Plasticultural Technologies Related Published Papers

Compiled by

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Precision Farming Development Centre

(Sponsored by NCPAH, MoA, GoI, New Delhi)

Soil and Water Management Research Unit

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Message

Indian agriculture is facing stiff challenges in terms of ever-increasing food demand triggered by population increase on one hand and shrinking land and water resources on the other, not only this, but there is change in food habit and increasing use of fruits and vegetable in the human diet. In order to meet the demand of food, fruits and vegetable, it is necessary to focus more towards horticultural crops. In this context, MoA, GoI, New Delhi liberally funding the project *viz.,* Precision Farming Development Centre through NCPAH in net work mode across the country, is the step in right direction. These centers are working in close association with the state Government. The research and developmental work done under this project is essential for increasing input use efficiency, crop productivity and sustaining soil health through plasticulture application in agriculture. The technologies generated through this project have positively impacted the state agriculture production scenario. I feel proud that NAU, Navsari is affiliated central government program and serving the Gujarat state in most effective ways. I hope the work done under this project by Navsari centre will go long way in bringing prosperity to Gujarat Agriculture and increase farmer's income. I congratulate the team of PFDC scientists for bringing out this publication on **"Plasticultural Technologies Related Published Papers"**. I am sure; this will fulfill the aspiration of NCPAH. I wish all the success for future activities of this project.

Place: Navsari

Date: 10-10-2018

(C. J. Dangaria)

Director of Research
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Foreword

Under the circumstances of shrinking land and water resources, precision farming technologies provide an excellent option for enhancing input use efficiency. In this direction, PFDC Navsari has been doing excellent work *i.e.,* covering technology development / refinement, demonstrations, trainings, publications, HRD *etc.* aspects. Over 20 years, PFDC, Navsari has given many recommendations for the farmers. Not only this, but the centre has also done some additional activities within the sanctioned budget and contractual staffs. I am happy to forward publication on **"Plasticultural Technologies Related Published Papers"** and appreciate the commendable work done by the PFDC team.

Place: Navsari
Date: 10-10-2018

(S. R. Chaudhari)

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Research Papers

1. Productivity and Profitability of *Rabi* Pigeonpea Increased through Drip Irrigation with Mulch under South Gujarat Condition

Savani N. G., Patel R. B. Solia B. M., Patel J. M. and Usadadiya V. P.

Source: International Journal of Agriculture Innovations and Research (2017) , page:758

Abstract

A field experiment was conducted during *rabi* seasons of 2011-12 to 2013-14 at Navsari on the productivity and profitability of pigeonpea through drip irrigation and mulch. The experiment was laid out in randomized block design with four replications, keeping four levels of irrigation regimes (I_1 : Drip at 0.4 PEF, I_2 : Drip at 0.6 PEF, I_3 : Drip at 0.8 PEF and I_4 : Surface irrigation at 0.8 IW/CPE: 60 mm depth (normal spacing 90 x 20 cm) and three levels of mulch (M_0 : No mulch, M_1 : Sugarcane trash @ 5 t/ha and M_2 : Black plastic mulch with 50µ). The soil of experimental site was clay in texture, having pH 8.0, low in available nitrogen, medium in available phosphorus and high in available potassium. Growing of *rabi* pigeonpea resulted significantly higher grain and stover yields due to 0.8 PEF levels of irrigation. The grain yield registered under 0.8 and 0.6 PEF were 11 and 9 per cent higher over 0.4 PEF level. Yield attributes as well as yields of pigeonpea were also produced significantly higher in black plastic mulch. The interaction effect observed between irrigation and mulch were significant in respect to plant height, yield attributes and yields of pigeonpea. WUE decreased with increase in level of irrigation. Drip irrigation scheduled at lower level (0.4 PEF) recorded higher WUE with 48 per cent water saving. For getting potential production and profit from the *rabi* pigeonpea, scheduling of irrigation at 0.8 PEF through drip with sugarcane trash mulch @ 5 t ha^{-1}.

Key words: Drip irrigation, Pigeon pea, Plastic mulch, Water saving and WUE

Introduction

Pigeonpea (*Cajanus cajan* L.) has been considered as second most important crop after chickpea. The demand for pulses is increasing due to increasing population. To meet the demand, pigeonpea productivity has to be increased. Effective management of irrigation water is an important issue in crop production, since irrigation is a precondition for crop growth, development and production per mm of water and productivity per unit area. Drip irrigation is the precise application of irrigation water in the root zone with enhanced water use efficiency (WUE) (Tarawalie *et al*., 2012). There are reports that pigeon pea yield increased tremendously when irrigated through drip method. Similarly, it is anticipated positive effect of mulching on yield of pigeonpea. The practice of mulching in agriculture has been widely used as a management tool. Mulching improves the soil physical condition by enhancing aggregation and conserving soil moisture by increasing infiltration, checking losses by evaporation and run off. It also favourably modifies the soil thermal regime, retards soil erosion and improves soil health. Due to mulching the beneficial effects of plastic mulch for enhanced water and fertilizer utilization and weed control. The polyethylene mulch is very common in high value vegetable crops have been recognized. The plastic mulch increases the soil temperature and moisture of upper layer of soil. Hence, the present study was initiated to study the influence of drip irrigation and mulch on yield and water use efficiency in *rabi* pigeonpea.

Material and methods

The field experiment was conducted at soil and water management research Farm, Navsari during the *rabi* seasons of 2011-12 to 2013-14. The experiment was laid out in randomized block design with four replications, keeping four levels of irrigation regimes (I_1 : Drip at 0.4 PEF, I_2 : Drip at 0.6 PEF, I_3 : Drip at 0.8 PEF and I_4 : Surface irrigation at 0.8 IW/CPE: 60 mm depth (normal spacing 90 x 20 cm) and three levels of mulch (M_0 : No mulch, M_1 : Sugarcane trash @ 5 t ha^{-1} and M_2 : Black plastic mulch with 50µ). The soil of experimental site was clay in texture, having pH 8.0, low in available nitrogen (242 kg ha^{-1}), medium in available phosphorus (46 kg P_2O_5 ha^{-1}) and high in available potassium (368 kg K_2O ha^{-1}). Pigeonpea crop was sown in 1st fortnight of November at a spacing of 60 x 20: 120 cm in paired row during all the three years of experimentation and harvested at the physiological maturity stage in the end of May. Recommended doses of fertilizer, *i.e.* 20:40:0 kg NPK ha^{-1} was applied through urea and single super phosphate at time of sowing.

Results and discussions

Effect of Irrigation

Plant height of pigeonpea increased gradually with decreasing rate up to harvest stage. Irrigation levels resulted in significant variation in plant height to various growth stages through drip irrigation at 0.8 PEF level accounted higher plant height at harvest over rest of the levels. This was also true for number of secondary branches per plant. The differences were significant with regard to yield attributes *viz.,* number of pods and grain weight per plant. The increased in number of pods and grain weight per plant under drip irrigation might be due to adequate water supply at critical growth stages and ultimately reflected in higher uptake of nutrients which might have resulted in better pod development and grain feeling. This finding is conformity with those reported by Mahalakshmi (2011). The results further indicated that, among different levels of irrigation, 0.8 PEF recorded significantly higher grain yield (1409 kg/ha) and stover yield (3108 kg/ha) as compared to irrigation at 1.0 IW/CPE ratio. The grain yield registered under 0.8 and 0.6 PEF were 11 and 9 per cent higher over 0.4 PEF level. Similar trend was also observed for stover yield of pigeon pea. This implies that drip irrigation favours in terms of growth and yield attributes in comparison to remaining levels of irrigation, due to availability of sufficient moisture supply throughout the entire growth period. These results are in accordance with the findings of Thanki and Solanki (2010) and Mahalakshmi (2011) for *rabi* pigeonpea.

Effect of mulch

Among the different mulch treatments, mulching with black plastic mulch of 25 micron appreciably increased plant height and number of secondary branches of pigeonpea might be due to mulching lead to better plant growth by changing the micro climate through conserving moisture by virtue of reducing evaporation, modifying soil moisture, controlling weeds, thus economizing the use of irrigation water. Moreover, adequate availability of moisture to plant, results in full cell turgidity and eventually higher meristematic activity, leading to more foliage development, greater photosynthetic rate and consequently better plant growth. These results are in conformity with findings of Yadav *et al.* (2006). Number of pods and grain weight per plant as well as grain and stover yields of pigeonpea were also produced significantly higher in black plastic mulch. Black plastic mulch treatment noted 48 per cent higher grain yield over no mulch. The increase in number of pods per plant apparently seems to be due to increase in number of secondary

branches per plant which were higher in black plastic mulch. These observations are in accordance with those of Ghose and Biswas (1984).

Interaction effect

The interaction effect observed between irrigation and mulch were significant in respect to plant height, yield attributes and yields of pigeonpea. The plant height was significantly higher with 0.8 PEF and 0.6 PEF with black plastic mulch, while number of pods and grain weight per plant also significantly highest under the same treatment combination *i.e.* 0.8 PEF with black plastic mulch. Remarkably the higher yield of grain (1774 kg ha^{-1}) was registered with irrigation level 0.6 PEF + black plastic mulch, which remained at par with 0.4 PEF with plastic mulch and 0.8 PEF with sugarcane trash mulch @ 5 t ha^{-1}.

Water use efficiency

The water use efficiency obtained under irrigation levels of 0.4, 0.6, 0.8 PEF through drip and surface irrigation were 3.65, 3.02, 2.45 and 1.90 kg/ha-mm of water used, respectively. This indicated that WUE decreased with increase in level of irrigation. Drip irrigation scheduled at lower level (0.4 PEF) recorded higher WUE of 3.65 kg/ha-mm with 49 per cent water saving.

Economics

The economics empathetically establishes the fact that adoption of drip irrigation is more remunerative than surface irrigation. Not only this, but drip irrigation and sugarcane trash mulch also save irrigation water to the extent of 49 per cent as compared to surface method of irrigation. If this saved water is used for irrigation an additional area under *rabi* pigeonpea, the monetary benefit may be still more.

It is concluded that the potential production and profit from the *rabi* season pigeonpea (cv. GT 102) can secured by scheduling of irrigation at 0.8 PEF through drip with sugarcane trash @ 5 t ha^{-1}. Due to higher cost of plastic sheet, it was not economical for mulching in pigeopea crop.

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Table1: Growth, yields and economics of *rabi* pigeon pea as influenced by different levels of irrigation and mulch (Pooled of three years)

Treatment	Plant height at harvest (cm)	Secondary branches per plant	Pods per plant	Grain weight per plant (g)	Yields (kg ha^{-1})		Income (Rs. ha^{-1})	Water saving (%)	WUE (kg ha^{-1} mm)
					Grain	Stover			
Irrigation levels (I)									
I_1 : Drip at 0.4 PEF	162	13.6	210	73.43	1269	2603	73488	49	3.65
I_2 : Drip at 0.6 PEF	164	13.6	197	75.77	1395	2905	79481	32	3.02
I_3 : Drip at 0.8 PEF	167	13.8	216	82.60	1409	3108	84247	16	2.45
I_4 : Surface irrigation at 0.8 IW/CPE	156	13.1	214	69.93	1294	3436	77240	-	1.90
S. Em.±	1.84	0.17	4.7	1.54	28	90	-	-	-
CD (P=0.05)	5.0	0.50	13.0	4.25	81	253	-	-	-
Mulch levels (M)									
M_0 : No mulch	157	12.9	192	70.62	1084	2409	64606	-	-
M_1 : Sugarcane trash @ 5 t/ha	160	13.3	207	73.24	1337	3103	79022	-	-
M_2 : Black plastic sheet (50µ)	169	14.3	228	82.43	1604	3526	69714	-	-
S. Em.±	1.59	0.15	4.1	1.33	24	78	-	-	-
CD (P=0.05)	4.0	0.43	11.0	3.94	69	219	-	-	-

Table 2: Effect of irrigation and mulch on grain yield (kg ha^{-1}) of pigeonpea

Irrigation /Mulch	M_0 : No mulch	M_1 : Sugarcane trash @ 5 t/ha	M_2 : Black plastic
I_1 : Drip at 0.4 PEF	855	1300	1651
I_2 : Drip at 0.6 PEF	1166	1245	1774
I_3 : Drip at 0.8 PEF	1198	1674	1554
I_4 : Surface irrigation at 0.8 IW/CPE	1118	1331	1435
S. Em.±	49		
CD (P=0.05)	138		

2. Enhancing Productivity of Horticultural Crops Using Micro irrigation Technologies

Patil, R. G., B. M. Solia and N. G. Savani

Source: Global seminar, ASPEE, NAU, Navsari (2015)

Abstract

In view of diversity in agro climatic conditions in India, variety of horticultural crops are grown. Though, area under horticultural crops has increased, yet the productivity remained stagnant during past two decades. Increasing the productivity of horticultural crops is rather compulsion in the context of dwindling land as well as water resources and increase in demand of mostly vegetable and fruits. In present paper, water management towards improving water use efficiency (WUE) using micoirrigation system (MIS) along with enhancing productivity of horticulture crops have been discussed.

Introduction

In India, array of horticultural crops are grown due to presence of diversified agro climatic conditions across the country. Among the horticultural crops, fruit crops constitute about 30 per cent area. Of this, around 50 per cent area is occupied by the mango (22.97 lakh ha) and banana (8.30 lakh ha). The area under fruit crops is steadily on the rise as it increased from 28.74 lakh ha during 1991-92 to 63.83 lakh ha during 2010-11. Though, production of horticultural crops has increased almost three times during this period, yet the productivity remained stagnant over this period *i.e.,* around 11.0 t/ha. This implies that an increase in production of horticultural crops is mainly due to area expansion and not due to increase in productivity (Anon., 2011). In the context of shrinking land and water resources, the only option left with us is to increase the productivity of crop per unit of input, area and time. For enhancing the productivity of any crop, water is the most crucial input. However, the availability of water for irrigation purpose is facing stiff challenges from domestic and industrial sectors as well. Not only will this, but provision of water for environmental and ecological concerns also have to be made. The sector wise water requirement given in table 1 clearly suggest that the proportion of water available for irrigation purpose will decrease to 72.8 per cent during 2050 from 83.3 per cent during 1990. But in real term, the water requirement for irrigation will increase from 460 BCM during 1990 to 1205 BCM during 2050. In comparison to 1990, the water requirement by 2050 for domestic, irrigation, energy, industries and others sectors will increase by 3.8, 2.61, 11.6, 4.27 and 2.42 times, respectively. This suggests that energy sector will be the major competitor of water for irrigation sector. On the top of this, the dominant method of irrigation practiced in large parts of India is surface irrigation under which crop utilize only less than one half of the water released and remaining half gets lost in conveyance, application, run-off and evaporation. For minimizing these losses, adoption of micro irrigation methods like drip, sprinkler *etc*. is the necessity of the hour. In this direction, considerable efforts have been made by state as well as central governments and as a result there is steady increase in area under micro irrigation system (MIS) in India. This increase is more in state like Maharastra, Andhra Pradesh, Tamil Nadu, Karnataka, Gujarat *etc.* Simultaneously, large numbers of technologies related to MIS including mulching, fertigation *etc.* have been developed and are being developed / refined by SAUs, ICAR institutes, R and D organizations *etc.* for agriculture and horticultural cops. But the rate at which these technologies are being adopted by the farmers is very slow due to number of reasons like initial high investment, highly technical, inadequate awareness about MIS among the farmers *etc.*

Table 1: Sector wise water requirements in India

Purpose	Water use in the year							
	1990		2000		2025		2050	
	BCM	% of total	BCM	% of total	BCM	% of total	BCM	% of total
Domestic	25	4.5	44	6.6	77	6.2	95	5.7
Irrigation	460	83.3	520	78.5	983	78.7	1205	72.8
Energy	19	3.5	27	4.1	70	5.6	212	12.8
Industries	15	2.7	30	4.6	46	3.7	64	3.9
Others	33	6.0	41	6.2	72	5.8	80	4.8
Total	**552**	**100**	**662**	**100**	**1248**	**100**	**1656**	**100**

BCM : Billion cubic meter ***Source :*** *Mandvia (2005)*

1. Technology development

As water availability for irrigation is declining with progress of time due stiff competition from domestic, industries and other sectors, its efficient utilization is becoming more and more important. In the context of enhancing the productivity of horticultural crops, drip, fertigation, sprinkler and mulching technologies are considered to be the most efficient methods.

1.1 Fruit crops

Drip technology: In light of the diversified agro climatic situations in India, ICAR, MoA (NCPAH), SAUs and R and D organizations have made concerted efforts for developing situation wise crop specific MIS technologies. These technologies basically envisage volume of water to be applied per tree/plant, frequency of water application, drip system layout, dripper discharge, season or month wise operating time *etc.* Generally, drip method of irrigation is compared with conventional method of irrigation with respect to water/fertilizer saving, yield increase and quality improvement. Subsequently, cost economic of the MIS *vis-a-vis* conventional method of irrigation is also computed. Some of the important technologies developed for fruit crops across the country are reported in table 2. Irrespective of crop and location, along with increase in yield, water saving to the extent of 47 per cent could be achieved. In addition, the results also indicate fertilizer saving up to 40 per cent in heavy feeder crop like banana.

Table 2: MIS technologies for some fruit crops in India

SN	Crop	Location/state	Yield increase over control (%)	Water saving (%)	Fertilizer saving (%)
1	Banana	Navsari/Gujarat	3	38	40
2	Papaya	Junagadh/Gujarat	20	27	20
3	Kinnow	Delhi/Delhi	31	22	-
4	Grapes	Dharwad/Karnataka	19	47	-
5	Ber	Belvatgi/Karnataka	24	19	-
6	Gauva	Allahabad/UP	27	17	-
7	Mango	SKNagar/Gujarat	9	21	-
8	Sapota	Paria/Gujarat	17	21	-

Source: *Singh (2001) and Savani et. al. (2012)*

Drip + mulching technology: Drip method of irrigation enables to apply required volume of water frequently in root zone and it also facilitates application of water soluble fertilizers as well as chemicals. If mulching is coupled with drip method of irrigation, then more yield advantage can be realized by the farmers. Basically mulching means covering the root zone area either with plastic or crop residues or pebbles or weed biomass. Adoption of mulching

particularly with drip system, moderate the soil temperature, increase soil air CO_2 content which ultimately improves nutrient availability, control weeds up to 90 per cent and minimize evaporation loss of water from soil surface. This is ultimately reflected on and yield of crop and water saving. The yield advantage irrespective of crop and location ranges from 21 per cent with banana at Navsari to 85 per cent with mango at Lucknow (Table 3).

Table 3: Drip + mulching technologies for some fruit crops in India

SN	Crop	Location /state	Yield increase (%)	Water saving (%)	Remarks	*Reference*
1	Banana	Navsari /Gujarat	21	40	40 % N & K saving	*Savani et. al. (2012)*
2	Papaya	Navsari /Gujarat	32	40	90 % weed control with BPM	*Savani et. al. (2012)*
3	Ber	Danti /Gujarat	25	Rain fed	Upward movement of salt was restricted	*Savani et. al. (2012)*
4	Cashew	Bhubaneswar/ Orissa	80	20	BPM	*Misra et. al. (2008)*
5	Apple	Bajaura, Kullu	31	-	Less fruit drop over control (6.44 %) with BMP	*Thakur et.al.(1993)*
6	Pomeg-ranate	Kalyani, Nadia.(W.B.)	69	-	BPM	*Chattopadhyay and Patra (1993)*
7	Mango	Lucknow / UP	85	-	Less fruit drop over control (45.10 %) with BMP	*Singh and Singh (2005)*

Inter cropping in drip irrigated banana: Normally, inter cropping in drip irrigated banana is not practiced. But by changing planting geometry and planting time, some of winter season short duration crops like onion, garlic and cauliflower can be grown successfully. One such study conducted at Navsari (Gujarat) empathetically proved that in drip irrigated banana planted during October, onion was found more remunerative than garlic and cauliflower (Anon., 2012-13). This study further indicate that in between two rows of banana (2.4 m), if one additional lateral *i.e.* at 1.2 m is provided, then 58-60 per cent area can be covered with onion. This option recorded highest fruit yield of 107 t/ha. Further, there is no need to apply any additional volume of water for inter crop (Table 4).

