND METHODS

Field experiments were conducted on watermelon and muskmelon crops in system approach. Therefore, field experiments were conducted as farmers participatory research in 20 hectares area in four villages *viz*., Nallampakkam, Vadanerkunam, Neikuppi and Nolambur village of Marakkanam and Olakkur blocks (Villuppuram district) during December 2011 to August 2012.Three treatments *viz*.,T_1-Surface irrigation (Furrow irrigation with 2.4m spacing),T_2-Drip fertigation (2.4Lateral spacing, 0.6emitter spacing and dripper capacity is 2 liter $hour^{-1}$); and T_3-Drip Fertigtion+ Polyetheylene mulching (30µ thickness 1.2 m width and sliver coated with black sheet) was chosen for the study. The experiments were laid out in Randomized Block Design with eight replications. The experiments was conducted in 4 locations in 1000m^2 plot area in the respective farmers field. The study area soil characteristics and cropping system adopted in the study area are given in Table 1 and 2 respectively.

Table 1. Locations and soil fertility status

Locations	No. of Experiments	Soil Type	Fertility Status			
			O.C (%)	N Level	P Level	K Level
Nolambur	6	Red sandy loam	0.32	L	M	M
Neikuppi	4		0.37	L	M	M
Vadanerkunam	7	Sandy loam	0.42	M	L	H
Nallampakkam	3		0.34	M	L	H

Table 2.Details of Cropping programme and hybrids

Month	December to February (First crop)	March to May (Second crop)	June to August (Third crop)
Crops	Water Melon (WM)	Musk Melon (MM)	Water Melon (Ice Box) (WM Ibox)
Hybrids	NS 295,Apurva, Sindhuri and Cashis	Nirmal 64 and Kundhan	Kirane, NS 926, Bahuja, Mithula and Saritha
Age of Transplanting	12-15 days	12-15 days	12-15 days

The sowing was done with farmers as direct dibbling of seeds at 3-4 seeds with a spacing of 2.4x1.0m spacing in a with furrow irrigation method (control).The fertilizers for control were applied at the rate of 100:50:50 NPK kgha^{-1}. The recommended dose of entire P_2O_5 and K_2O were applied as basal dose and nitrogen was applied in two equal split as basal and top dressing at 30 days after sowing. The water-soluble fertilizers in equal split basis upto 60 days were applied in T_2 treatment (Drip fertigation) in the respective field. In treatment T_3, repeated the T_2water-soluble fertilizer in a polyethylene made mulching practices. The drip irrigation was installed at 2.4 m lateral spacing with 0.6 m emitters spacing with 2 LPH discharge rate. For mulching polyethylene thin film (25-30 micron) silver coated top surface and black bottom side of the polyethylene sheet has been used for mulching. The farmyard manure at the rate of 20 tonnes ha^{-1} was incorporated in to soil uniformly to all the treatments. The non-selective herbicide (Glyphosate 41% SL) was sprayed after the completion of first crop to avoid weed infestation. Then the dried plants and weeds are not removed from the field that act as residue for the subsequent crops. Therefore, second crop was sown without imposing ploughing. Second and third crop was also been practiced as like the earlier one. The observations on growth, flowering, yield and quality parameters were recorded. The statistical analysis of variance technique as described by Panse and Sukhatme (1985) was carried out to study the treatment significance.

RESULTS AND DISCUSSION

Effect on Growth and Yield

The results revealed that drip fertigation and mulching significantly influenced the growth parameters of watermelon and muskmelon crops *viz*., number of branches per plant, and number of nods per plant over control. Among different treatments, treatment T_3 resulted more number of branches per plant, number of nods per plant and there was significant difference between them due to the treatment effect. However control recorded the minimum growth (Table 3,4, and5). The increase in growth parameters was attributed to regular sufficient soil moisture near root zone and nutrients due to drip irrigation and Fertigation. The extended retention of moisture and availability of moisture also leading to higher uptake of nutrient without any loss and loss through fertigation that enhance proper growth and development of plants, resulted higher growth of plant, as compared to control. The changes in soil temperature below polyethylene mulch could be attributed to different manners of heating and heat transfer to soil and also to heat accumulation during day and loss during night. Similar findings were also been reported by Ban *et al.* (2004), Ansary and Roy (2005) in wateremelon, Al-Majali and Kasrawi (1995) in muskmelon crops. Under T_2 drip fertigation alone, performs better than the farmer practice of furrow irrigation, which has shown significant differences in terms of growth attributes.