Table 4: Banana fruit equivalent yield (t/ha) as affected by various intercropping treatments

Treatment	2009-10	2010-11	2011-12	Pooled
Area				
A_1	95.3	86.6	97.4	**93.1**
A_2	101.0	101.5	102.3	**101.6**
A_3	106.3	101.9	110.3	**106.1**
S.Em±	2.1	2.9	2.3	1.4
CD at 5 %	6	8	7	4
Crop				
C_1 Onion	104.4	107.3	109.3	**107.0**
C_2 Garlic	103.1	91.2	103.3	**99.2**
C_3 Cauliflower	95.0	91.4	97.4	**94.6**
S.Em±	2.1	2.9	2.3	1.4
CD at 5 %	6	8	7	4
Sole	85.7	85.0	89.8	**86.9**
CV %	7	10	7	9
C X A	NS	NS	NS	NS
Y				*
Other interactions				NS

Note: Area under Intercrop (A):

A_1 = 25 - 27 % (without lateral shifting *i.e.* along the row)

A_2 = 33 % (with lateral shifting *i.e.* between two rows)

A_3 = 58-60 % (A_1 + A_2)

1.2 Vegetable crops

As far as vegetable crops are concerned, depending upon the planting geometry, drip as well as sprinkler techniques have been developed for different locations. In certain vegetable crops, drip, mini and macro sprinklers technologies were tried at different locations and their techno-economic viability have been proved.

Drip technology: Among the vegetable crops, higher water saving of 60 per cent was recorded with drip irrigated brinjal and that of minimum (20%) was obtained with potato crop over surface method. In rest of the crops, drip irrigation could save water around 40 to 50 per cent. Along with water saving, increase in yield of vegetable crops under drip irrigation was ranging from 6 per cent in okra to as high as 47 per cent in chilies as compared to surface method of irrigation (Table 5).

Table 5: Drip, mulching and fertigation technologies for vegetables crops

SN	Crop / type of application	Recommended treatment	% water saving	% increase in yield
1	Bitter gourd – drip + mulch	0.6 PEF + BPM	40	-
2	Brinjal (low energy drip)	Paired rows (0.6 x0.6 x 1.2 m) 35 lit water / day/35m^2 area	60	-
3	Cauliflower	0.60 PEF	44	20
4	Chilies – drip + mulch	Double paired planting (45 x 45 x 75 x 75 cm) + 125 kg N/ha + BPM	-	47
5	Okra (Fertigation)	0.40 PEF + 80 % N	52	6
6	Potato (Fertigation)	0.80 PEF + 60 % N	20	-
7	Tomato (Fertigation)	Paired row planting (50 x 50 x 150 cm) + 60 % NPK	23	33

Source: Anon. (2010-11)

Sprinkler technology: In closely grown crops mini and macro sprinkler were tested in onion, garlic, okra, cabbage, cauliflower and potato crops. Here also, water saving and yield increase was observed (Tables 6 and 7).

Table 6: Mini sprinkler technologies for some vegetable crops

SN	Crop / type of application	Recommended treatment	% water saving	% increase in yield
1	Onion	0.60 IW/CPE	42	21
2	Garlic (Herbigation)	0.80 IW/CPE	-	-
3	Potato	1.40 IW/CPE	35	17

Source: Anon. (2010-11)

Table 7: Macro sprinkler technologies for some vegetable crops

SN	Crop	Recommended treatment	% water saving	% increase in yield
1	Cabbage	0.50 IW/CPE	50	3
2	Cauliflower	0.90 IW/CPE	34	11
3	Okra	0.80 IW/CPE	28	19
4	Potato	0.90 IW/CPE	46	4

Source: Anon. (2010-11)

1.3 Flower crops

At Soil and Water Management Research Unit, NAU, Navsari (Gujarat) drip irrigation, fertigation and mulching studies in flower crops *viz.,* rose, tuberose, gladiolus and marigold were carried out. Here also water saving to the extent of 24 per cent in gladiolus and yield increase up to 54 per cent was recorded in rose due to adoption of MIS technologies (Table 8).

Table 8: MIS technologies in flower crops

SN	Crop (Spacing: cm)	% water saving	% yield increase	Schedule	Remarks
1	Rose – drip + fertigation + mulching (100 x 100 x 120)	17	54	Winter: 150-180 min. Summer: 210-270 min.	25 % fertilizer saving
2	Tuberose - drip (30 x 120)	-	42	50 min. Oct.- Feb., 85 min. onward	-
3	Gladiolus – drip + fertigation (20 x 20 x 60)	24	22	First 4 irrigation at 20 - 22 days interval and remaining 4 irrigation at 14- 16 days interval	-
4	Marigold – mulching (30 x 50)	-	25	Nov.: 1.0 hr & 45 min. Dec.: 1.0 hr & 20 min. Jan.: 1.0 hr & 35 min. Feb.: 2.0 hr & 05 min. March: 2.0 hr & 25 min.	-

1.4 Use of poor quality water for irrigation

Adoptions of drip irrigation coupled with mulching also facilitate use of marginally poor quality waters for irrigation purpose. In Gujarat, poor quality water is predominantly occurring due to longest sea coast of the state. Use of poor quality water for irrigation is

rather compulsion in Gujarat. In this direction, few studies with drip and mulching were conducted using brinjal as test crop (Table 9) at two locations. Based on these long term experiments conducted at fixed site, it was found that fruit yield of brinjal was more with saline water of 4 to 6 ds/m than less saline water. Not only this, but there was no built of salinity in soil due to use of drip irrigation and mulching. This is mainly due to use of less volume of water through drip than flood method of irrigation as well as mulching restrict the upward movement of soluble salts.

Table 9: Use of poor quality waters in brinjal

SN	Crop (Spacing: cm)	% water saving	% yield increase	Schedule	Remarks
1	Brinjal (50 x 75 x 100) **Location:** Danti	37	17	Winter: 45- 75 min. Summer: 75-105 min.	< 6 dS/ saline water used
2	Brinjal (50 x 75 x 100) **Location:** Navsari	-	21	Winter: 75-90 min. Summer: 90-120 min.	Saline water up to 4 dS/m + Mulching

Source: *Savani et. al. (2012)*

2. Impact of MIS in horticultural crops

As a part of transfer of technology, the drip + mulching technology developed for banana crop at PFDC, Soil and Ware Management Research Unit, NAU, Navsari (Gujarat) also demonstrated on large scale at farmers' fields. The data presented in table 10 clearly indicate that under South Gujarat conditions, farmers could harvest 13 per cent higher yield with drip + mulch as compared to drip alone (Anon., 2010-11). In addition to yield advantage, in the opinion of the farmers, the banana crop with mulching was harvested by about 30 to 40 days earlier than no mulch which enable them to fetch higher price. An increase in fruit yield of banana obtained under mulching could be attributed to the increase in soil air CO_2 content which ultimately improves the nutrient availability. Similarly, this also true for vegetable crops (Table 11).

Table 10: Fruit yield of banana on farmers' fields

Farmer No.	Yield (t/ha)		
	Drip + BPM	Drip alone	% increase over drip alone
1	80	71	13
2	86	73	18
3	89	79	13
4	76	69	10
5	84	73	15
6	69	61	13
7	78	67	16
Mean	**80**	**71**	**13**

BPM: Black plastic mulch (50 micron thickness, 50 % area coverage)

Table 11: Results of demonstrations of vegetable crops on research farms and farmers' fields

Technology	Yield on research farms (t/ha)	Yield on farmers' fields (t/ha)	Increase in yield over control (%)	Water saving (%)	Fertilizer saving
Tomato					
Drip + BPM	30	35	50-58	40	40% N of RD
Drip + STM	26	30	25-37	40	40% N of RD
Control (Farmers' method)	19	24	-	-	-
Okra					
Drip + BPM	11.4	10	28-44	40	20% N of RD
Control (Farmers' method)	7.9	7.8	-	-	-
Brinjal					
Drip + BPM	57	-	29	40	20% N of RD
Control (Farmers' method)	44	-	-	-	-

Because of these efforts, the farmers of Gujarat have realized the importance of MIS in horticultural crops. As a result of this, at present the area under MIS in Gujarat has reached to around 8.0 lakh ha and is steadily increasing because of proactive action of Government, GGRC and University. Along with drip, use of plastic as mulch in crops like banana, water melon and papaya is also getting momentum which has already occupied about 1500-2000 ha/year area in Gujarat.

3. Potential of MIS in horticulture crops in India

Considering the agro climatic conditions and availability of water for irrigation in different parts of India, National Task Force on Micro irrigation, Govt. of India has estimated crop wise theoretical potential area suitable for drip and sprinkler in India. Out of 69.50 million ha potential area for drip and sprinkler, about 23.40 per cent area (16.30 million ha) belongs to horticultural crops. Within horticultural crop, 73 per cent area (11.90 million ha) is suitable for drip and remaining 27 per cent for sprinkler method of irrigation. Among the horticultural crops, fruit + plantation crops constitute about 50 per cent area for drip (Table 12).

Table 12: Theoretical potential area of horti. crops for drip and sprinkler in India (M ha)

SN	Crop	Area (M ha)		
		Drip	Sprinkler	Total
A. Horticultural crops				
1.	Vegetable	3.6	2.4	6.0
2.	Spices and condiments	1.4	1.0	2.4
3.	Flower, medicinal and aromatics	-	1.0	1.0
4.	Fruits	3.9	-	3.9
5.	Plantation crops (Coconut, oil palm *etc*.)	3.0	-	3.0
	Sub total (A)	***11.9***	***4.4***	***16.3***
B. Agricultural crops				
1.	Cereals	-	27.6	27.6
2.	Pulses	-	7.6	7.6
3.	Oil seeds	3.8	1.1	4.9
4.	Cotton	7.0	1.8	8.8
5.	Sugarcane	4.3	-	4.3
	Sub total (B)	***15.1***	***38.1***	***53.2***
	Grand total	**27.0**	**42.5**	**69.5**

Source: *Rajput and Patel (2012)*

4. Issues related to MIS in India

MIS in India could be promoted in an effective way if the issues involved at research, development and promotional aspects could be taken up simultaneously. Some of the important issues are given below:

- MIS have proven to be a highly technology driven combining water saving with favourable crop response especially of row crops.
- There is growing awareness, especially in water scare areas for use of micro irrigation as benefit and cost ratio is much higher although investment is high.
- Industrial growth of MIS in India favours the widespread use, but industry needs discipline for quality and providing services to safeguard the technology.
- MIS research in India has received attention but integration among different programs are lacking. Through effective integration and linkages more useful information could be generated and duplication could be avoided.
- There is a need to strengthen the information system in MIS, which should be user's friendly and guide to farmers.
- There is also a need to attract more investment for capital formation and technology should be designed to have shift from subsidy-driven mode to farmer-driven mode.
- With the launching of the macro management scheme, the state governments will be in a position to assign more priority to the MIS programs in their work plans. However, they will have ensure proper monitoring of the programs in terms of installation of good quality systems backed with proper after sale service.

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3. Fertigation Studies in Horticultural Crops

B. M. Solia, R. G. Patil and S. L. Pawar

Source: 21 days training manual for scientists, ASPEE, NAU, Navsari (2015)

Introduction

India is the second most populous country in the world. The per capita cultivable land resource is shrinking day by day. To meet the food, fibre, fuel, fodder, and other needs of the growing population, the productivity of agricultural land has necessarily to be increased. It requires increased use of agricultural inputs like quality seeds, fertilizers, water, agro-chemicals, *etc.,* in such a manner that do not create any environmental problems.

Plant needs different chemical elements to grow and thrive. The most important chemical elements include (i) carbon, hydrogen and oxygen, which are basic life building blocks and are available in plenty from air and water, (ii) nitrogen, phosphorus and potassium which are the macro nutrients and affect the plant growth significantly, (iii) sulfur, calcium, and magnesium as secondary nutrients and (iv) boron, chloride, copper, iron, manganese, molybdenum and zinc as micronutrients in very small quantities.

Absence or inadequacy of any nutrient limits the plant growth. The purpose of applying fertilizer is to provide a balanced dose of all the types of nutrients needed by the plant to grow and yield adequately. Most fertilizers supply nitrogen, phosphorus and potassium. The other elements are needed in much less quantities and are generally available in most of the soils or supplied inadvertently through low analyses fertilizer or organics.

The large scale use of fertilizers in India started in the late 1960s, after the introduction of high yielding varieties, which pioneered the "Green Revolution". The important fertilizers currently being used are urea, di-ammonium phosphate, single super-phosphate and muriate of potash. These fertilizers supply mainly NPK, whereas the requirements of other essential nutrients are largely met only from soil and to some extent from organic manures. Currently, about 16 million tonnes of N, P_2O_5 and K_2O are being used annually as fertilizers, which corresponds to an average NPK use of 87 kg/ha (IFA, 1992).

Fertilizer is a costly input. Large quantities of fertilizers are imported to meet the increasing demand. But the efficiency of utilization of chemical fertilizers in the country is very low. It has been reported that nitrogen use efficiency seldom exceeds 40 per cent under lowland and 60 per cent under upland conditions. In case of phosphorous and potassium the efficiency hardly exceeds 20 per cent (Singh *et.al.,* 2000).

Since last 25 years, the Indian soils are experiencing an average deficit @ 8-10 mt of nutrients per annum. During 1998-99, 16.8 mt of fertilizer nutrients were added against the removal of 30 mt nutrients by plants. About 70 per cent of the total gross cropped area in the country experienced a nutrients depletion of more than 50 kg/ha annually. Almost 50 per cent of the nutrients removal is accounted by potash, whereas its use hardly exceeds 6 per cent (Singh *et.al.,* 2000). Considering the level of crop production during 1996-97 in India, the annual nutrient removal from soil is about 26 mt, whereas supply from chemical fertilizers is around 14 mt thus leaving a gap of about 12 mt (IFA, 1992).

Fertilizer application through the drip irrigation system *i.e.,* fertigation is the most advanced and efficient practice of fertilization. Fertigation combines the two main factors in plant growth and development, water and nutrients. The right combination of water and nutrients is the key for high yield and quality of produce. Fertigation is the most efficient method of fertilizer application, as it ensures application of the fertilizers directly to the root zone of the crop (Patel *et.al.,* 2000). In fertigation, fertilizer application is made in small and frequent doses that fit within scheduled irrigation intervals which also matche with the plant water use. Significant savings in the use of fertilizers and increase in yield (Table 1) have been reported by different research workers (Anon., 2001).

Table 1: Savings in fertilizer and increase in crop yield under fertigation as compared to conventional method of fertilizer application

SN	Crop	Saving in fertilizer (%)	Increase in yield (%)
1	Okra	40	18
2	Onion	40	16
3	Broccoli	40	10
4	Banana	20	11
5	Potato	40	30
6	Tomato	40	33

Source: *Anonymous, 2001*

Advantages of fertigation

- Ensures a uniform and regular flow of water as well as nutrients, resulting in increased growth rates leading to higher yields and quality.
- Offers greater versatility in the time of nutrient application to meet specific crop demands. In most cases, fertilizers can be applied regardless of weather or field conditions.
- Improves availability of nutrients and their uptake by the roots.
- Safer application method, as it eliminates the danger of burning the plant root system.
- Simple and more convenient application method that saves time, labor and energy.
- Timely applications of small but precise amounts of fertilizer directly to the root zone allows growers to effectively manage fertilizer programs, this improves fertilizer use efficiency and reduces nutrients leaching below the root zone.
- Reduction in soil compaction.
- Potential reduction in environmental contamination.
- In general, cost of application by fertigation is about one-third the cost of conventional application methods
- Minimizes operator handling, mixing and dispensing of potentially hazardous materials.
- In addition, people and non-target crops are not exposed to inadvertent chemical drifts.

Disadvantages of fertigation

- Uneven nutrient distribution when the irrigation system is faulty.
- Over fertilization if excess water is applied to the crops.
- Chemical reactions of fertilizer with calcium and bicarbonate in water, which can lead to clogging of drip fertigation system.
- Potential chemical back flow into water supply.
- Calibration – The calibrated injection rate may need to be changed during the application period.
- Non-target chemical application can occur as a result of malfunctioning equipment
- Management requirements: safe and effective fertigation requires careful and attentive management.
- Beneficial only when the drip irrigation system is adequately designed, fully functional and properly managed

Pre-requisites for successful fertigation

In order to achieve uniform distribution of plant nutrients the fertigation system must fulfill following requirements.

- The system must be designed correctly and operated efficiently. Each and every dripper must deliver the same volume of water during the irrigation period.

- Poor distribution of nutrients may result from blockage caused by fertilizer particles or chemical deposits in the systems, so the material to be used must be free from residues/deposits and fertilizer material must not cause excessive corrosion of irrigation system components.
- In order to obtain uniform mixing of the nutrients and water in the irrigation systems the operating pressure variations should be minimum.
- Selection of most appropriate fertilizer according to soil conditions, plant requirements and costs.

Precautions needed during fertigation

When fertilizer is being injected into a drip irrigation system, there are certain precautions a farmer should take, including:

- Be sure the placement of the drip tubing does not interfere with the cultivation system. For example: If planting tomatoes down the center of a raised bed, place the drip tubing about 15 cm off center. This will prevent damaging the tubing when making holes for the transplants and when inserting supporting stakes.
- Make sure the fertilizer solution is compatible with the quality of water into which it is being injected. Some fertilizers can cause a precipitate that will clog the drip system or filter system. For example: calcium and phosphorus fertilizers should not be mixed with water containing sulfates in solution.
- The suction line in the fertilizer tank should be fitted about 30 cm above the tank base to prevent any un-dissolved solids from entering the system. Calcium nitrate and potassium nitrate will sometimes leave a scum of impurities on the surface; skim off the scum.
- A small screen should be put on the end of the suction line to help eliminate solid particles or un-dissolved fertilizer from entering the system and stopping it up.
- Do not inject fertilizers in combination with pesticides or chlorine.
- The injection point must be upstream of the filter system so that the filter will remove any un-dissolved fertilizer or precipitates that occur.
- Before beginning injection of a fertilizer, bring the drip irrigation system up to operating pressure. At this point even the part of the irrigation system farthest from the source should be pressurized.
- After fertigation is completed, irrigate with plain water so that the system is flushed out and fertilizer is washed into the plant beds.
- Select fertilizer solutions to help adjust water pH if necessary.
- The time needed to distribute the fertilizer should be less than the time needed to supply enough water to the field. Do not over irrigate because this will leach some of the fertilizer out of the root zone. If the amount of fertilizer that must be applied is too much for the irrigation interval, split the application over time (i.e., twice per week or some other arrangement).
- Never inject any material that is not labeled and recommended for the crop and for injection through the system. Always follow label directives.
- The use of material that might cause precipitation and clogging of the system should be avoided.

Characteristics of fertilizers for fertigation

All types of fully-water soluble granular and liquid fertilizers are suitable for fertigation. However, for higher yield and quality, chloride-free fertilizers such as Multi-K (potassium nitrate), Mono Ammonium Phosphate and Mono Potassium Phosphate are preferable. Soluble dry fertilizers containing N, P and K in different combinations are also available in the market. Liquid fertilizers with varying N, P and K contents are also available but these are more expensive. Mostly, Nitrogen (N), Potassium (K), or both are injected. But

Phosphorous does not move very freely in the soil therefore half of its recommended dose be normally applied before planting.

Microelements may be added in chelate form. Commercially prepared liquid fertilizers for fertigation are also acceptable. These are usually combinations of N and K. The commonly used fertilizers with their nutrient contents are given in table 2.

All fertilizers applied through drip irrigation must meet the following criteria:

a) Fully soluble (<0.02% insoluble in water)
b) Quick dissolution in water
c) Fine grained product
d) High nutrient content in the saturated solution
e) No chemical interaction between the fertilizer and irrigation water
f) Minimum content of conditioning agents

Table 2: Nutrient contents of some commercially available granular fertilizers

Name of fertilizers	Chemical form	N: P: K content (%)
Ammonium Nitrate	NH_4NO_3	34-0-0
Ammonium Sulfate	$(NH_4)_2SO_4$	21-0-0
Urea	$CO(NH_2)_2N$	46-0-0
Urane solution	$CO(NH_2)_2NH_4NO_3$	32-0-0
Mono Ammonium Phosphate	$NH_4H_2PO_4$	12-61-0
Potassium Chloride	KCl	0-0-60
Potassium Nitrate	KNO_3	13-0-44
Calcium Nitrate	$Ca(NO_3)_2$	15-0-0
Potassium Sulfate	K_2SO_4	0-0-50
Single Super Phosphate (SSP)	$Ca(H_2PO_4)H_2O+2CaSO_4.2H_2O$	18-0-0
Mono Potassium Phosphate	KH_2PO_4	0-52-34
Phosphoric acid	H_3PO_4	0-52-0

Concentration of different nutrients in fertilizer solution

Nutrient concentrations in fertilizer stock solutions can range from very weak to near maximum strength. The maximum strength (maximum possible concentration) of a stock solution is limited by the solubility of the fertilizer(s) dissolved in the solution. But the stock solution should be diluted and brings the concentration of different nutrients (Green air product, 2001) up to its acceptable limits by the plant (Table 3). Lower or higher concentrations could result in poor plant health.

Table 3: Acceptable concentration of different nutrients (ppm)

SN	Nutrients	Acceptable limits of concentration (ppm)	Average acceptable concentration (ppm)
1	Nitrogen	150 - 1000	250
2	Phosphorus	50 - 100	80
3	Potassium	100 - 400	300
4	Calcium	100 - 500	200
5	Magnesium	50 - 100	75
6	Sulfur	200 - 1000	400
7	Copper	0.1 - 0.5	0.05
8	Boron	0.5 - 5.0	1.0
9	Iron	2.0 - 10	5.0
10	Manganese	0.5 - 5.0	2.0
11	Molybdenum	0.01 - 0.05	0.02
12	Zinc	0.5 - 1.0	0.5
13	Sodium	20 - 100	50
14.	Corbonates	20 - 100	60
15.	Sulphate	200 - 300	250
16.	Chloride	50 - 100	70

Source: *Green air product (2001)*

Consumption rate of nutrients by the plants

The exact fertilizer application rates needs to be applied to crops according to the actual uptake as it changes according to the plant growth rate. Usually, this kind of detailed information is neither available nor easy to implement, since the composition of the fertilizer solution and the fertilizer application rates must be changed continuously. Soil solution and plant tissue tests can be used to monitor the efficiency of the fertigation procedure.

The consumption rate of nutrients by the plant (Singh, 1991) depends upon type and variety of crop, plant population, growth stage, climatic condition and expected yield. Nutrient consumption rates (Table 4) are not affected by the characteristics of the growing medium and the irrigation method. The availability of nutrients depends upon the quality of growing medium to supply nutrients to the plant. The buffering capacity of a growing medium depends on its resistance to chemical changes (pH and EC). Clay type and organic matter content are the major factors affecting these two parameters for any type of soil.

Table 4: General nutrient recommendations for some important crops

Crops	Nutrients requirement (kg/ha)		
	N	P	K
Potato	175	80	310
Green beans	130	40	160
Cabbage	370	85	480
Carrot	125	55	200
Cauliflower	250	100	350
Cucumber	70	50	120
Brinjal	175	40	300
Onion and Garlic	120	50	160
Pumpkin	90	70	160
Radish	120	60	120
Tomato	140	65	190

Suggested guidelines for leaf/petiole sampling

Assessing the nutrient status in critical parts of plant is one of the important tools for knowing the nutrient requirement of crop. This can be used as a tool for scheduling fertilizer in different crops. The guideline for selecting ideal plant analysis is given below.

Crop	Plant part to be sampled	Age, stage, position and other conditions
Apple	Recently matured leaf including petiole	June 15 to August 15 fro prunear base of current season growth at bloom stage
Banana	20 cm^2 section of leaf 3rd fully open leaf blade on both side of midrib in centre of the leaf	3rd fully open leaf
Grape	Petiole	45 days after pruning at bloom stage opposite to flower cluster
Guava	Recently matured leaf	3rd pair in August or December at bloom stage
Citrus	Leaves including petiole	Selection of 5-7 month old terminal, spring cycle leaves of mature trees
Ber	Recently matured leaf	Middle of the shoot 7-8th from apex. Keep cemtral part of the leaf middle of the shoot at bloom stage
Mango	Leaves including petiole	Collect 4-7 month old leaves from middle of the shoot
Pineapple	Middle one third portion of white basal portion of leaf	Fully developed leaf 'D" leaf 3-4 months after planting

Nutrient removal by some fruits and vegetable crops (Kg/ha)

Crop	Yield (t/ha)	N	P_2O_5	K_2O
Apple	25	100	45	180
Banana	40	250	60	1000
Citrus	30	100	60	350
Grape	20	170	60	220
Mango	15	100	25	110
Papaya	50	90	25	130
Pineapple	50	185	55	350
Cabbage	70	370	85	480
Carrot	30	125	55	200
Cauliflower	50	250	100	350
Cucumber	40	70	50	120
Egg Plant	60	175	40	300
Okra	20	60	25	90
Onion and Garlic	35	120	50	160
Spinach	25	120	45	200
Tomato	50	140	65	190

Devices for fertigation

After considering the fertilizer scenario in India and the crop nutrient requirement, type of fertilizer suitable for fertigation, their concentration, prerequisite and precaution before/during fertigation, it is necessary to understand the means with which best fertigation can be done. For fertigation, depending upon the area to be fertigated and the system possessed by the farmers, there are three types of devices which can be used for effective fertigation in any crops. These are i) By-pass pressure tank ii) Venturi system and iii) Direct injection system.

By-pass pressure tank*:* This method employs a tank into which the dry or liquid fertilizers are kept. The tank is connected to the main irrigation line by means of a by-pass so that some of the irrigation water flows through the tank and dilutes the fertilizer solution. This by-pass flow is brought about by a pressure gradient between the entrance and exit of the tank, created by a permanent constriction in the line or by a control valve.

Venturi Injector*:* A constriction in the main water flow pipe increases the water flow velocity thereby causing a pressure differential (vacuum) which is sufficient to suck fertilizer solution from an open reservoir into the water stream. The rate of injection can be regulated by means of valves. This is a simple and relatively inexpensive method of fertilizer application.

Direct injection system: With this method, a pump is used to inject fertilizer solution into the irrigation line. The type of pump used is dependent on the power source. The pump may be driven by an internal combustion engine, an electric motor or hydraulic pressure. The electric pump can be automatically controlled and is thus the most convenient to use. However, its use is limited by the availability of electrical power. The use of a hydraulic pump, driven by the water pressure of the irrigation system, avoids this limitation. The injection rate of fertilizer solution is proportional to the flow of water in the system. A high degree of control over the injection rate is possible, no serious head loss occurs and operating cost is low. Another advantage of using hydraulic pump for fertigation is that if the flow of water stops in the irrigation system, fertilizer injection also automatically stops. This is the most perfect equipment for accurate fertigation.

Recommended schedule of fertigation for some horticultural crops

SN	Crop/Variety (Spacing:cm)	Schedule	Fertilizer saving (%)
1	Banana/ Grand nine (2.4 m x1.2 m) with mulching	15 equal splits of N and K at 10 DI, starting from 60 DAP	30-40
2	Papaya/Taiwan 786 (2.4 m x 2.4 m)	14 equal splits of N and K at 15 DI, starting from 30 DAP	-
3	Turmeric/*Sugandham* 3 rows (30 cm x 20 cm) on raised bed of 90 cm of top width followed by a furrow of 30 cm depth	9 equal splits of 50 % N and K at 15 DI, starting from cessation of monsoon	20-25
4	Round melon (*Tunda*) Summer (Local) (2 m x 1 m)	12 equal splitsof N and K at 15 DI, starting after 45 DAP	-
5	Onion/pillipatti (10 cm x 15 cm)	9 equal splits of N and K at 10 DI, starting from 30 DAP	20-30
6	Brinjal/SurtiRavaiya(Pared row: 60 cm x 60 cm x 120 cm) + BPM (25µ, 45 % coverage)	6 equal splits of N and K at 15 DI, starting from 30 DAP	20-25
7	Gladious/Psittacinus hybrid 4 rows on raised bed of 1m (Paired row: 20 cm x 20 cm x 60 cm)	10 equal splits of N and K at 7 DI, starting from 30 DAP	20-30
8	Rose/Gladiator (Paired row:1 m x 1m x 2 m)	Except Kharif 20 equal splits of N and K at 15 DI	

DI: Days interval, DAP: Days after planting ***Source:*** *Savani et.al. (2012)*

Scope of fertigation in India

In view of the following points, there is vast scope of fertigation in India.

- Steady increase in area under MIS which facilitate fertigation in horticultural as well as other field crops
- For realizing full benefits of MIS, fertigation is a must
- Poor fertilizer use efficiency widening the gap between demand and supply of gaps *i.e.* mining of soils
- Increase in area under horticultural crops
- Increase in cost of fertilizer leading to higher cost of cultivation

Conclusions

Based on the information presented here, following conclusions are drawn

- There is need to educate farmers about different aspects of fertigation for realizing full benefits of fertigation
- Fertigation improves fertilizer use efficiency due to application at higher frequency *i.e.* fertilizer saving (20-40 %)
- Fertigation enhance crop yield and improves quality
- Inadequate manpower in the field of fertigation
- High cost of water soluble fertilizers

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4. Precision Farming in Horticultural Crops

B. M. Solia, R. G. Patil and R. T. Khatri

Source: 21 days training manual for scientists, ASPEE, NAU, Navsari (2015)

It is information and technology based farm management system to identify, analyze and manage variability within fields for optimum profitability, sustainability and protection of the land resource without disturbing the environment. It basically means adding the right amount of treatment at the right time and the right location within a field.

The Precision Farming (PF) being followed in India, is not a PF in real sense. At the same time, it not possible to follow **PF in real sense under Indian conditions owing to:**

- Fragmented land holding (80 % farmers hold less than 2 ha land)
- Poor financial status of the farmers
- Prevalence of highly diversified crops or cropping sequences
- Unassured availability of quality seed or planting material of desired crop and variety
- Inadequate knowledge about PF among the farmers
- High fluctuations in prices of farm produce
- Scanty marketing intelligence (demand / supply trend)
- Difficult to characterize natural resources (soil, climate *etc*.) at individual field level
- In general, ignorance of crop site suitability criteria
- Unassured irrigation water supply

In India, array of horticultural crops are grown due to presence of diversified agro climatic conditions across the country. Among the horticultural crops, fruit crops constitute about 30 per cent area. Of this, around 50 per cent area is occupied by the mango (22.97 lakh ha) and banana (8.30 lakh ha). The area under fruit crops is steadily on the rise as it increased from 28.74 lakh ha during 1991-92 to 63.83 lakh ha during 2010-11. Though, total production of horticultural crops has increased almost three times during this period, yet the productivity remained stagnant over this period *i.e.,* around 11.0 t/ha. This implies that an increase in production of horticultural crops is mainly due to area expansion and not due to increase in productivity (Anon., 2011). In the context of shrinking land and water resources, the only option left with us is to increase the productivity of crop per unit of input, area and time.

In other words, we have to increase the input use efficiency through adoption of modern agro techniques in different crops. PF is one such comprehensive tool which not only increases the input use efficiency and yield but also protect the environment.

Advantages of PF

- Improves crop yield
- Provide information to make better management decisions
- Reduces chemical and fertilizer cost through more precise application
- Provide accurate farm record
- Increases profit margin
- Reduces pollution

Tools for PF

1. Remote sensing (RS)
2. Geographic information system (GIS)
3. Global positioning system (GPS)
4. Variable rate technology (VRT)
5. Yield monitoring

6. Yield mapping

1. Remote sensing (RS):

Remote sensing is a tool for collection, processing and analysis of data to exact information from earth surface without coming in to physical contact with it. It holds great promise for precision agriculture because it is potential for monitoring spatial variability over time at high resolution.

2. Geographic information system (GIS):

It is a computer based management system used for computation, storage, analysis and display of spatial data in the form of a map. The GIS is the key to extracting value from information on variability. It is rightly called as "brain of precision farming". It helps in agriculture in two ways:

- One is in linking and integrating GIS data (soil, crop, weather, field history *etc.*) with simulation models.
- Another is to support the engineering component for designing implement and GPS guided machines.

3. Global positioning system (GPS):

GPS is important to find out the exact location in the field to assess the spatial variability and site specific application of inputs.

4. Variable rate technology (VRT):

VRT consists of farm field equipment with the ability to precisely control the rate of application of crop inputs that can be varied in their application, commonly include fertilizer, weed control, insect control, plant population and irrigation. In agriculture it is used to optimize the input or maximize the crop yield from a given quantum of unit.

5. Yield monitoring:

Yield monitor are crop yield measuring devices installed in harvesting equipment. The yield data from the monitor is recorded and stored at regular interval along with positional data received from the GIS unit. GIS software takes the yield data and produce yield map**.**

6. Yield mapping:

Mapping of yield and correlation of that map with the spatial and temporal variability of different agronomic parameters helps in development of next season crop management strategy.

Application of PF

1. Water management
2. Surface covered cultivation
3. Controlled environment structure
4. Organic farming
5. Precise space utilization
6. Micro propagation / tissue culture
7. IPM/INM

1. Water managements:

As water availability for irrigation is declining with progress of time due stiff competition from domestic, industries and other sectors, its efficient utilization is becoming more and more important. In the context of PF, drip and sprinkler methods of irrigation are considered as most efficient methods.

a. ***Drip technologies:*** In light of the diversified agro climatic situations in India, ICAR, MoA (NCPAH), SAUs and R and D organizations have made concerted efforts for developing situation wise crop specific MIS technologies. These technologies basically envisage volume of water to be applied per tree/plant, frequency of water application, drip system layout, dripper discharge, season or month wise operating time *etc.* Generally, drip method of irrigation is compared with conventional method of irrigation with respect to water/fertilizer saving, yield increase and quality improvement. Subsequently, cost economic of the MIS *vis-a-vis* conventional method of irrigation is also computed. Some of the important technologies developed for fruit crops across the country are reported in table 1. Irrespective of crop and location, along with increase in yield, water saving to the extent of 47 per cent could be achieved. In addition, the results also indicated fertilizer saving up to 40 per cent in heavy feeder crop like banana.

Table 1: MIS technologies for some fruit crops in India

SN	Crop	Location/state	Yield increase over control (%)	Water saving (%)	Fertilizer saving (%)
1.	Banana	Navsari/Gujarat	3	38	40
2.	Papaya	Junagadh/Gujarat	20	27	20
3.	Kinnow	Delhi/Delhi	31	22	-
4.	Grapes	Dharwad/Karnataka	19	47	-
5.	Ber	Belvatgi/Karnataka	24	19	-
6.	Gauva	Allahabad/UP	27	17	-
7.	Mango	SKNagar/Gujarat	9	21	-
8.	Sapota	Paria/Gujarat	17	21	-

Source: *Singh (2001) and Savani et.al. (2012)*

b. Drip + mulching technology: Drip method of irrigation enables to apply required volume of water frequently in root zone and it also facilitates application of water soluble fertilizers as well as chemicals. If mulching is coupled with drip method of irrigation, then more yield advantage can be realized by the farmers. Basically mulching means covering the root zone area either with plastic or crop residues or pebbles or weed biomass. Adoption of mulching particularly with drip system, moderates the soil temperature and increases soil air CO_2 content which ultimately improves nutrient availability, control weeds up to 90 per cent and minimize evaporation loss of water from soil surface. This is ultimately reflected on the yield of crop and water saving. The yield advantage irrespective of crop and location ranges from 21 per cent with banana at Navsari to 85 per cent with mango at Lucknow (Table 2).

Table 2: Drip + mulching technologies for some fruit crops in India

SN	Crop	Location / state	Yield increase over control (%)	Water saving (%)	Remarks	*Reference*
1.	Banana	Navsari / Gujarat	21	40	40 % N & K saving	*Savani et.al. (2012)*
2.	Papaya	Navsari / Gujarat	32	40	90 % weed control with BPM	*Savani et.al. (2012)*
3.	Ber	Danti / Gujarat	25	Rain fed	Upward movement of salt was restricted	*Savani et.al. (2012)*
4.	Cashew	Bhubaneswar / Orissa	80	20	BPM	*Misra et.al. (2008)*
5.	Apple	Bajaura, Kullu / HP	31	-	Less fruit drop over control (6.44 %) with BMP	*Thakur et.al.(1993)*
6.	Pomegranate	Kalyani, Nadia / WB	69	-	BPM	*Chattopadhyay and Patra (1993)*
7.	Mango	Lucknow / UP	85	-	Less fruit drop over control (45.10 %) with BMP	*Singh and Singh (2005)*

As a part of transfer of technology, the drip + mulching technology developed for banana crop at PFDC, Soil and Ware Management Research Unit, NAU, Navsari (Gujarat) also demonstrated on large scale at farmers' fields. The data presented in table 3 clearly indicate that under South Gujarat conditions, farmers could harvest 13 per cent higher yield with drip + mulch as compared to drip alone (Anon. 2010-11). In addition to yield advantage, in the opinion of the farmers, the banana crop with mulching was harvested by about 30 to 40 days earlier than no mulch which enable them to fetch higher price. An increase in fruit yield of banana obtained under mulching could be attributed to the increase in soil air CO_2 content which ultimately improves the nutrient availability in soil.

Table 3: Fruit yield of banana on farmers' fields

Farmer No.	Fruit yield (t/ha)		% increase over drip alone
	Drip + BPM	Drip alone	
1	80	71	13
2	86	73	18
3	89	79	13
4	76	69	10
5	84	73	15
6	69	61	13
7	78	67	16
Mean	**80**	**71**	**13**

BPM: Black plastic mulch (50 micron thickness, 50 % area coverage)

2. Surface covered cultivation:

a. Mulching: Mulching is age old practice of covering the soil surface with crop residues or weed biomass or pebbles or plastic. Advantages of adoption of mulching technologies are: moderation of soil temperature, increases soil air CO_2 content, minimizes evaporation and weed growth. At PFDC, SWMRU, NAU, Navsari, lot of work on mulching has been done and the results of which are given in table 4.

Table 4: Effect of mulching in surface irrigated horticultural crops

SN	Crop	Location	Mulch material	Water saving (%)	Yield increase (%)	Remarks
1	Banana	Navsari	ST @ 15 t/ha	40	49	Due to BP early maturity up to 20-30 days
			BP	35	18	
2	Brinjal	Khandha	BP	-	27	80% Weed control
3	Chillies	Navsari	ST @ 10 t/ha	-	14	-
			BP	-	62	
4	Cauliflower	Navsari	BP	-	33	75% weed control
			GP	-	21	33% weed control
			YP	-	15	59% more weed infestation
5	Marigold	Navsari	ST @ 5 t/ha or BP	20	25	-
6	Okra	Navsari	BP + 50 ppm NAA	-	25	90 % weed control
7	Sapota	Paria	GM (20% coverage)	54	25	-

Source: *Patil et.at. (2013)*

Note: GP: Green plastic mulch**, YP:** Yellow plastic mulch, **TP:** Transparent plastic mulch, **BP**: Black plastic, **ST**: Sugarcane trash

b. Soil solarization: It is method of heating the soil by covering it with thin transparent polyethylene sheets during hot period to control soil born diseases. This technology is mostly suitable for preparing healthy nurseries of vegetable, flower *etc.* It controls fungul as well as nematode population causing diseases at nursery stage.

3. Controlled environmental conditions:

This includes green house, polyhouses, tunnels *etc.* These are framed structures covered with a transparent or translucent material which provide protection for crop and create environment for growing crops even either during off or pre or postponement of season. The green houses are generally of three types *i.e.,* high cost green houses with full automation, medium cost green houses with partial automation and low cost poly houses or naturally ventilated poly houses (NVPH). Though, high cost green houses are ideally relates to PF, yet the scope of NVPH is more in India due to fragmented land holding, poor financial status of farmers, inadequate marketing linkages *etc.* Some work related to NVPH has been done at PFDC, SWMRU, NAU, Navsari. The technologies generated are popularized among the farmers through demonstration on farmers' fields (table 5).