The results indicated that the drip fertgation coupled with mulching had increased the growth of watermelon and also on number of fruits and weight of watermelon significantly than the drip fertigation alone and or farmer practice of furrow irrigation. In the first crop (watermelon) recorded highest fruit yield of 38.6 t ha^{-1} under drip fertigation coupled with polyethylene mulching (T_3) as compared to either drip fertigation alone (T_2) (31.1 t ha^{-1}) and or farmer practice of furrow irrigation (T_1) (21.8t ha^{-1}). Similar trend was followed in second crop (Muskmelon) and third crop (Watermelon Ice box).The more number of fruits per plant and fruit weight was due to congenial soil moisture throughout the crop growth period, higher uptake of nutrition for better growth of fruit through fertigation using water-soluble fertilizers. The above results were in consonance with those of Johnson *et al*. (2000), Ansary and Roy (2005) in watermelon, Rani *et al.* (2012) in pointed gourd. Enhanced growth also consistently increased higher fruit set and lesser male to female flower ratio than control. This might have been influenced by favourable soil temperature and moisture conditions. The current findings are in accordance with Andino and Motsenbocker (1998), Johnson *et al*. (2000), Ansary and Roy (2005) in watermelon and Hanna (2000) in cucumber.

In particular, maximum fruit yield recorded under treatment T_3. The yield increase in is positively correlated with crop growth and individual fruit weight that was registered under T_3. Yield of watermelon was higher in drip irrigated treatments with fertigation, particularly with mulching application. Plants under T_3 treatment produced larger fruit and have higher fruit yield per plant because of better plant growth due to favourable hydro-thermal regime of soil. The above results were in consonance with those of Rudich *et al*. (1978), Battikhi and Ghawi (1987), Bhella (1988), Al-Majali and Kasrawi (1995), Johnson *et al*. (2000), Ban *et al.* (2004), Ansary and Roy (2005) and Arancibia and Motsenbocker (2008) in watermelon, Ibarra–Jimenez *et al*. (2008), Hallidri (2001) in cucumber, Ibarra *et al.* (2001) in muskmelon. In three-crop sequence, recorded highest cumulative fruit yield of 136t ha^{-1}, which was 56 per cent yield advantage over the drip fertigation alone. In comparison with the conventional irrigation the yield advantage is more that 247per cent. This showed that drip fertigation combined with polyethylene mulching paved way for still conservation of water resources apart facilitate for ambient rhizosphere environment for enhanced productivity with least competition from the weeds by smothering effect of mulching sheet.

Water Productivity

Three crops sequence with irrigation through drip T_2& T_3 and furrow irrigation practiced in control. Among the treatments huge quantity of irrigation water was saved over the control. For the three crops 401 mm of water used under drip fertigation coupled with mulching, the saving was around 88.5 per cent over control and 34.8 per cent over drip fertigation alone. This might be due to lesser evaporation because of polyethylene mulching. Mulching practices minimize the water requirement to the tune of 40 per cent (Table 6 and 7). This showed that quantum of water can be saved, if we go for crop diversification coupled with drip and mulching particularly in ground water over exploited regions like Olakkur and Marakkanam block of Viluppuram district. To produce one kilo gram of fruit requires nearly 30 liter which was comparatively very low as compared to other crops. Alternatively, less water consumption helped the reduction in irrigation that ranged up to 63 per cent. The resulted reduction in irrigation hours minimize the electricity cost to the tune of more than 60 per cent under the current conservative studies.

Table 3.Yield attributes of water melon influenced by Irrigation methods and polyethylene mulching (First crop)

Treatments	Branches $Plant^{-1}$ (No.)	No. of Nodes	M:F ratio	Fruits $plant^{-1}$ (No.)	Fruit weight (Kg.)	Yield (t ha^{-1})
Furrow irrigation	7.9	34	5.9	1.2	2.6	21.8
DF	12.6	43	5.1	1.6	3.1	31.1
DF + Mulching	14.3	48	4.2	1.7	3.5	38.6
S. Ed	0.21	1.4	0.3	0.15	0.05	2.1
C.D. (p=0.05)	**0.45**	**2.9**	**0.7**	**0.41**	**0.12**	**4.3**

Table 4.Yield attributes of muskmelon influenced by irrigation methods and polyethylene mulching (Second crop)