Table 5: Results of NVPH demonstrations on farmers' fields

District	Taluka	No. villages	No. of farmers	Crop taken	Yield increase (%)	Net income realized (Rs/50 m^2 /season)
Surat	Kamrej Mandavi	5	5	**Seedlings** (Brinjal, chilies, tomato, cauliflower, cabbage, marigold, gaillardia, chrysanthemum, capsicum, onion, papaya etc.)	100-225	5000-25000
Valsad	Valsad	9	11			
Navsari	Chikhali Jalalpore Navsari	7	8			
Tapi	Vyara	4	11			
Narmada	Dediyapada Sagbara	3	7	**Leafy veg.** (Palak, coriander, green garlic, fenugreek, lettuce, tandalja etc.)	50-150	4000-8000
The Dangs	Ahwa	6	14			
Total: 7	10	34	56			
				Crops		
				Rose	45-60	4000-15000
				Tomato	50-75	7500-10000

Farmers' opinion about the NVPH technologies

- Uniform and better germination as compared to conventional practices.
- Early maturity and harvesting of crop in polyhouse as compared to open field.
- During monsoon, it is possible to take seedlings/leafy vegetables and thereby getting higher prices, while in open field it is not possible due to heavy rain.
- Seedlings grown under green house perform better than open field nursery.
- Due to healthy look of crop, the produce grown inside the polyhouse fetches higher price as compared to open field.
- Income of the farmers increased due to polyhouse cultivation.
- Damage to structure in the event of torrential rain during monsoon.

4. Organic farming:

Organic farming is a system of agriculture that uses natural and biodegradable input while deliberately avoiding the use of synthetic fertilizer. It mainly includes the use of vermicompost, manures, biofertilizers, animal husbandry, greenleaf manures, biological management and crop rotation. It is claimed that organic farming improves quality of produce as well as soil health.

5. Precise space utilization:

a. High density planting: HDP is a system of planting more number of plants than optimum through manipulation of tree size. It accommodates 500-100000 plants/ha. Following methods are applied to control the size of plants in HDP:

- Genetically dwarf scion cultivars
- Dwarfing rootstock and interstock
- Training and pruning
- Use of growth retardants

b. Inercropping in drip irrigated crops: It is restricted due to localized application of water and nutrients. However, in order to utilize the space more efficiently in wider spaced but initially slow growing crops like banana under drip irrigation, short duration crops like onion, garlic, cauliflower *etc.,* can be grown successfully. One such study conducted at Navsari (Gujarat) empathetically proved that in drip irrigated banana planted during October, onion was found more remunerative than garlic and cauliflower (Anon., 2010-11). This study further indicated that in between two rows of banana (2.4 m), if one additional lateral *i.e.* at

1.2 m is provided, then 58-60 per cent area can be covered with onion. This option recorded highest fruit yield of 108 t/ha. Further, there is no need to apply any additional volume of water for intercrop separately (Table 6). In other words, it increases the land equivalent ratio (LER) and water use efficiency (WUE).

Table 6: Banana equivalent yield (t/ha) under different treatments

Situations	Banana equivalent yield (t/ha)			
	Intercrops (C)			Mean
	Onion	Garlic	Cauliflower	
A_1	100.90	98.02	92.74	**97.22**
A_2	107.66	103.94	95.38	**102.33**
A_3	116.95	107.34	101.80	**108.70**
Mean	**108.50**	**103.10**	**96.64**	
Sole	**85.70**			
	S.Em±		**CD @ 5%**	**CV %**
C	2.07		6.04	7
A	2.07		6.04	
C x A	4.14		NS	

Note: Area under Intercrop (A):

A_1 = 25 - 27 % (without lateral shifting *i.e.* along the row)

A_2 = 33 % (with lateral shifting *i.e.* between two rows)

A_3 = 58-60 % ($A_1 + A_2$)

c. Meadow orcharding: It is also known as ultra high density planting system. It accommodates 20000-100000 plants/ha. It is literally called as grass land. In order to maintain trees in the ideal shape form, severe top pruning is practiced similar to mowing of grassland.

6. Micro propagation:

Micro propagation refers to the production of plant from very small plant parts, tissues or cells, grown aseptically in a test tube or containers under controlled environment.

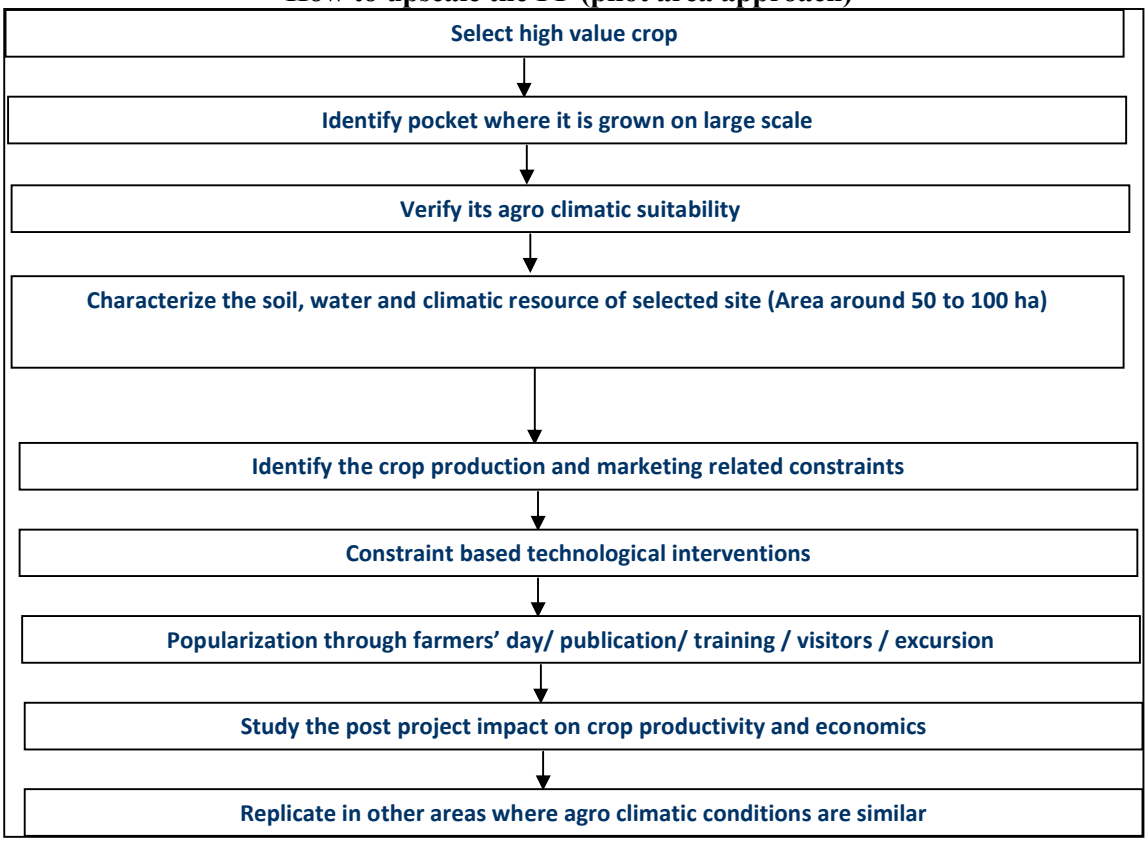
7. Integrated pest management (IPM):

A pest management practices which involves a mixture of practices such as use of resistant varieties, managing the natural predators of pest, cultural practices and judicious application of pesticides to control the pests.

8. Integrated nutrient management (INM):

INM is application of nutrients from organics as well as inorganic sources. It aims at improving physio-chemical and biological properties of the soil.

How to upscale the PF (pilot area approach)



Conclusions:

Based on the experiences so far, true PF in India is distant dream due to various constraints. However, there is good scope of increasing input use efficiency through adoption of some components of PF individually and more so through combination of drip + fertigation + mulching.

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5. Comparative study of Hybrid Tea rose (*Rosa hybrida* L.) cv. 'Gladiator'

Patil, S. J.; Patel, N. L.; Gaikwad, S. S. and Aklade, S. A.

Source: Haryana J. Horti. Sci. (2010), Vol.;39, Page:223

Abstract

The present investigation entitled "Comparative study of Hybrid Tea rose (*Rosa hybrida* L.) cv. 'Gladiator'" was conducted during summer season in the year 2003-2004 and 2004-2005 at Regional Horticultural Research Station, Navsari Agricultural University, Navsari. Both the situations (50 per cent shadenet and open field) had significant effect on growth, yield and quality of flowers. The vigorous plant growth in respect of plant spread, number of leaves and shoots per plant, fresh and dry weight of pruned shoots was observed under open field except plant height and total leaf area which were maximum in under shadenet. Shadenet induced early flowering in rose. The rose plants grown under shadenet had superior quality of flowers with more longevity while, the production of flowers was maximum with more vase life under open field situation. Better color of flowers of rose was obtained under 50 per cent shadenet as compared to open field condition.

Keywords: Gladiator, Shadenet and open field

The *Rosa hybrida* L. is a vigorous shrub with mild fragrance, foliage soft gray-green, the leaflet oval and usually three to five leaves. Branches very prickly with hooked. Flowers are of large size, blaming red color of cv. 'Gladiator'. Considering the importance of rose as cut flower and its popularity, it was thought worthwhile to carryout research as on use of 50 per cent shade net.

Material and methods

A field experiment was conducted during the year 2003 and 2004 at Regional Horticultural Research Station, Navsari Agricultural University, Navsari with two main situations *viz.,* shadenet (50% S_1) and open field (S_2). The experimental soil belongs to Vertic Ustochrepts with low organic carbon, medium in available P and high in available K content. The soils are non calcareous in nature with no problem of salinity and sodicity.

Results and discussion

Effect on growth attributes

The results (Table-1) of the present investigation revealed that growth attributes *viz.,* plant spread, leaves per plant, shoots per plant, fresh and dry weight of pruned shoots were noticed maximum under open field situation (S_2) while plant height and total leaf area per plant was maximum under shadenet (S_1). Increased growth attributes under open field situation might be due to the fact that rose plant requires bright sunlight for the whole day or atleast 6 hours (Biswas, 1984) which increased photosynthesis and ultimately increased growth. Increase in plant height might be due to rise in temperature inside the covering (Malhotra and Kumar, 2000).

Days required for first flower bud initiation after pruning

It is evident from the results presented in Table 1 indicated that the days required for first flower bud initiation were significantly minimum

(25.78 days) under shadenet (S_1). This might be due to the fact that light is the most important factor influencing the growth and flowering in rose (Moe, 1972; Cockshull and Hand, 1975). Very high light intensity has been reported to be injurious to the rose plant. Fifty per cent shadenet reduces the intensity of natural light by 50 per cent in the summer months (Malhotra and Kumar, 2000).

Quality parameters

The results indicated that flower quality parameters like length and girth of flower stalk, flower diameter and number of petals per flower were noticed maximum under shadenet situation. This might be due to higher carbohydrates in plants maintained in 50 per cent shading due to decrease in respiration rate and these carbohydrates were used in the production of cut blooms and this energy was distributed among other flower parts on the plant (Malhotra and Kumar, 2000). It is clear from results that the shadenet (S_1) recorded maximum fresh weight of petals per flower, which might be due to more number of petals per flower produced under shadenet. A perusal of the data revealed that the fresh weight of flower was significantly maximum in shadenet situation (S_1). This might be due to bigger sized flower, more number of petals and higher petal weight of flower under shadenet.

Longevity and Vase life of flower (days)

The results showed that shadenet situation (S_1) significantly increased the longevity of flower. This might be due to longer and thick stalk, bigger sized flower and more number of petals containing more carbohydrates and due to 50 per cent shadenet, which decreased respiration rate (Malhotra and Kumar, 2000).

It is evident from the results that open field situation (S_2) had significantly increased the vase life of flower. This might be due to that open field flowers were much stronger than those of shadenet flowers.

Yield

The results of the present investigation indicated that number of flowers per plant and number of flowers per hectare were the maximum in open field situation (S_2). This might be due to the fact that the total number of leaves were maximum under open field which accumulated more carbohydrates and were directly used for increasing the number of flowers. This might be also due to more number of shoots in open field which had produced more number of flowers.

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Table-1: Effect of different situations on average growth, flowering, quality and yield of Hybrid Tea rose (*Rosa hybrida* L.) cv. 'Gladiator' (Pooled)

Observations	50 % shade net (S_1)	Open field (S_2)	S.Em. ±	CD at 5%	CV %
Plant height (cm)	99.78	89.61	0.79	2.88	6.47
E-W Plant spread (cm)	71.33	72.18	0.89	NS	8.51
N-S Plant spread (cm)	69.27	69.91	0.55	NS	4.34
Leaves per plant	345.32	350.84	84.87	NS	15.98
Total leaf area per plant (cm^2)	22329.03	21280.20	763.78	2998.48	17.16
Shoots per plant	26.89	32.24	5.83	NS	15.29
Fresh wt. of pruned shoots per plant (g)	91.917	101.313	2.513	9.136	9.44
Dry wt. of pruned shoots per plant (g)	28.633	32.642	0.734	2.88	11.74
Initiation of first flower bud after pruning (days)	25.78	29.33	0.25	0.91	7.03
Flower stalk length (cm)	61.44	38.98	0.83	3.05	11.85
Flower stalk girth (cm)	1.75	1.60	0.024	0.09	10.92
Flower diameter (cm)	11.63	8.42	0.22	0.81	17.13
Fresh wt. of flower (g)	10.160	7.607	0.205	0.745	17.81
Petals per flower	38.43	30.17	0.60	2.21	13.55
Fresh wt. of petals per flower (g)	8.281	5.611	0.162	0.59	17.12
Longevity of flower (days)	18.24	12.85	0.31	1.13	15.23
Vase life of flower (days)	6.83	9.14	0.17	0.64	16.96
Flowers per hectare	65839	67575	16353.15	NS	14.41

6. Moisture regimes and fertigation study in gladiolus var. 'Hybrid Psittacinus'

S. A. Aklade; B. M. Solia; S. J. Patil; A. P. Patel and R. G.Patil

Source: Haryana J. Horti. Sci. (2010), Vol.;39, Page:293

Abstract

A field experiment with gladiolus as a test crop was conducted at Soil and Water Management Farm, Navsari Agricultural University, Navsari (Gujarat). The treatments comprised of three levels of each of different moisture regimes (0.6, 0.8 and 1.0 PEF) and fertigation (60, 80 and 100 % RDF of N & K) under drip along with surface method of irrigation as control (1.0 IW/CPE, 60 mm depth, RDF=100 %) in RBD during 2008-09. The spike yields and corms/plant were affected significantly due to irrigation and fertigation levels. The treatment receiving irrigation at 0.8 PEF + fertigation @ 100 per cent of RDF (N & K) recorded significantly higher spike yields (5.67 lakh spikes/ha) and corms/plant (3.67 corms/plant) as compared to other treatments. However, in both the cases it was at par with 0.8 PEF + fertigation @ 80 per cent RDF, 1.0 PEF + fertigation @ 80 per cent RDF and 1.0 PEF + fertigation @ 100 per cent RDF. The results of present study suggest that farmers can achieve higher yield along with 20 per cent of water and fertilizer saving by adopting drip and fertigation practices in gladiolus grown under South Gujarat conditions.

Keywords: Gladiolus, drip and fertigation

Gladiolus (*Gladiolus sp.*) takes its name from the Latin word 'gladius' meaning a 'Sword' on account of the sword like shape of its foliage. Gladiolus is an herbaceous plant, belongings to the family *Iridaceae*, order *Liliales* and class *Monocotyledonae*. In India, gladiolus had become one of the most important commercial crops. Out of various factors responsible for successful growing of gladiolus, application of manures and fertilizers is one of the most important factors. Fertilizer requirement for rapidly growing plants vary with climatic conditions, irrigation and soil type. The work related to water and nutrient requirement of gladiolus under South Gujarat conditions is not available and hence, the present experiment was carried out.

Material and Methods

The present study was conducted at Soil and Water Management Research Unit Farm, Navsari Agricultural University, Navsari during 2008 – 09. The experiment was laid out in Randomized Block Design with ten treatment combinations comprising three levels each of moisture regimes (I_1=0.6, I_2=0.8 and I_3=1.0 PEF) and fertigation (F_1=60, F_2=80 and F_3=100 % of recommended dose of NPK: 200:100:100 NPK ha^{-1}) under drip along with surface method as control (1.0 IW/CPE, 60 mm depth, RDF=100 %). The selected healthy corms were planted on raised bed at a spacing of 20 x 20 x 60 cm as paired row planting. The soil of the experimental field was clay in texture and neutral in reaction. The drip system was operated at 1.2 kg/cm^2 pressure wherein laterals were placed at 120 cm and drippers at 60 cm spacing with 3 lph discharge rate. Whereas fertigation (N & K only) was done at 7 days interval in 10 equal splits starting after one of planting and whole amount of P was applied as basal at the time of planting. The various

observations on growth, flowering and yield were recorded and analyzed statistically.

Results and Discussion

Plant height and number of sprouts per plant were affected significantly due to the different levels of moisture regimes and fertigation. Significantly higher plant height (54.43 cm) and number of sprout/plant (3.60) were recorded with I_2F_3 treatment, which was at par with I_2F_2 for plant height and for number of sprout it was on same bar with I_3F_3, I_3F_2, and I_2F_2. Whereas, the minimum values of both the characters were recorded with control. The vigour of the plant indicated the response of the treatments on growth assessing characters and this could be due to better supply of nutrients and water in the root zone by fertigation. Apart from this, continuous moist root zone under drip irrigation also improves nutrient availability, which ultimately might have increased the growth of gladiolus. The earlier workers *viz*., More *et al*. (1994) on clay soil of Parbhani in tinda, Anon., (1999) on clay soil of Navsari in rigde gourd, Birbal *et al*. (2003) on loamy soil of Hisar in bottle gourd and Singandhupe *et al*. (2003) on laterite soil of Bhubneshwar in pointed gourd had also reported the benefits of drip irrigation.

The results presented in table1 further revealed that the length of spike as well as that of rachis and number of florets per spike were found significantly affected due different levels of moisture regimes and fertigation. Among these, the treatment I_3F_2 recorded the maximum spike length of 61.72 cm, rachis length of 44.85 cm and more number of florets (11.70) per spike. However, it was found to be at par with I_3F_3, I_2F_3, I_1F_3, I_2F_2 and I_1F_2 treatment which were superior over control for above parameters. In fact, water requirement is quite high before pre and post flowering period of gladiolus thus, the water requirement might have not been fulfilled at lower moisture regime. Similar observations were also reported by Bastug *et al*. (2006) Begum *et al*. (2007) and Patil (2009) in gladiolus. Fertigation @ 80 per cent RDF (F_2) showed superiority over the treatment receiving fertigation @ 60 and 100 per cent RDF (F_1 and F_3) for these characters. The results of present study indicated that higher level of fertigation failed to produce beneficial effect on number of florets per spike, length of spike and rachis, seems to be due to induction of dormancy caused by higher dose of fertilizers. Between the two methods, drip performed better than surface irrigation, as reflected by WUE of 989 spikes/ha-mm with 0.8 PEF as against 511 spikes/ha-mm with surface method of irrigation.

Numbers of spikes (3.4/plant and 5.67 lakhs/hectare) were found to be significantly higher with I_2F_3 which was statistically at par with all the treatments except I_1F_1 and control. The corm yield was also influenced significantly, where in I_2F_3 registered significantly more number of corms per plant (3.6). However, it was at par with I_3F_3, I_3F_2, I_2F_2 and I_1F_3 treatments. The beneficial effects of drip irrigation and fertigation on growth and floral parameters ultimately reflected on the spike and corm yields of gladiolus. This is evident from the significant positive association observed between spike and corm yield with growth as well as floral parameters (Table-3). From WUE point of view, it was found to decrease with increase in PEF. This indicate that increase in number of spike is not proportionate

with the increase in volume of water applied (Table-2). Because of this, spike yield recorded at 0.8 or 1.0 PEF were at par with each other. In other words, one can save about 25 per cent water without any compromise in spike yield.

Table-1: **Effect of moisture regimes and fertigation on growth, flowering and yield of gladiolus cv. Hybrid Psittacinus**

Treatments	Plant height at 75 DAP (cm)	No. of sprouts per plant at 60 DAP	Length of spike (cm)	Length of rachis (cm)	No. of florets per spike	No. of spikes per plant	No. of spikes per ha (lakh)	No. of corms per plant
I_1F_1	46.96	2.65	53.58	38.21	10.05	2.88	4.79	3.1
I_1F_2	49.93	2.80	56.90	39.70	10.20	2.90	4.83	3.25
I_1F_3	50.32	2.88	58.91	42.57	10.60	3.10	5.17	3.4
I_2F_1	48.87	3.08	55.09	38.53	9.75	3.08	5.12	3.15
I_2F_2	52.08	3.18	57.13	40.47	10.80	3.35	5.58	3.35
I_2F_3	54.43	3.60	60.38	42.95	11.10	3.40	5.67	3.6
I_3F_1	49.24	3.13	55.04	39.30	10.40	2.95	4.92	3.1
I_3F_2	50.06	3.25	61.72	44.85	11.70	3.18	5.29	3.35
I_3F_3	49.75	3.45	61.40	44.21	11.25	3.13	5.21	3.55
Control	42.96	2.40	46.65	32.23	9.25	2.23	3.71	2.75
SEm ±	1.401	0.169	2.178	2.105	0.439	0.096	0.161	0.116
CD at 5 %	4.098	0.494	6.373	6.157	1.286	0.282	0.470	0.338
CV %	5.7	11.1	7.7	10.4	8.4	6.4	6.4	7.1

DAP = Days after planting

Table-2: Water applied and saving under different treatments in gladiolus cv. Hybrid Psittacinus

Treatments	Water applied (mm)	WUE (No. of spikes/ha-mm)	Water saving (%) over control
Drip (PEF)			
0.6	444	1110	39
0.8	552	989	24
1.0	660	779	9
Surface	726	511	---

WUE = Water use efficiency

Table-3: Correlation between number of spikes and corms per plant with growth as well as floral characters of gladiolus (n=40)

SN	Characters	Correlation (r)	
		No. of spikes/plant	No. of corms/plant
1	Plant height at 75 DAP (cm)	0.68**	0.53**
2	No. of sprouts per plant at 60 DAP	0.56**	0.62**
3	Length of spike (cm)	0.63**	0.53**
4	Length of rachis (cm)	0.49**	0.32*
5	No. of florets per spike	0.50**	0.40*

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7. Drip and mulching studies in papaya under South Gujarat conditions

B. M. Solia; S. J. Patil; S. A. Aklade; A. P. Patel and R. G. Patil

Source: Haryana J. Horti. Sci. (2010), Vol.;39, Page:198

Abstract

An experiment was conducted on "Drip and mulching studies in papaya under South Gujarat conditions" with three treatments *viz.,* i) drip @ 0.6 PEF, ii) drip @ 0.6 PEF + black plastic mulch @ 20 % area coverage (50 micron) and iii) control (1.0 IW/CPE, 60 mm depth) in RBD with eight replications at Soil and Water Management Farm, Navsari Agricultural University, Navsari (Gujarat) during 2006-07 and 2007-08. The results indicated that the growth parameters *viz.*, stem girth, number of leaves, length of leaf, width of leaf and petiole length were affected significantly due to different treatments during individual year as well as in pooled analysis. Significantly higher values were recorded with drip + black plastic mulch (BPM) treatment which was at par with drip alone. Adoption of drip + BPM recorded significantly higher fruit yield and number of fruits per plant in both the years as well as in pooled as compared to control. However, it was at par with drip alone in all the cases. The extent of increase in fruit yield was 40 and 27 per cent with drip + BPM and drip alone, respectively over control. This was also reflected on WUE as it was more than double over control.

Keywords: Papaya, drip and black plastic mulch

Papaya is an important fruit crop of Gujarat. It is grown in most of the districts of state and area under this crop is increasing steadily every year. In Gujarat papaya is grown in 11192 ha with the productivity of 40 t/ha (Anon., 2008). Though, the productivity is more than the national average of 24.3 t/ha., yet there is good scope of increasing productivity of papaya by adopting drip irrigation, fertigation and mulching. This has been already proved in different crops and the extent of increase in yield varies from 12 to 32 per cent along with considerable saving in water and fertilizer (Savani *et al.*, 2005) Further, mulching along with drip has been found to be more beneficial in increasing productivity (Solia *et al.,* 2009). As the information related to these aspects under South Gujarat conditions is scanty, present experiment was conducted.

Material and Methods

An experiment was conducted with three treatments *viz.,* i) drip @ 0.6 PEF, ii) drip @ 0.6 PEF + black plastic mulch @ 20 % area coverage (50 micron) and iii) control (1.0 IW/CPE, 60 mm depth) in RBD with eight replications at Soil and Water Management Farm, Navsari Agricultural University, Navsari (Gujarat) during 2006-07 and 2007-08. The experimental soil belongs to Vertic Ustochrepts with low in organic carbon, medium in available P and high in available K content. Papaya var. Taiwan 786 was panted at 2.5 X 2.5 m. The lateral lines of 16 mm diameter with online two drippers (8 lph) were placed 30 cm away on either side of papaya plant. The system was operated at 1.2 kg/cm^2 pressure at an alternate day.

Results and Discussion

Biometric: The results presented in table 1 indicate that the growth parameters *viz.,* stem girth, number of leaves, lenght of leaf, width of leaf and petiole length were affected significantly due to different treatments. Significantly higher values were recorded with drip + BPM treatment which was at par with drip alone.

Table 1: Effect of different treatments on growth parameters of papaya (pooled of 2 years)

Treatment	Plant height (m)	Stem girth (cm)	No. of leaves/ plant	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)
1) Drip	1.81	44.18	26.42	86.43	85.06	82.25
2) Drip + BPM	1.82	45.43	31.74	86.99	87.12	85.24
3) Control	1.66	39.31	22.81	79.87	78.00	75.37
S.Em ±	0.03	0.64	0.84	1.34	1.178	1.69
CD @ 5 %	NS	1.84	2.42	3.87	3.40	3.37
CV (%)	5.00	6.00	12.00	7.00	6.00	6.00
Y x T	NS	NS	NS	NS	NS	NS

Yield: Similarly, the results presented in table 2 indicate that the number of papaya fruits per plant and yield (t/ha) were significantly influenced due to treatments during individual year as well as in pooled analysis also. Adoption of drip + black plastic mulch (BPM) recorded significantly higher values of number of fruits/plant (50. 69) and fruit yield (66.70 t/ha) compared to control. Though, the yield difference between drip + BPM and drip alone was not significant in number of fruits/plant, yet fruit yield was significantly more with drip + BPM than drip alone (60.60 t/ha).

Table 2: Effect of different treatments on number of fruits per plant and fruit yield (t/ha) of papaya

Treatment	Number of fruits per plant			Yield (t/ha)		
	2006-07	2007-08	Pooled	2006-07	2007-08	Pooled
1) Drip	47.50	46.00	46.75	59.51	61.70	60.60
2) Drip + BPM	51.62	49.75	50.69	67.70	65.80	66.70
3) Control	38.62	38.12	38.37	48.40	47.30	47.80
S.Em ±	2.10	2.62	1.62	2.90	1.77	1.67
CD @ 5%	6.38	7.96	4.70	8.80	5.38	4.80
CV (%)	12.97	16.64	14.87	14.0	8.61	11.60
Y x T	NS	NS	NS	NS	NS	NS

Soil respiration and temperature: In order to understand the reasons of increase in yield under mulching as well as drip method of irrigation, soil respiration in terms of CO_2 content in soil air and temperature were recorded during March and April months using LC pro photosynthesis analysis system (Bio Scientific, London). The data presented in table 3 indicate that month wise not much variation in CO_2 content in atmosphere was noticed. However, difference between atmosphere and soil CO_2 content was tremendous with respect to drip and mulching treatment. The CO_2 content was maximum in drip + mulch (830 vpm) followed by drip alone (464.5 vpm) and it was least in control (317.0 vpm). The higher CO_2 content in soil air indicate more

microbial activites which ultimately enhances nutrient availability in soil. This seems to be the reason for higher fruit yield of papaya recorded with drip + mulch in comparison to drip alone and control. The beneficial effect of drip as well as mulch has also been reported in different crops like banana and rose (Anon., 2009).

Table 3: Effect of different treatments on content of CO_2 in soil

Treatment	CO_2 Concentration (vpm)						
	March 2008			April 2008			Mean of diff.
	Soil	Atmo.	Diff.	Soil	Atmo.	Diff.	
Drip	954	403	551	788	410	378	464.5
Drip + BPM	1198	406	792	1276	408	868	830.0
Control	766	401	365	681	412	269	317.0

Note: Soil temperature did not show much variation (27.5^0 to 29.9^0C) and hence not reported here.

Economics: Considering the fruit yield and cost of cultivation, gross income and net profit were calculated (Table 4). Among all the treatments drip + BPM treatment recorded higher net profit of Rs. 2,66,770. Not only this, adoption of drip + BPM also enhanced the WUE by 131 per cent over control. Based on the findings of present study, drip + BPM is economically viable technology in papaya grown under South Gujarat conditions.

Table 4: Economics of papaya under different treatments

SN	Details	Treatments		
		Drip	Drip + BPM	Control
1	Fixed cost (Rs/ha)	15700	27700	2500
2	Variable cost (Rs/ha)	41530	40530	44530
3	Total cost (Rs/ha)	57230	68230	47030
4	Yield (t/ha) Yield increase over control (%)	61 27	67 40	48 -
5	Gross income (Rs/ha)	305000	335000	240000
6	Net realization (Rs/ha)	247770	266770	192970
7	Additional net realization over control	54800	73800	-
8	Net realization only due to mulch	-	19000	-
9	Water applied (mm)	828	828	1380
10	Water saving (%)	40	40	-
11	WUE (kg/ha.mm)	74	81	35

Note: Papaya selling price = Rs. 5 /kg

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8. Precision Farming Technologies for the Tribal Areas of South Gujarat

B. M. Solia, S. L. Pawar, A. P. Patel, M. A. Patel, S. A. Aklade, S. J. Patil and R. G. Patil

Source: National Seminar on Sustainable Development of Tribal Area at KVK , WAgai (2009), Page: 21

Gujarat is blessed with diversified natural resources. This is evident from arid climate in North and North-West, semi arid climate in Saurashtra and middle and sub-humid in Southern parts of Gujarat. The rainfall varies between less than 200 mm in Kutch to more than 2000 mm in the Dangs. This is also true for soil types, as sandy in northern parts, sandy loam to loam in middle, calcareous in Saurashtra and clay in Southern parts of the state. From physiography point of view, Gujarat is divided into three units *i.e.,* coastal area on the West, mid plains including Saurashtra and hilly as well as undulating topography in the East. The eastern hilly belt consists of parts of Banasantha, Sabarkantha, Panchmahals, Godhra, Narmada, Tapi, Valsad and the Dangs districts. In this region, the soils are shallow in depth and poor in fertility mainly due to erosion caused by rain water. Though, rainfall is high, yet this region experiences water scarcity situation during winter and summer seasons. This is mainly due to run-off of rain water caused by of undulating topography. Rain water harvesting and storage is difficult due to highly permeable lower strata of the soils. Because of these conditions, tribal farmers are able to grow single crops only during monsoon season, that too with very low productivity. Under the circumstances, tribal population of this region is resorted to migration to mid plain during winter and summer seasons. In order to mitigate the problem of migration, there is need to take soil and water conservation measures on large scale and enable the farmers to grow minimum two crops in a year.

In this context, state government, central government, other agencies, NGOs *etc.* are implementing number of programs related to soil and water conservations on watershed basis, check dam, animal husbandry, fruit and vegetable producing units, marketing network, cold storage, improved agro techniques, improved seed, introduction of new crops, organic farming etc. For these programs, Navsari Agricultural University, Navsari is providing technical back up through its regional stations *viz.,* Main Rice Research Stattion and KVK, Vyara, Hill Millet Research Station and KVK, Waghai, Niger Research Station, Vanarashi and Fruit Research Station, Paria. Based on the status of natural resources in the eastern hilly region of South Gujarat, the technologies *viz.*, naturally ventilated poly house (NVPH), low tunnel and low energy drip (LED) developed by PFDC, SWMRU, NAU, Navsari are worth to implement for improving the financial status of the tribal farmers. Adoption of these technologies will not only improve the financial status, but will also provide food and nutrition security to the trbal population.

Technology development

The precision farming technologies developed by Soil and Water Management Research Unit, NAU, Navsari for tribal areas are discussed here.

NVPH/Low tunnel: These technologies offer an excellent opportunity to grow high value crops during off-season with maximum input use efficiency. This has special relevance in the present day scenario of shrinking land and water resources. At PFDC, Navsari few technologies related to protected cultivation have been developed (Table 1). These comprise of basically low cost (naturally ventilated) and medium cost (fan pad cooling system) green houses, in which former type does not require power supply or cooling mechanism. Hence, more emphasis has been given to NVPH. The results presented in table 1 clearly suggest that as compared to open field conditions, not only yield increase by 2-3 folds but considerable water saving was also achieved. Similarly, very simple and affordable technology *viz*., low tunnel particularly for paddy nursery raising and some vegetable crops was tested and found promising under South Gujarat region.

Table1: Protected cultivation technologies

Type	Crop	Yield increase (%)
Naturally ventilated poly house (NVPH)	Vegetable nursery	185
	Leafy vegetables	50
	Tomato	159
Fan and pad cooling system poly house (MCGH)	Leafy vegetables	290
	Rose	52
Low tunnel	Palak (Geotextiles/ transparent white plastic sheet)	104 /73
	Green coriander (Geotextiles/ transparent yellow plastic sheet)	98 / 65
	Paddy nursery (Transparent plastic)	For hastening growth of seedlings during winter

LED: Drip method of irrigation is becoming popular particularly with resource rich farmers growing highly remunerative crops. This is because of the reason that initial cost of drip irrigation system is very high. But for resource poor farmers located in water scarcity area, drip is a distant dream. So there is good scope to develop low energy drip system for such farmers. Hence, study was taken up for standardization of low energy drip irrigation method for kitchen garden and hilly areas at PFDC farm, NAU, Navsari.

As in this experiment, two crops were tested with varying coverage of area, it was necessary to convert biomass production in terms of money per 5000 liter water. However, yield of chillies was extremely poor and hence its economic was not calculated. This is being small area, economics has been calculated with and with out labour charges. The corresponding net income for A_4 treatment is Rs.232 and Rs.387 with BCR of 1:1.21 and 1:6.27 (Table 2). This empathetically suggests that brinjal crop is highly remunerative under low energy drip system.

Based on above, the farmers of hilly areas/ kitchen garden of South Gujarat are advised to irrigate brinjal crop through low energy drip system in about 25 to 35 m^2 area using 35 litre of water per day for realizing a net profit of about Rs. 300 to 350. The crop should be planted in paired rows (0.6 x 0.6 x 1.2 m) with row length of 4.8 m. Such 4 sets of paired rows can be made in the available area. The lateral should be placed in between two rows and micro tube should be placed at 60 cm apart *i.e*., each micro tube (Diameter: 1.2mm, Length: 7.5 mm) cover two plants. The system should be operated on alternate day.

Table 2: Economics of brinjal crop under low energy drip system

SN	Particulars	A_1 (8.64m^2)	A_2 (17.28m^2)	A_3 (25.92m^2)	A_4 (34.56m^2)
1	Fixed cost (Rs/area covered)	16	19	22	25
2	Variable cost (Rs/area covered)				
	a. With hired labour	86	112	140	167
	b. With family labour	13	21	29	37
3	Total cost (Rs/area covered)				
	a. With hired labour	102	131	162	192
	b. With family labour	29	40	51	62
4	Yield (kg/area covered)	31.63	41.23	56.37	70.61
5	Total income (Rs/area covered)	190	247	338	424
6	Net income (Rs/area covered)				
	a. With hired labour	88	116	176	232
	b. With family labour	177	226	309	387
7	Quantity of water applied (lit/area covered)	5015	5095	5195	5255
9	WUE (g/l)	6.25	8.04	10.84	13.38
10	CBR				
	a. With hired labour	1 : 0.86	1 : 0.89	1 : 1.09	1 : 1.21
	b. With family labour	1 : 4.00	1 : 5.65	1 : 6.06	1 : 6.27

Note: Selling price of brinjal (Rs 6.0 /kg)

Transfer of technologies

After development of location and crop specific technologies, it is of prime importance to transfer these technologies to the farmers in effective ways. The activities of demonstrations and trainings being done for popularizing these technologies among the farmers are briefly given below.

Demonstrations: NVPH with LED technologies are being demonstrated (Nos. 56) in tribal areas of South Gujarat and results obtained so far in farmers' fields are encouraging (Table 3). In all cases, there is tremendous increase in yield which ultimately reflected on net income realized by the farmers.

Table 3. : Results of NVPH demonstrations on farmers' fields

District	Taluka	No. villages	No. of farmers	Crop taken	Yield increase (%)	Net income realized (Rs/50 m^2 /season)
Surat	Kamrej Mandavi	5	5	**Seedlings** (Brinjal, chilies, tomato, cauliflower, cabbage, marigold, gaillardia, chrysanthemum, capsicum, onion, papaya)	**100-225**	**5000-25000**
Valsad	Valsad	9	11			
Navsari	Chikhali Jalalpore Navsari	7	8			
Tapi	Vyara	4	11			
Narmada	Dediyapada Sagbara	3	7	**Leafy veg.** (Palak, coriander, green garlic, fenugreek, lettuce, tandalja)	**50-150**	**4000-8000**
The Dangs	Ahwa	6	14			
				Crops		
				Rose	45-60	4000-15000
				Tomato	50-75	7500-10000
Total: 7	**10**	**34**	**56**			

Trainings*:* As these technologies are skill oriented, it is essential to train the stakeholders for technical know-how. The training is given to the farmers either directly or through government departments / cooperatives/NGOs *etc.* (Table 4).

Table 4: Details regarding training programs conducted

Year	No. of training programs organized		Total	No. of trainees
	Farmers	Extension worker		
1999-00	4	2	6	122
2000-01	9	2	11	266
2001-02	8	1	9	236
2002-03	13	1	14	340
2003-04	14	5	19	496
2004-05	14	4	18	480
2005-06	20	1	21	250
2006-07	19	4	23	680
2007-08	19	6	25	725
2008-09	23	13	36	1317
2009-10	38	4	31	1445
Total	**181**	**43**	**224**	**6872**

Farmers' opinion about the technologies:

- Uniform and better germination as compared to conventional practice.
- Early maturity and harvesting of crop in poly house as compared to open field.
- During monsoon, it is possible to take seedlings/leafy vegetables and thereby getting higher prices, while in open field it is not possible due to heavy rain.
- Seedlings grown under green house perform better than open field nursery.
- Due to healthy look of crop, the produce grown inside the poly house fetch higher price as compared to open field.
- Income of the farmers increased due to poly house cultivation.
- Damage to structure in the event of torrential rain during monsoon.

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9. Large Scale Adoption of Drip and Sprinkler in Potato – A Survey

M. S. Malik, B. M. Solia, S. J. Patil, A. P. Patel, S. A. Aklade and R. G. Patil

Source: J. of Indian Society of Costal Agri Resources (2010), Vol.: 28, Page: 40

Abstract

In order to get feed back from the farmers who have adopted micro irrigation system in potato on large scale (800 ha) in Deesa taluka of Banaskantha district of Gujarat, present survey was conducted. The information thus collected from 53 farmers was tabulated and interpreted. Farmers opined that sprinkler system is better than drip system in potato. The results of the crop specific survey revealed that in the opinion of the farmers saving in water was 50 -75 %. While 67 and 38 per cent farmers said that labour saving was in between 50 - 75 % and less than 50 % in drip and sprinkler, respectively. It was also observed from the survey that 6 and 36 % higher yield of potato with drip and sprinkler was obtained in comparison to surface method, respectively. Major problems faced by potato growers with drip and sprinkler were poor quality of micro irrigation system material supplied (valves, GI-PVC fittings, pressure gauge *etc.*) (39 %), poor technical knowledge about MIS (36 %) and poor after sell service (30 %). It is also observed from the survey that plant geometry followed by the farmers was not uniform.