Treatments	Branches Plant^{-1}(No.)	No. of Nodes	M:F ratio	Fruits plant^{-1} (No.)	Fruit weight (Kg.)	Yield (t ha^{-1})
Surface	7.4	24	6.2	1.9	1.1	9.6
DF	8.9	33	5.8	2.6	1.8	29.7
DF + Mulching	10.2	41	4.3	3.1	2.2	41.7
S. Ed	0.18	1.1	0.3	0.15	0.03	1.8
C.D. (p=0.05)	**0.37**	**2.3**	**0.7**	**0.41**	**0.07**	**3.9**

Table 5.Yield and Yield attributes of watermelon(Ice Box) as influenced by irrigation methods and polythene mulching (Third crop)

Treatments	Branches Plant^{-1}(No.)	No. of Nodes	M: F ratio	Fruits plant^{-1} (No.)	Fruit weight (Kg.)	Yield (t ha^{-1})
Surface	6.3	21	5.9	1.2	1.3	7.7
DF	7.2	36	5.3	2.3	1.9	26.4
DF + Mulching	8.7	43	4.6	2.9	2.3	44.3
S. Ed	0.13	1.3	0.2	0.18	0.04	1.5
C.D. (p=0.05)	**0.26**	**2.7**	**0.5**	**0.39**	**0.08**	**3.1**

Table 6. Water productivity in melon based cropping system as influenced by irrigation methods and polyethylene mulching

Treatments	Irrigation requirement(IR) (mm)			Effective rainfall (ER) (mm)			Water requirement (IR+ER) (mm)			Total Water requirement for 3 crops	% Water Saving over surface & DF over Mulching	
	WM	MM	WM IBox	WM	MM	WM IBox	WM	MM	WM IBox			
Surface	200	250	225	21	15	45	221	265	270	756	-	-
DF	145	170	165	21	15	45	166	185	210	561	34.8	-
DF + Mulching	97	113	110	21	15	45	118	128	155	401	88.5	39.9

Table.7. Water Productivity as Influenced by Irrigation method and Mulching

Treatments	Crop and water productivity				Water to produce 1 kg fruit (Lit.)
	Total WR for 3 crops (mm)	CUM	Fruit Yield (t ha^{-1})	Water use efficiency(kg/m^3/ha)	
Surface	756	7560	39.1	5.17	193.4
DF	561	5610	87.2	15.54	64.3
DF + Mulching	401	4010	136	33.91	29.5

Table 8.Economic analysis as influenced by irrigation and polyethylene mulching (Rs. ha^{-1})

Treatments	Yield (t ha^{-1})	Cost of cultivation	Gross income	Net income	Benefit cost ratio
Watermelon (First crop)					
Surface	21.8	45,000	1,30,800	85,800	2.9
DF	31.1	48,000	1,86,600	1,38,600	3.8
DF + Mulching	38.6	63,000	2,31,600	1,67,600	3.7
Muskmelon (Second crop)					
Surface	9.6	45,000	76,800	31,800	1.7
DF	29.7	51,000	2,37,600	1,86,600	4.6
DF + Mulching	41.7	48,000	3,33,600	2,85,600	6.9
Watermelon (Ice Box) (Third crop)					
Surface	7.7	45,000	61,600	16,600	1.4
DF	26.4	51,000	2,11,200	1,60,200	4.1
DF + Mulching	44.3	48,000	3,54,400	3,06,400	7.4

(Rs.1.99) and drip

Economic benefits

The cumulative annual crop field analysis indicated that among the treatments drip fertigation combined with polyethylene mulching has increased the annual cost of production that increased the net profit to the maximum level of Rs. 7.59lakhs ha^{-1}, which was followed by drip fertigation alone (Rs. 4.85lakhsha^{-1}) and in control (Rs.1.34 lakhs ha^{-1}). Besides it also increase higher benefit cost ratio (Rs.5.77) over the control fertigation (Rs.4.23) alone in cumulative of three melon crops (Table 8).

CONCLUSION

The farmers participatory research has emanated interesting observation like tripled the productivity of melon based cropping system with four times higher net income than the conventional method of farming. This shows the ample scope for the conservative agriculture in water deficit regions

and copes up the increasing demand of water particularly in ground water over exploited regions in Tamil Nadu. The polyethylene mulching has showed tremendous influence on crop growth and yield and so water productivity in combination with drip fertigation. Since the ground water is over exploited the drip fertigation coupled with mulching method for the melon based cropping system paved way for the effective utilization of ground water towards maximizing the virtual water productivity.

Acknowledgement: The authors sincerely thank the World Bank in financial aiding through TN-IAMWARM project for implementation to the farmers field as farmers participatory research in Ongur sub-basin at villuppuram District.

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