***(Key words:** Drip, Sprinkler, Potato)*

Gujarat is one of the potato growing states in the country. Potato crop is grown predominantly on light textured soils of North and Central regions of the state. This crop occupies around 40,000 ha area in the state with total production of 978 t with an average productivity of about 25 t/ha. Though, farmers have started adopting drip and sprinkler methods of irrigation in potato, yet the potential benefits are not fully realized by them. This is because of the reasons that they are over irrigating the crop and in most of the cases fertigation is not adopted. On account of this, the main purpose of water saving through use of either drip or sprinkler is defeated. Not only this, but the logic behind providing subsidy for drip and sprinkler is also lost. For realizing the full benefits of these systems, it is necessary to get feed back from the farmers about MIS. The adoption of drip/sprinkler on such a large scale (800 ha) in particular pocket that too in single crop of potato is not a common phenomenon. In order to get feedback from the farmers, a survey of farmers who adopted MIS in potato was planned.

Material and Methods

In all, 53 farmers consisting of 37 sprinkler, 6 drip and 10 flood were randomly selected from the target area of Deesa taluka (Banaskantha district) for present survey. A well designed module of questionnaire was prepared and tested prior to survey. Each selected farmer was personally interview by investigator with the help of questionnaire. Subsequently, the information thus obtained was tabulated and where ever required per cent values were computed for interpretation purpose.

Results and Discussion

General information

Land holding: The area identified for survey is in Deesa taluka of Banaskantha district where majority of the farmers (94 %) are adopting agriculture + animal husbandry farming system. From land holding point of view, small and medium farmers constitute 87 per cent while large farmers are only 13 per cent (Table 1).

Table 1. Distribution of farmers according to farming system and land holding (n=53)

SN	Parameters	Category	No. of farmers	%
1.	**Farming system**	Farming alone	0	0
		Farming + Animal Husbandry	50	94
		Farming + Service	0	0
		Farming + Business	1	2
		Farming + Animal Husbandry + Service	1	2
		Farming + Animal Husbandry + Business	1	2
2	**Land holding**	< 2 ha (Small)	22	42
		2-4 ha (Marginal)	24	45
		> 4 ha (Large)	7	13

Soil type: The data show that the soils of the area are mostly sandy and loamy without any problem of soil salinity (Table 2).

Table 2. Distribution of farmers according to soil type, soil testing and soil salinity (n=53)

SN	Parameters	Category	No. of farmers	%
1.	**Type of soil**	Medium black	2	4
		Loamy	36	68
		Sandy	15	28
2.	**Soil testing**	Yes	31	58
		No	22	42
3.	**Soil salinity**	Yes	0	0
		No	53	100

Water source: It is clear from the data that the major source of irrigation water is personal tube wells (83 %) followed by participatory tube wells (9 %) and wells (6 %). About 50 % of the farmers have analyzed their soil and water samples. This implies that there is awareness among the farmers about importance of soil and water testing (Table 3).

Table 3. Distribution of farmers according to irrigation source and water analysis (n=53)

SN	Parameters	Category	No. of farmers	%
1.	**Irrigation source**	Well	3	6
		Tube well personal	44	83
		Tube well participatory	5	9
		Canal	1	2
2.	**Water analysis**	Yes	24	45
		No	29	55

Benefits of MIS: In this pocket, drip/sprinkler system was adopted by the farmers mostly during 2005-07. The adoption of drip/sprinkler on such a large scale (800 ha) in particular pocket and that too in single crop of potato is really astonishing. The basic motive behind this is to save irrigation water (100 %), improve quality of produce (83 %), increase yield (79 %) and reduce labour cost (48 %). Some of the farmers were of the opinion that adoption of drip/sprinkler will mitigate the problem of receding water table also (Table 4).

Table 4. Distribution of farmers based on the motive behind adopting drip/sprinkler n=42*

SN	Motive	No. of farmers	%	Rank
1.	**Efficient use of water**	42	100	I
2.	**Improving quality of produce**	35	83	II
3.	**Increasing yield**	33	79	III
4.	**Reducing labour cost**	20	48	IV
5.	**Mitigate receding water table problem**	16	38	V
6.	**Protecting soil deterioration due to use of poor quality water**	2	5	VI
7.	**Save crop during drought**	1	2	VII

* One farmer did not reply.

Improvement in quality of produce: In order to understand the benefits of the system, farmers were specifically asked about improvement in quality of produce, early maturity and getting premium prices. The response in this regard by the farmers was positive as 44, 5 and 44 per cent of them realized the benefit of improvement in quality, early maturity and premium price, respectively, due to adoption of drip/sprinkler system (Table 5).

Table 5. Distribution of farmers based on the quality improvement, maturity and premium price realized by the farmers n= 43

SN	Parameters	Category	No. of farmers	%
1.	Quality improvement	Yes	19	44
		No	2	5
		Not replied	22	51
2.	Early maturity	Yes	2	5
		No	15	35
		Not replied	26	60
3.	Premium price	Yes	19	44
		No	1	2
		Not replied	23	53

Water and labour saving: It is apparent from the data (Table 6) that majority of the drip and sprinkler owners felt that saving in water was 50 -75 %. While 67 per cent farmers said that labour saving was in between 50 and 75 % in drip. In sprinkler, 38 per cent of the farmers were of the opinion that labour saving was less than 50 % (Table 6).

Table 6. Water and labour saving experienced by the potato growers of North Gujarat n=43

SN	Parameters	Category	Drip (N = 6)		Sprinkler (N = 37)	
			No. of farmers	%	No. of farmers	%
1.	Water saving	75 %	0	0	0	0
		50 – 75 %	6	100	27	73
		< 50 %	0	0	7	19
		Not replied	0	0	3	8
2.	Labour saving	75 %	0	0	1	3
		50 – 75 %	4	67	5	13
		< 50 %	2	33	14	38
		Not replied	0	0	17	46

MIS procurement: For procurement of the irrigation system, 67 per cent farmers availed the benefit of subsidy. Among the respondents, about 53 per cent of them procured the system through bank loan. This is interesting to note that about 33 to 47 per cent farmers have installed the system without taking advantage of either subsidy or bank loan (Table 7).

Table 7. Distribution of farmers based on availing subsidy and bank loan n=43

SN	Parameters	Category	No. of farmers	%
1.	Subsidy	Yes	29	67
		No	14	33
2.	Bank loan	Yes	23	53
		No	20	47

At the time of survey, majority of the farmers have adopted sprinkler in this area since 2006-07. Most of the sprinkler owners were growing potato with sprinkler first time indicate that farmers are not fully aware about the use of MIS. The yield data reported in table 8 were collected from few selected farmers in potato. These values clearly indicate the increase in yield with drip and more so with sprinkler method of irrigation as compared to

control. Though, farmers have adopted MIS, yet the volume of water applied is on higher side (20-30 %). This suggests that there is need to train the farmers about schedule of MIS so as to derive desired benefits of the system. However, this information is derived from single time survey which needs to be repeated after 2 or 3 years of adoption of MIS (Table 8). Similar benefits of drip have also been reported by Deshmukh and Nagare (1989) from Maharashtra, Rao (1989) from Tamil Nadu and Chaudhari (1995) and Timbadia *et al.* (2008) from Gujarat.

Table 8. Average yield and operating time of MIS by potato growers of North Gujarat

SN	Parameters	Drip	Sprinkler	Control
1.	**Average yield (t/ha)**	31 * (6)	39 (36)	29 (0)
2.	**Average net profit ('000 Rs/ha)**	52	96	51
3.	**Average water depth (mm/day)**	8 to 9	7 to 8	12 to 15

*( ) = data in parenthesis are per cent increase over control

Problems experienced by the MIS farmers

Apart the above information, it was tried to enlist the problems being experienced by the MIS farmers. This will enable to probe the causes of low adoption of MIS in crop like potato and also to take appropriate policy decision by the planner. Some of the major problems experienced by the farmers are listed below along with per cent of farmer.

- Damage to riser/lateral pipe mainly by squirrel (24 %)
- Poor after sell service (30 %)
- Poor technical knowledge about MIS (36 %)
- Poor quality of MIS material supplied (valves, GI-PVC fittings, pressure gauge *etc.*) (39 %)
- High initial investment in drip as compared to sprinkler (more than double).
- Uneven distribution of water in case of sprinkler (27 %).

Suggestions by the farmers:

Some of the important suggestions/indications given by the farmers' are given below.

- Sprinkler system is cheaper than drip system.
- Wilt problem in later stage of the crop is less under drip than sprinkler and flood methods of irrigation.
- Sprinkler system is more suitable than drip system for farmers following potato–groundnut cropping sequence.
- Drip system is tedious in handling as compared to sprinkler system.

Highlight of the survey:

- Planting geometry followed by the farmers was not uniform.
  Control: 55 x 7.5 cm, 45 x 7.5 cm
  Drip: 15 x 7.5 x 60 cm
  Sprinkler: 55 x 12.5 cm, 52.5 x 7.5 cm, 50 x 7.5 cm, 42.5 x 7.5 cm, 37.5 x 7.5 cm, 30 x 7.5 cm, 15 x 7.5 x 70 cm, 15 x 7.5 x 60 cm, 15 x 7.5 x 45 cm, 15 x 7.5 x 32.5 cm, 10 x 7.5 x 30 cm
- Poor technical knowledge about operation schedules and specification of MIS:
  - Discharge rate of sprinkler (None of the farmer was able to tell)
  - Operating time and pressure of sprinkler were not uniform among the farmers
  - Varying distance between two sprinklers
- Inadequate knowledge of fertigation schedule
- Difficulty in repairing and cleaning of sprinkler nozzles
- Some cases of drip, materials supplied was either excess or less
- Surrounding farmers are ready to install the MIS in potato after seeing the results of MIS

Conclusions

- In potato, sprinkler system is preferred over drip system in North Gujarat
- There is need to maintain recommended plant population
- There is need to train the farmers
- This survey needs to be repeated after 2/3 years

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10.Economics of Drip Irrigation in Sugarcane and Banana - A Survey

M. S. Malik, B. M. Solia, S. J. Patil, A. P. Patel, S. A. Aklade and R. G. Patil

Source: J. of Indian Society of Costal Agri Resources (2010), Vol.: 28, Page: 51

Abstract

Efforts are made by the state and centre governments to popularize the pressurized methods of irrigation among the farmers. In spite of all these efforts, the area under drip irrigation particularly in sugarcane and banana is not increasing at the expected rate. In order to assess the economic viability of drip irrigation system (DIS) with special reference to banana and sugarcane crops, a special survey was conducted covering whole of South Gujarat except The Dangs district. A standard questionnaire was formulated and 40 drip owners (22 banana + 18 sugarcane growers) were interviewed personally. The extent of net profit earned by the farmers with DIS was 55 % higher in sugarcane and that in banana it was almost doubled (93 %) as compared to conventional method of irrigation. The farmers have also mentioned DIS benefits like, water, fertilizer and labour charges saving to the tune of 36 to 45 %, 26 to 30 % and 47 %, respectively, along with early maturity (87 %) and improvement in quality (89-95 %) particularly in banana crop. The results of the survey also revealed that major problems experienced by the farmers were damage to DIS by rat and animal, poor after sell service, poor technical knowledge about DIS, poor quality of DIS material, non availability of power supply during day time, threat of burning in sugarcane and inspite of better quality of produce, drip owners are not getting premium price.

*(**Key words:** Drip, Sugarcane, Banana)*

For promoting micro irrigation in agriculture – horticulture sector, centre and state government are spending huge amount in terms of subsidy for the benefits of the farmers. The major objectives behind this are to save natural resources *viz.,* water, fertilizer, electricity *etc*. The GoG has set up a GGRC for implementation and monitoring the micro irrigation schemes in the state. As a result of this, GGRC has covered 165990 ha area under drip method of irrigation in Gujarat since its inception in 2005 (Raman, 2009). In spite of all these efforts, the area under drip irrigation particularly in sugarcane and banana is not increasing at the expected rate. In order to find out problems being faced by the banana and sugarcane farmers' in adopting drip irrigation, government has asked to conduct a survey. The basic idea behind this survey is to get feed back from the farmers and take appropriate policy decision for enhancing area under drip irrigation. Accordingly, a survey on economics of drip irrigation in sugarcane and banana for South Gujarat was conducted.

Material and Methods

In order to assess the economic viability of drip irrigation system (DIS) with special reference to banana and sugarcane crops, a special survey was conducted covering whole of South Gujarat except The Dangs district. In all, randomly selected 40 drip owners (22 banana + 18 sugarcane growers) were interviewed with the help of standard questionnaire.

Results and Discussion

Economics

Though, all the farmers expressed their concern about high initial investment in DIS, yet the extent of net profit earned by them with DIS was 55 % higher in sugarcane and that in banana it was almost doubled (93 %) as compared to conventional method of irrigation (Table 1). The magnitude of net profit realized by the sugarcane and banana farmers, empathetically proves the economic viability of DIS under farmers' fields situation. An

additional area of 5000 ha under DIS in sugarcane + banana crops since 2004-05 also substantiate the area expansion under DIS.

Benefit of DIS as per farmers' opinion

In addition to economical benefits of DIS, farmers have also credited the benefits *viz.,* water saving to the extent of 36 to 45 %, fertilizer saving to the tune of 26 to 30 %, saving in labour charges (47 %), induces early maturity in crops (70 %) (Table 2) and improves quality of produce particularly in banana (89-95 %) to DIS. Similar benefits of drip have also been reported by Deshmukh and Nagare (1989) from Maharashtra, Rao (1089) from Tamilnadu and Chaudhari (1995) and Timbadia *et al.*(2008) from Gujarat.

Problems experienced by the farmers

The major problems experienced by the farmers are: damage to DIS by rat/animal (56-59 %), poor after sell service (59-61 %), non availability of power supply during day time (20 %), poor technical knowledge about DIS of the farmers (56-59 %), poor quality of DIS material supplied mainly valves, GI-PVC fittings, pressure gauge *etc.* (56-68 %), threat of burning in sugarcane (28 %) and in spite of better quality of produce (89-95 %) drip owners are not getting premium price. In view of these problems, there is need to some policy decision like covering of sugarcane under insurance, realizing premium price *etc*.

Suggestions by the farmers

Some of the important suggestions given by the farmers' which may be considered before taking any policy decision(s) are: DIS should be designed on crop sequence basis rather than single crop, in the cases of small land holding, head unit of DIS needs to be shared by a group of farmers, farmers intending to install DIS should get electric connection on priority basis, GGRC should draft all the forms in Gujarati rather than in english, farmers installing DIS on rental land should also get benefit of subsidy and the benefits of early maturity induced by DIS in sugarcane is not realized by the farmers owing to delay in harvesting.

The conclusions emerged from the present survey are as below.

- The magnitude of net profit realized by the sugarcane and banana farmers empathetically proves the economic viability of DIS under farmers' fields situation.
- Some of the important suggestions given by the farmers based on their experiences may form basis for taking policy decisions by GoG as well as GoI.
- For enhancing know – how of the DIS, there is need to train the farmers.

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Table 1. Average yield and net profit obtained by the sugarcane and banana growers of South Gujarat

Crops	Average yield (t/ha)		Average net profits (Rs/ha)	
	Before drip	**After drip**	**Before drip**	**After drip**
Sugarcane	117	149 (27 %)	41698	65285 (55 %)
Banana	52	75 (44 %)	56178	108556 (93 %)

( ) = data in parenthesis are increase over before drip

Table 2. The benefits of drip irrigation realized by the sugarcane and banana growers of South Gujarat

Category	Sugarcane		Banana	
Improvements in quality of produce				
	No. of farmers	**%**	**No. of farmers**	**%**
Yes	13	72	22	100
No	5	28	0	0
Early maturity of crop				
Yes	11	61	17	77
No	7	39	5	23

11. Impact Analysis of Training Related to Plasticulture Application in Agriculture

M. S. Malik, B. M. Solia, S. J. Patil, A. P. Patel, S. A. Aklade and R. G. Patil

Source: J. of Indian Society of Costal Agri Resources (2010), Vol.: 28, Page: 56

Abstract

A survey was conducted for knowing the extent of adoption of technologies and feed back from the trainees, a set of standard questionnaire was circulated to 300 respondents by post. The farmers' were selected from all over the state. Out of 300 questionnaire, 52 were received back and the information thus obtained was tabulated and interpreted. In general, farmers opined that due to adoption of drip technology they could save water to the extent of 30 to 60 %, fertilizer saving to the tune of 25 to 40 % and saving in labour charges by 20 to 40 % along with induction of early maturity in crop and improvement in quality of produce. The results of the survey revealed that the major problems faced by the farmers were damage to riser/lateral pipe by rats/animals/squirrel, poor technical knowledge, poor after sell service, high initial investment and timely unavailability of spare parts. The pattern of adoption of technology is drip > drainage > sprinkler > green house = mulching. The extent of adoption of technology in different zone is South Gujarat > Kutch > North Gujarat > Saurashtra > middle Gujarat.

***(Key words:** Drip, Sprinkler, Green house, Drainage, Mulching)*

For promoting plasticultural technologies in agriculture and horticulture sectors, MoA, GoI, New Delhi through NCPAH established Precision Farming Development Centres (PFDC) across the country. Which envisages technology development and transfer to farmers fields. Under this project, annually about 25 trainings are organized covering different aspects of plasticulture. In order to assess the impact of these trainings on extent of adoption of technologies and feed back if any, present survey was taken up. The findings of the survey are presented here.

Material and Methods

PFDC, Soil and Water Management Research Unit, Navsari Agricultural University, Navsari organizes about 20-25 trainings annually on different aspects of soil and water management covering entire state. For this purpose, respondents were selected from the last five years trainings organized by PFDC, SWMRU, NAU, Navsari. For knowing the extent of adoption of technologies, feed back from the trainees *etc.*, a set of standard questionnaire was circulated to 300 respondents by post. The farmers were selected randomly from all over the state. Out of 300 questionnaire, 52 were received back and the information was tabulated and interpreted.

Results and Discussion

General information about the trainees

The information given in tables 1 and 2, clearly indicate that the training imparted covers all the aspects of soil and water management. This is evident from the per cent distribution of the respondents (Table 1). Among the land holding groups, majority of the respondents belong to medium (2-4 ha) and large (>4 ha) category. While in case of irrigation sources, well and tube well holders showed more interest in training than farmers of canal command (Table 2). This implies that there is good scope of bringing more area under MIS in lift command.

Table 1. Technology wise distribution of respondents received the training (n = 52)

SN	Technologies taught during the training	No. of respondents	% of respondent
1	**Drip**	23	44
2	**Sprinkler**	19	37
3	**Green house**	17	33
4	**Mulching**	12	23
5	**Drainage**	13	25

Table 2. Land holding and irrigation source wise distribution of respondents (n = 52)

SN	Parameters	Category	No. of respondents	% of respondent
1	**Land holding**	< 2 ha	8	15
		2 to 4 ha	15	29
		> 4 ha	14	27
		Not mentioned	15	29
2	**Irrigation source**	Well	18	35
		Tube well	25	48
		Canal	16	31
		Pond	1	2
		Others	2	4
		Not mentioned	5	10
3	**Irrigation quality**	Good	22	42
		Medium	21	40
		Poor	2	4
		Not mentioned	7	14

In order to see the response of trained farmers zone wise, the respondents were grouped zone wise (Table 3). It is interesting to note that farmers from South Gujarat have adopted drainage, drip and mulching technologies in relatively more than remaining zones. Further, water logging and salinity is a severe problem in Ukai-Kakrapar command, which might have compelled the farmers to adopt subsurface drainage technology in more numbers. An another important point here is that the total cost of drainage system is borne by the farmers. Though, there is no subsidy on drainage, yet the farmers are ready to adopt drainage technology. The next in order under South Gujarat zone is drip and mulch. Which could be due to more area under sugarcane and horticultural crops. The zonewise distribution of the farmers in drip and sprinkler technologies clearly suggest that adoption of type of system is governed by the cropping pattern of the zone.

Table 3. Zone wise technologies adopted by the trainees

Zone	Technology wise number of farmers					Total
	Drip	Sprinkler	Green house	Mulching	Drainage	
South Gujarat	5	-	1	4	10	**20 (51)***
Middle Gujarat	2	1	-	-	-	**3 (8)**
North Gujarat	2	3	-	-	-	**5 (13)**
Saurashtra	3	1	-	-	-	**4 (10)**
Kutchh	4	-	3	-	-	**7 (18)**
Total	**16 (41)***	**5 (13)**	**4 (10)**	**4 (10)**	**10 (26)**	**39**

( )* = percentage of farmers adopted one or more than one technology

Benefits realized by the farmers

The questionnaire was in such a way that at the end of survey, it was planned to get the information about the benefits realized by the farmers at field level. The magnitudes of benefits realized by the farmers are listed below.

- Water saving to the extent of 30 to 60 %
- Fertilizer saving to the tune of 25 to 40 %
- Saving in labour charges (20 to 40 %)
- Induces early maturity in crops like banana (85 %)
- Improves quality of produce in crops (90%)
- Premium price of the produce (46 %)
- Adoption of sprinkler is necessary to arrest receding water table particularly in North Gujarat (36 %)
- Adoption of SSD is necessary in water logged and saline soils of canal command area (38 %)

The results of present survey clearly brought out the fact that those who adopted different improved technologies could realize the advantages over conventional practices. Similar benefits of drip irrigation have also been reported by Thorat and Bhoite (1992) from Maharashtra and Chaudhari (1995) and Timbadia *et. al* (2008) from Gujarat.

Problems experienced in adoption of improved technologies

Apart from the benefits realized by the farmers, it was envisaged in survey to bring out the difficulties encountered by the farmers while adopting the technologies. The difficulties experienced by the farmers are: damage to riser/lateral pipe mainly by rats/animals/squirrel (54 %), poor after sell service (32 %), poor technical knowledge (57%), poor quality of material supplied (7 %), high initial investment (82 %), clogging of dripper (29 %) particularly in area with saline ground water, clogging of sprinkler (14 %), timely unavailability of spare parts (36%), DIS should be designed on crop sequence basis rather than single crop and difficulty in interculturing operation in drip irrigated crops.

Suggestions by the farmers

In order to know the suggestions of the farmers based on their experiences, few questions were included in the questionnaire. These suggestions may help in resolving the problems faced by them. So also these suggestions/opinion given by the respondents may be considered before formulating any appropriate strategy/policy for large adoption of these technologies in the state. The suggestions given by the farmers are: low cost and more durable technology should be developed, farmers should be self trained for repairing and maintenance in the technologies adopted by them, subsidy should be provided to drip beneficiaries for storage of their systems, planting geometry in drip should be in such a way that interculturing operation need not be interrupted, marketing strategy of drip irrigated products should be separate from that of marketing of general produce, there is need to have skilled manpower at village level, training should be arranged at village level, subsidy should be provided to small farmers for maximum benefits of SSD and fertigation equipments should be provided with sprinkler set.

Based on the survey data it is concluded that there is need to train the farmer in depth about improved technologies which he is going to adopt. In order to cover large number of farmers, there is need to do Human Resource Development minimum at district level through organizing trainers training program. The pattern of adoption of technology is drip > drainage > sprinkler > green house = mulching. The extent of adoption of technology in different zones is South Gujarat > Kutch > North Gujarat > Saurashtra > middle Gujarat

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12.Mulching Technologies for Increasing Crop Yield

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Source: WMRG, SWMRU, NAU, Navsari (2013), Chapter : 11, Page: 125

Mulching is an age old agricultural practice primarily done for moisture conservation under rainfed farming situation. Earlier, the materials used for covering the soil surface (mulching) were crop residue, leaf litter, pebbles, loose soil (interculturing) *etc.* However, with an advent of synthetic materials suitable for mulching, its applicability has become more versatile than ever before. This is because of the reason that apart from moisture conservation, synthetic mulch material also control weed effectively, restricts upward movement soluble salts in soil, moderates soil temperature, increases soil air CO_2 content, induces early maturity in crop, improves nutrient availability in soil, repels certain insects, improves quality of produce, increases interval period between two irrigation *etc.* So, synthetic mulch can also be used effectively under irrigated agriculture. Not only this, but it is best suited along with drip method of irrigation. Among the different synthetic materials like LDPE, HDPE, flexible PVC, woven and non woven fabrics *etc.,* LLDPE film (Linear low density polyethylene) is widely used for mulching in different crops and seasons. As far as color of the LLDPE film used for mulching is concerned, black color film (black plastic) was found to be the best in most the crops and seasons. Though, this film has added advantages over natural or organic mulch materials, it has two major limitations *viz.*, costly and not biodegradable.

For reducing the cost of mulch film, numbers of experiments with varying planting geometry were conducted in different agroclimatic conditions. Based on the results, adoption of paired row planting in field crops and 10-30 per cent canopy area coverage in plantation crop was found to be the more cost effective than 100 per cent coverage. Similarly, some private and government organizations are striving hard to develop biodegradable synthetic material which can be used as mulch film. In spite of cost and biodegradability limitations, commendable work using black plastic *vis-à-vis* grass or crop residue (sugarcane trash, paddy straw *etc.)* as mulch in different crops has been done under different agro climatic conditions of Gujarat. A brief account of such work done is discussed here.

Mulching in rainfed crops

Mulching with various materials was tried in variety of *kharif* and plantation crops at different locations in Gujarat. The results of some of the studies reported in table 1 clearly revealed that irrespective of crops and mulch material, the yield increase was ranging from 29 per cent with sugarcane trash mulch in pigeon pea at Achalia to 97 per cent with black plastic mulch in *ber* at Danti. As all the crops are long duration, mulching is laid only after cessation of monsoon. In spite of applying mulch even after half way of crop growth period, the mulching effect is quite remarkable. Irrespective of crops, the magnitude of increase in crop yield is more with black plastic than use of crop residue like, grass, castor shell, sugarcane trash *etc*. as mulch. In crops *viz.,* rainfed ber and cotton grown under coastal salt affected soil, the extent of increase in yield was more than 90 per cent. This was mainly due to lower concentration of soluble salts in root zone of the crop in mulching treatment than unmulched control. The reason for lower soluble salt content in root zone is due to restricted upward movement of soluble salts from lower layer to upper layer of soil due to mulching. Not only this, but in cotton fertilizer dose could also be reduced (Table 2). The yield of cotton obtained at 50 kg N/ha level with mulching was similar to that recorded with application of N @150 kg/ha to unmulched control.

Table 1: Mulching in rainfed crops

SN	Crop	Location (Zone)	Mulch material	Yield increase (%)	Remarks
1	Cotton	Danti (South Gujarat)	BP	93	• Coastal salt affected soil • Rainfall 1140 mm
			GM	60	
2	Cotton	Achhalia (South Gujarat)	SM	36	• Loamy soil • Rainfall 800-1000 mm
			GM	47	
			BP	58	
3	Castor	SK Nagar (North Gujarat)	Castor shell @ 15 t/ha	47	• Sandy soil • Low rainfall
4	Pigeon pea	Achhalia (South Gujarat)	SM	29	• Loamy soil • Rainfall 800 – 1000 mm
			GM	50	
			BP	78	
5	Brinjal	Achhalia (South Gujarat)	GM @ 5 t/ha	44	• Loamy soil • Rainfall 800 – 1000 mm
6	*Ber*	Danti (South Gujarat)	BP (40 % coverage)	97	• Coastal salt affected soil • Rainfall 1140 mm

Note: GM: Grass mulch**, SM:** Sugarcane trash mulch, **BP:** Black plastic mulch

Table 2: Seed cotton yield under different treatments of N and mulching (pooled over 3 year)

N level (kg/ha)	Mulching		
	BP	**GM**	**Control**
50	640	534	345
100	757	683	339
150	983	746	550

Mulching in irrigated crops

As like rainfed, mulching technologies were developed for both surface and drip methods of irrigation for different crops and agroecological situations of Gujarat. The mulching technologies developed are discussed separately for surface and drip methods of irrigation.

Surface irrigated crops: Under surface method of irrigation, mulch materials tested were different colored plastic and sugarcane trash. The results presented in table 3 indicate that irrespective of mulch type, the water saving varied between 20 per cent with sugarcane trash in marigold and as high as 54 per cent with grass mulch in sapota crop. Similarly, the extent of increase in yield was ranging from 10 per cent with sugarcane trash in sugarcane to 62 per cent with black plastic mulch in chilies. In crop like groundnut, to facilitate pegging of pods, a transparent plastic film of 7 micron thickness was tested which increased the pod yield by 50 per cent, however, it is necessary to follow effective weed control measure when transplant plastic mulch is used as mulch material. Similarly, this practice also enabled to prepond the sowing time of summer groundnut. Apart from water saving and yield increase, mulching with black plastic also control weed infestation up to 90 per cent. This reduces the labour required for weeding and thereby overall cost of cultivation. In crops like banana, mulching with black plastic also induces early maturity by about 20 to 30 days. This enables the banana growers to harvest the crop early which fetches higher price.

Table 3: Mulching in surface irrigated crops

SN	Crop	Location	Mulch material	Water saving (%)	Yield increase (%)	Remarks
1	Banana	Navsari	ST @ 15 t/ha	40	49	Due to BP early maturity up to 20-30 days
			BP	35	18	
2	Brinjal	Khandha	BP	-	27	80% Weed control
3	Chillies	Navsari	ST @ 10 t/ha	-	14	-
			BP	-	62	
4	Cauliflower	Navsari	BP	-	33	75% weed control
			GP	-	21	33% weed control
			YP	-	15	59% more weed infestation
5	Cotton	Navsari	BP	50	20	-
6	G'nut(S)	Navsari	7 micron TP	-	50	Sowing can be pre pond
7	Marigold	Navsari	ST @ 5 t/ha or BP	20	25	-
8	Pigeon pea	Navsari	ST @ 10 t/ha	-	47	-
9	Okra	Navsari	BP + 50 ppm NAA	-	25	90 % weed control
10	Sapota	Paria	GM (20% coverage)	54	25	-
11	S'cane	Khandha	ST @ 10 t/ha	34	10	-

Note: GP: Green plastic mulch**, YP:** Yellow plastic mulch, **TP:** Transparent plastic mulch, **BP**: Black plastic, **ST**: Sugarcane trash

Drip irrigated crops: In Gujarat, area under drip method of irrigation is increasing by lips and bound. Though, drip method of irrigation itself has number of advantages, yet these benefits can be further enhanced with the combined use of drip irrigation and mulching. The combined adoption of drip and mulch have added advantage of covering only wetted zone area *i.e.*, about 40 to 50 per cent as against the 100 per cent in surface method of irrigation. So, in drip + mulch technology, there is reduction in cost of mulch material. Under Precision Farming Development Centre, Soil and Water Management Research Unit, Navsari Agricultural University, Navsari, number of crops has been tested with drip + mulch technologies at research farm as well as at farmers' fields in few crops on large scale. These experiments and demonstrations were conducted by adopting paired row planting except banana and papaya crops which are basically planted at wider spacing of 2.4 m. Because of adoption of paired row planting, the system cost of drip is reduced almost by 40 per cent. Not only this, but it also facilitate laying of mulch easier than single row planted crop. In term of water saving, it varies between 20 and 50 per cent across the crops (Table 4). Similarly, the yield enhancement achieved was ranging from 7 per cent in castor with 20 to 30 days system off schedule starting from main spike emergence stage at Navsari (sub humid) to 71 per cent in castor at Achhalia (semi arid). In vegetable crops *viz.*, chilies and tomato, the increase in yield was of the order of 50-60 per cent. Apart from effective control of weed up to 90 per cent, adoption of drip + mulch technology could also save fertilizer up to 40 per cent without any reduction in yield. Based on results of drip + mulching technology, farmers have started using mulching with drip in crops like banana, papaya, water melon, vegetables *etc.*

Mulching technology for usage of saline water

In Gujarat, the ground water quality in general is poor and more so in coastal area. Under such situations, drip + mulch technology proved to be viable solution for achieving optimum yield level by using marginally poor quality waters for irrigation purpose. Otherwise, such waters can not be used for irrigation purpose by conventional method of irrigation even for salt tolerant crops. Some experiments were conducted on this aspect. Results of one such experiment is presented in table 5. The results clearly revealed that the brinjal fruit yield of 29.68 t/ha recorded with treatment receiving irrigation with best available water through drip was less than the mulching treatment irrigated with 8 dS/m salinity water (32.83 t/ha)through drip system. Even sugarcane trash mulch treatment irrigated with 8 dS/m salinity water also registered higher yield as compared to no mulch treatment irrigated with good quality water. Similarly, at each level of salinity, black plastic mulch showed superiority over sugarcane trash mulch as well as no mulch control.

In addition to yield, soil properties were also determined. The soil properties did not change much due to saline water used for irrigation particularly when mulching was applied to brinjal (*rabi*) followed by *kharif* transplanted paddy. This implies that adoption of drip + mulch in brinjal grown even on high clay containing soils enable to use poor quality water (up to 4-8 dS/m) for irrigation without much deleterious effect on soil properties.

Table 4: Mulching in drip irrigated crops

SN	Crop/spacing	Location	Mulch material	Water saving (%)	Yield increase (%)	Remarks
1	Banana (2.4 x 1.2 m)	Navsari	BP	40	13-21	20-40 % fertilizer saving
2	Bitter gourd (0.5 x 0.5 x 1.5 m)	Navsari	BP	40	18	Only with 25 % mulching area coverage
3	Brinjal (0.6 x 0.6 x 1.2 m)	Navsari	BP	40	40	20 % N saving
4	Bottle gourd (0.4 x 1.0 x 2.6 m)	SKNagar	Castor shell @ 5 t/ha	27	45	-
5	Castor (0.6 x 0.6 x 0.75 m)	Achhalia	BP	39	71	40 % N saving
6	Chillies (0.45 x 0.6 x 0.75 m)	Navsari	GP	34	59	-
7	Rose (1.0 x 1.0 x 2.0 m)	Navsari	BP	20	40	90 % weed control + 30 % fertilizer saving
8	Papaya (2.5 x 2.5 m)	Navsari	BP	40	20	Only with 20 % mulching area coverage
9	Smooth gourd (1.0 x 2.0 m)	Navsari	ST @ 2.5 t/ha	50	-	-
10	Tomato (0.50x 1.0 m)	Navsari	ST	45	57	40 % fertilizer saving
			BP	45	52	
11	Castor (0.6 x 0.6 x 1.2 m)	Navsari	BP	40	7	Stress 30 days after 50 per cent emergence of main spike stage

BP: Black plastic mulch**, ST:** Sugarcane trash mulch, **GP:** Green plastic mulch

Table 5: Fruit yield of brinjal (t/ha) under different treatments of irrigation on water salinity and mulching (Pooled over three years)

Treatment	Irrigation water salinity (dS/m)		
	BAW	4	8
No mulch	29.68	31.17	28.63
Sugarcane trash mulch	34.40	35.36	30.45
Black plastic mulch	37.28	36.06	32.83

BAW: Best available water

Mulching for improving soil health

In order to understand the reason for increase in yield due to mulching, in some experiment soil air CO_2 content which gives an idea about soil microbial activity along soil temperature were also recorded and the results are given in table 6. As the soil microbial activity is directly related to soil fertility, an increase in soil air CO_2 content indicates the improvement in soil fertility. At Precision Farming Development Centre, Soil and Water Management Research Unit, Navsari Agricultural University, Navsari banana and papaya crops were studied in details. In banana under drip irrigation, soil air CO_2 content was almost doubled in black plastic mulch as compared to unmulched control. This was also true to some extent in sugarcane trash mulch. Similarly, in papaya under drip irrigation, the soil air CO_2 content under drip alone was 378 vpm and that in drip + mulch it was 868 vpm as against the 269 vpm in unmulched + surface irrigation control. This suggests that the soil air CO_2 concentration was found to increase tremendously by adopting drip + mulch technology. This seems to be a major reason for increasing the crop yield.

Table 6: Mulching for improving soil health

SN	Crop	Mulch material	Yield increase (%)	Soil CO_2 Content (vpm)
1	Banana	BP + drip	21	683
		ST + drip	16	608
		Control	-	371
2	Papaya	Drip	28	378
		Drip + BP	40	868
		Control	-	269

Economics of mulching

Though, research and extension effort are being done by different institute, University, Govt. organizations, NGOs *etc*., yet mulching technology is not spread up to a desired level. This is mainly due to cost factor, high labour requirement for laying and removal, not biodegradable, availability of LLDPE film in local market, inadequate knowledge about mulching among the farmers *etc.* With respect to cost, it can be reduced to almost half by adopting paired row planting in crops like vegetable, flower, castor, pigeon pea, water melon *etc.* While in widely spaced crops (about 2.4 m row spacing) like banana, papaya *etc.* under drip method of irrigation, it is necessary to cover only wetting zone *i.e.,* around 40 to 50 per cent mulch coverage. This also helps in reducing the cost of mulching. Similarly, for minimizing labour requirement, mulch laying machines are now available in the market and becoming popular among the farmers. As on today, 100 per cent biodegradable films are not available in the market for which research is in progress. Further, for enhancing awareness among the farmers, there is need to scale up the training programs at state level.

The results reported in table 7 show that mulching with black plastic is economical even in crops like castor. The additional net income realized only due to mulching is around Rs. 15000/ha. While in high value crops like papaya, banana, rose, bitter gourd *etc.,* the

magnitude of increase in net realization varying between Rs. 28000/ha in bitter gourd and Rs. 40000/ha in banana. These data clearly suggest that adoption of mulching along with drip method of irrigation is found to be remunerative in most of the crop.

Table 7: Economics of mulching in different crops under drip method of irrigation

SN	Crop (Spacing)	Mulching material (area coverage %)	Yield increase (%)	Additional net realization over control (Rs/ha)	Net realization only due to mulch (Rs/ha)
1	Papaya (2.5 x 2.5 m)	BP (20)	40	73800	39000
2	Banana (2.4 x 1.2 m)	BP (50)	21	72000	40000
3	Rose (Pair:1x 1x 2 m)	BP (50)	40	78000	32000
4	Brinjal (Pair0.6 x 0.6 x 1.2 m)	BP (55)	32	40000	18000
5	Bitter gourd (Pair: 0.5 x 0.5 x 1.0 m)	BP (25)	18	65000	28000
6	Castor (Pair: 0.6 x 0.6 x 1.2 m)	BP (55)	22	35000	15000

13.Case Studies of Subsurface Drainage in Gujarat

N.G. Savani, A. M. Patil, R.G. Patel, B. M. Solia, and J. M. Patel

Source: SWMP pub. 21, NAU, Navsari (2009), Page: 66

In the quest of achieving self sufficiency in food grain production, Government of India has made concerted efforts in increasing area under irrigated agriculture by spending @ Rs. 1.25 to 1.50 lakh/ha. As a result of these efforts, our country has not only become self sufficient, but also started exporting the food grains. However, along with this success some ill effects like water logging, secondary salinization *etc*. are emerging and acquiring menacing proportion in most of the command areas. The existing command areas in Gujarat are not an exception to this phenomenon. The extent of areas with ground water table depth up to 1.5 m and between 1.5 to 3.0 m indicates the severity of the problems of water logging in the state (Table 1). On an average, 15 per cent of the total command area is water logged and another 24 per cent area is on the verge of water logging.

Table 1: Pre-monsoon water logged area in irrigation projects of Gujarat ('000 ha)

SN	Command	Depth of water table (m)		
		0-1.5	**1.5-3.0**	**0-3.0**
1	Kakarapar	11.46	66.00	77.46
2	Ukai (RBC)	2.15	21.06	23.21
3	Ukai (LBC)	2.04	13.08	15.12
4	Mahi (RBC)	3.94	28.80	32.74
5	Kadana (LBC)	0.80	5.05	5.85
6	Ghed area	69.00	--	69.00
7	Shetrunj (LBC)	0.02	5.54	5.56
	Total	**89.41 (15 %)**	**139.53 (24 %)**	**228.94 (39 %)**

Source : Gupta and Tyagi (1996)

Causes of water logging and salinity

Irrespective of the command area, the major causes of the water logging and secondary salinization with special reference to the South and middle Gujarat are heavy rainfall, aberration in suggested cropping pattern, ignorance of land irrigability classification, inadequate agricultural drainage net work, over irrigation, negligible conjunctive use, release of excess water, poor awareness about irrigated agriculture, mostly unlined canal network, cheaper availability of irrigation water, inclination towards high water consuming crops like paddy and sugarcane, aquatic weeds *etc*.

Among these, the predominant factors are climate and cropping pattern being adopted by the farmers. The monthly rainfall and evaporation values depicted in fig. 1 clearly show that in Ukai-Kakrapar Command (UKC) rainfall is invariably more than evaporation during monsoon season (June to September). The situation of water logging is further aggravated as high clay containing (> 40 %) soils occupying majority of the area of command.

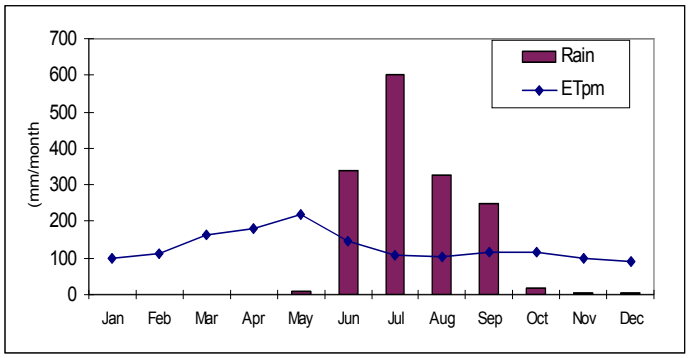

Fig. 1: Average monthly rainfall and evaporation of Bardoli taluka (part of UKC)

Source : IDNP Team (2003)

Another important factor is cropping pattern followed the farmers of command area. Due to the abundant availability of good quality irrigation water farmers not only tend to over irrigate but also change to the cultivation of water loving crops. In the Surat branch command area, the present cropping is dominated by high-water-consuming crops *viz*., sugarcane (61 %) and paddy (14 %). At UKC level also the same trend can be observed (Fig. 2). The main crops that were grown prior to commissioning of the project, *viz*., sorghum, pigeon pea; beans and gram, have been completely disappeared and rain fed rice varieties have been replaced by high yielding varieties that need more water.

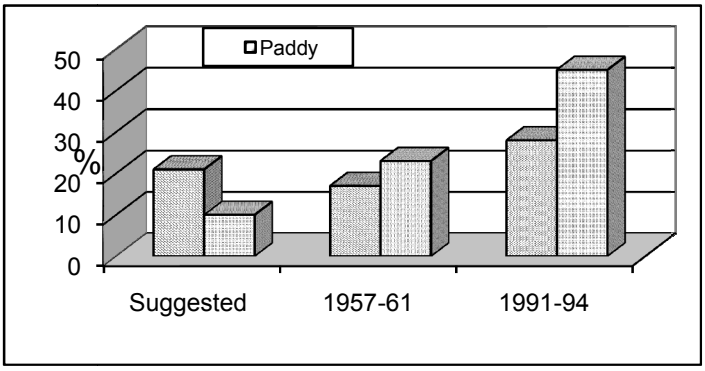

Fig. 2: Deviation from the suggested cropping pattern in Surat branch command

Source : IDNP Team (2003)

Prevalence of high water consuming crops in canal irrigated area not only bring water table up but also add considerable amount of soluble salts. The quantity of soluble salts added to soil at recommended level of irrigation with canal water per crop is varying between 0.5 t/ha in cotton and 3.6 t/ha in banana. The quantity of soluble salts added for soil increases almost 3 fold when slightly saline water (EC 1 dS/m) is used for irrigating the same crops (Table 2).

Table 2: Salts added to the soil through irrigation per season

Crops	Recommended irrigation			Salt added (t/ha/crop)		
	No. of irrigation	Depth (mm)	Total (mm/crop)	Canal	Ground water	
				0.3 dS/m	1 dS/m	2 dS/m
Sugarcane	18	80	1500	2.9	9.6	19.2
Paddy (S)	15	80	1200	2.3	7.7	15.4
Banana	24	80	1920	3.6	11.9	23.8
Okra (S)	13	60	780	1.5	5.0	10.0
Cotton	4	70	280	0.5	1.8	3.6

Source : IDNP Team (2003)

Ill effects of water logging and salinity

The cultivation of paddy and sugarcane continuously for years together has caused water logging and salinity problems which adversely affected the productivity of crops in UKC. The values depicted in fig.3 substantiate this statement that when exchangeable sodium percentage (ESP) exceeds 8, there is significant reduction in the cane yield. This is also true for effect of water logging on cane yield (Table 3). Irrespective of varieties, cane yield was tended to decline by about 5 per cent with rise in water table by every 25 cm over 200 cm water table depth.

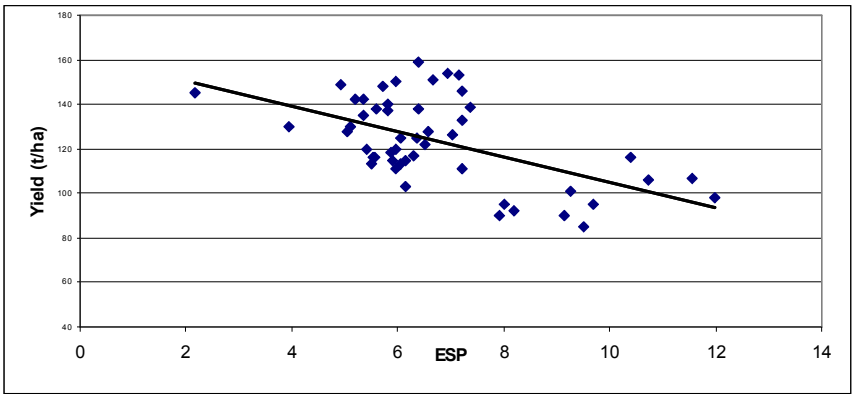

Fig. 3: Relationship between ESP and cane yield Patil *et al.* (2004)

Table 3: Estimated cane yield and per cent reduction in cane yield in relation to water table

SN	Water table (cm)	Estimated yield (t/ha)	% decrease in yield over 200 cm deep water table	
			Cumulative	Incremental
1	25	82.5	34.4	7.0
2	50	88.7	29.5	5.8
3	75	94.2	24.6	6.7
4	100	101.0	19.6	5.9
5	125	107.3	14.7	5.5
6	150	113.5	9.8	5.1
7	175	119.6	4.9	4.9
8	200	125.8	--	--

Case studies

1) Considering the severity and extent of water logging and secondary salinization problems in UKC, Soil and Water Management Research Unit, NAU (formerly GAU), Navsari conducted studies on subsurface drainage in 56 ha block at the farmers' fields situated in the jurisdiction of Chalthan Sugar Factory, Chalthan during 1984-85 to 1991-92. After installation of subsurface drainage, paddy and sugarcane yields were higher as compared to pre drainage yields. The pH and EC values also showed a decreasing trend with the progress of time after drainage.

2) Similarly, WALMI, Anand (middle Gujarat) also conducted pilot scale demonstration of subsurface drainage technology in Mahi Right Bank Canal Command during 1990-91. The soils were extremely saline and water logged and the area was almost lying barren. After installation of subsurface drainage, paddy crop was grown and yield level of 2 to 3 t/ ha was achieved.

3) Subsequently, for testing and demonstrating the drainage need on larger scale for controlling water logging and soil salinity, a collaborative project with ILRI, The Netherlands was approved by ICAR, Government of India with Navsari as one of the network centers and CSSRI, Karnal as the coordinating center. Under this project, two pilot areas were selected in UKC. The important characteristics of both the pilot areas are given in table 4. The distinct difference between both the pilot areas was cropping intensity *i.e.,* in Segwa it was 116 per cent and only 48 per cent in Sisodara. This was mainly because of severity of water logging and salinity problems were more in Sisodra than in Segwa. The cropping intensity of 48 per cent in Sisodra suggests presence of barren land in pilot area.

Table 4: Important characteristics of pilot areas

SN	Particulars	Pilot area	
		Segwa	Sisodra
1	Taluka/ district	Kamrej/ Surat	Ankleshwar/Bharuch
2	Climate	Sub humid	Semi arid
3	Branch/ minor	Surat branch/ Segwa minor	Kosamba branch/ Pandvai minor
4	Size of pilot area (ha)	188	169
5	Cropping intensity (%)	116	48
6	Major crops	Sugarcane, paddy	Sugarcane, paddy
7	Major constraints	Water logging and initiation of salinization	Extreme water logging and high salinity/sodicity
8	Source off irrigation water (ha)		
	- Canal	76	76
	- Well alone	37	--
	- Drain	4	--
	- Conjunctive use	26	--

Source : IDNP Team (2003)

Drainage design

After completion of pre project survey and analysis of drainage related parameters of soil, drainage design details were worked out and system installation work was initiated during 1998. The system details are presented in table 5.

Table 5: Information about drainage system installed

Particulars	Segwa				Sisodara	
	Singular pipe drains (m)	Area (ha)	Composite pipe drains (m)	Area (ha)	Open drains (m)	Area (ha)
Drain depth/ spacing	0.9/ 30	4.2	1.2/ 30	2.6	0.8/ 30	2.0
	0.9/ 45	5.6	1.2/ 45	5.7	0.8/ 60	14.0
	0.9/ 60	5.4	1.2/ 60	4.6		
Installation method	M	--	M + E	--	M	--
Envelop	None	--	Some	--	--	--
Amendment	None	--	Some	--	--	--
Total area (ha)		**15.2**		**12.9**		**16.0**

M= Manual, M + E= Manual + excavator Source : IDNP Team (2003)

At Segwa pilot site, singular and composite closed subsurface drainage (CSSD) systems were installed at 30, 45 and 60 m spacing with and without amendment and envelop. In all, 28.1 ha area was brought under CSSD in phased manner. While at Sisodra, only open subsurface drainage (OSSD) was laid out in16 ha area with 30 and 60 m drain spacing. Both these pilot areas were monitored vigorously for soil, drain water, ground water level and crop yield parameters.

Monitoring

After installation of CSSD in Segwa pilot area, salinity and sodicity parameters of the soil were monitored periodically. The soluble salt content in soil (0 – 90 cm) under CSSD was declined from initial value of about 4.0 dS/m in 1998 to 1.0 dS/m in 2002 (Fig. 4). Similar by sodicity was also tended to decline after installation of CSSD system at Segwa (Fig.5).

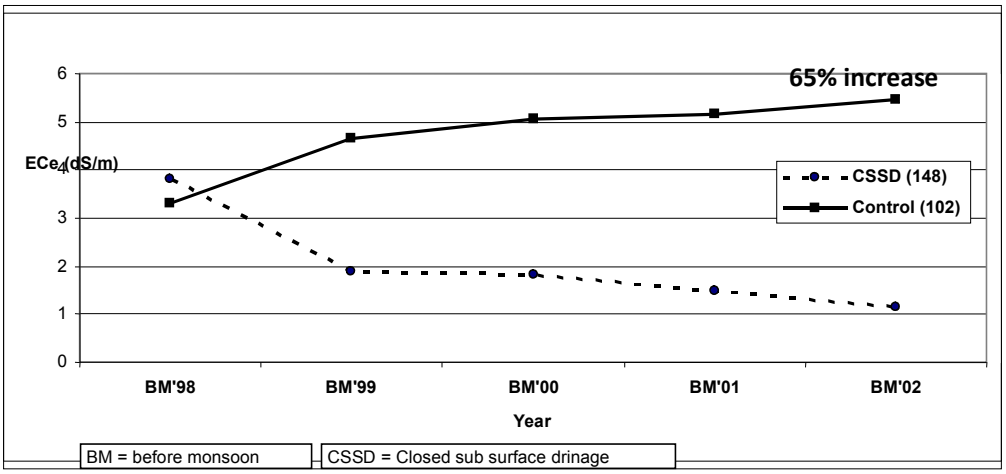

Fig. 4 : Periodical changes in soil salinity under CSSD and control blocks

Source : IDNP Team (2003)

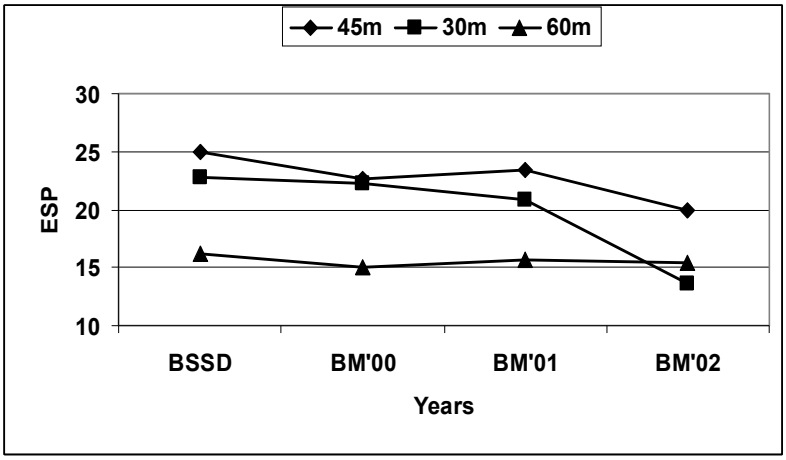

Fig. 5: Periodical changes in soil sodicity under different drain spacing of CSSD (Segwa)

Source : IDNP Team (2003)

The values of quality parameters of drain water depicted in fig. 6 revealed that with progress of time EC, SAR and RSC showed declining trend. Looking to the reduction in salinity and sodicity parameters of drain water after first year of CSSD installation indicate that drain water can be used safely for irrigation.

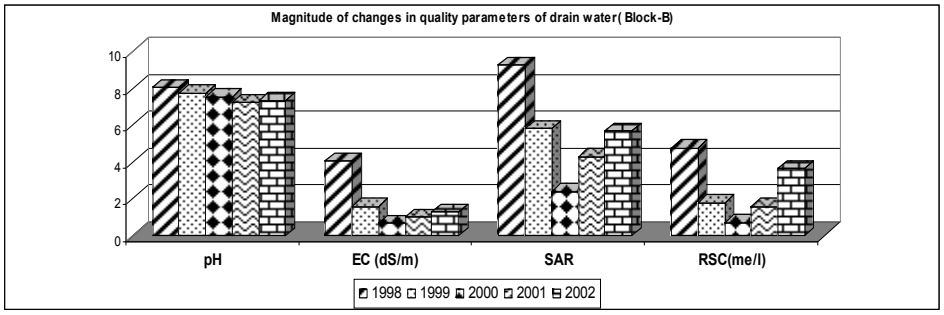

Fig. 5: Periodical changes in quality parameters of drain water

Source : IDNP Team (2003)

Apart from decrease in soil salinity and sodicity, on annual basis ground water table level was lowered down by 0.15 to 0.33 m in subsurface drainage blocks (Table 6). This was reflected positively, as the yield of sugarcane was increased by 44, 31 and 5 per cent with 30, 45 and 60 m drain spacing, respectively over control. In case of OSSD, the grain yield of paddy was increased by three folds.

Table 6: Effect of drainage on crop yield and water table

Particulars	Yield (t/ha)	% increase in yield	Water table (m bgl)		
			Pre	Post	Difference
Sugarcane (Segwa)	**CSSD**				
Control	80	-	0.35	0.35	0.00
30 m drain spacing	115	44	0.53	0.74	0.21
45 m drain spacing	105	31	0.32	0.46	0.14
60 m drain spacing	84	05	0.53	0.72	0.19
Paddy (Sisodara)	**OSSD**				
Control	0.6	-	-	-	-
OSSD	1.8	200	0.55	0.88	0.33

bgl = below ground level Source : IDNP Team (2003)

Economics

Considering the cost installation of CSSD and OSSD along crop yields, economics was computed for both the type of system at different spacings. In view of economic viability of the system, drain spacing of 45 m for CSSD was recommended and details are given in table 7. The benefit : cost ratio of 1.7, internal rate of return of 58 per cent and pay back period of 2 – 3 years empathetically establishes the techno economical viability of CSSD.

Table 7: Economics of singular system CSSD (45 drain spacing)

SN	Particulars	Control plots	Drained plots
1.	Cost of installation (Rs./ha)	-	20,400.00
2.	Cost of cultivation (Rs./ha)	31,386.00	41,143.00
3.	Yield (t/ha)	78	105
4.	Gross income (Rs./ha)	63,555.00	85,500.00
5.	Benefit : Cost ratio	-	1.7
6.	Internal rate of return	-	58
7.	Pay back period (years)	-	2 - 3

Source : IDNP Team (2003)

Impact of the project

Having been convinced by seeing the perceptible increase in crop yields and improvement in soil physical conditions on large scale in farmers' fields, they have started adopting drainage technology by bearing 100 per cent cost of the system under the technical guidance of Soil and Water Management Research Unit, NAU, Navsari. After completion of Indo-Dutch Network Project in 2003, about 36 farmers have installed CSSD/OSSD system covering about 55 ha area in South Gujarat (Anon., 2007).

These farmers have cultivated variety of crops in CSSD/OSSD field and they observed tremendous increase (40-45 %) in yield. They also experienced that fields are reaching to *vapsa* condition quickly thereby facilitating interculturing which control weeds and provide aeration to growing crop. Though, the area is only 55 ha, yet it shows the impact of drainage pilot area. The reasons for slow pace of adoption of drainage technology are: unavailability of corrugated PVC pipes in small quantity, high initial investment, and effluent disposal problem in inter-locked fields and in some cases absence of natural *nalla*.

Strategy for increasing adoption rate of drainage technology:-

1. Delineation of severely water logged and salt affected areas in the canal command.
2. Create awareness about subsidy scheme of land reclamation among the farmers.
3. Drainage needs to be adopted on community basis.
4. Participation of sugar co-operative needs to be intensified.
5. Establishment of drainage company at state level *i.e.* on the line of GGRC for micro irrigation.

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14. Prediction of fruit yield of banana using stem girth and yield attributes

Patil, S. J., Solia, B. M. and Patil, R. G.

Source: Green Farming J. (2010), Vol.: 1, Page: 219

Abstract

Banana being fruit of common man its consumption is increasing day by day and consequently the area under this crop which increased from 4.66 lakh ha during the year 2001-02 to 6.04 lakh ha during the year2006-07 (Anon., 2008). Because of varietal improvement and improved cultural practices, the yield of banana is also showing increasing trend. This is evident from the increase in productivity of banana at national level from 30.50 t/ha during the year 2001-02 to 34.77 t/ha during the year 2006-07 (Anon., 2008). Due to increase in area as well as productivity of banana, it is necessary to have sound marketing strategy, otherwise the economy of banana will distort. In order to plan sound marketing strategy, it is rather essential to have approximate estimate of fruit yield well in advance.

Material and method

For this purpose, present study was conducted using banana variety Grand Naine. The crop was planted in 1.5 X 1.5 m geometry and mulched with 50 micron black plastic in one block (19.5 X 30 m) and sugarcane trash in another block (19.5 X 30 m). All other recommended practices were followed during entire crop growth period. The stem girth was measured at lower (10 cm above ground), upper (10 cm below leaves) and middle (centre of lower and upper girth) portion of the pseudostem six month after planting. Similarly, yield attributes *viz.*, bunch length, number of hands and fingers per bunch, length and girth of fruit and yield were recorded at the time of harvesting. These observations were used for computing correlation and developing regression equations (Panse and Sukhatme, 1967).

Result and discussion

The simple correlation coefficient values reported in table 1 clearly indicate that banana fruit yield was associated positively and significantly with stem girth (lower, middle and upper), bunch length, number of hands per bunch and number of fingers per bunch. While, it was not so in the cases of finger length and girth. In view of highly significant correlation between fruit yield and girth recorded at lower, middle and upper points of pseudostem, individual girth wise linear regression equations were computed. Among these, the girth measured at 10 cm above ground level (lower) showed better fit (R^2=0.323) than middle (R^2=0.247) and upper point (R^2=0.189) girth.

Table-1: Correlation coefficient (r) of yield and yield attributes of banana cv. Grand Naine

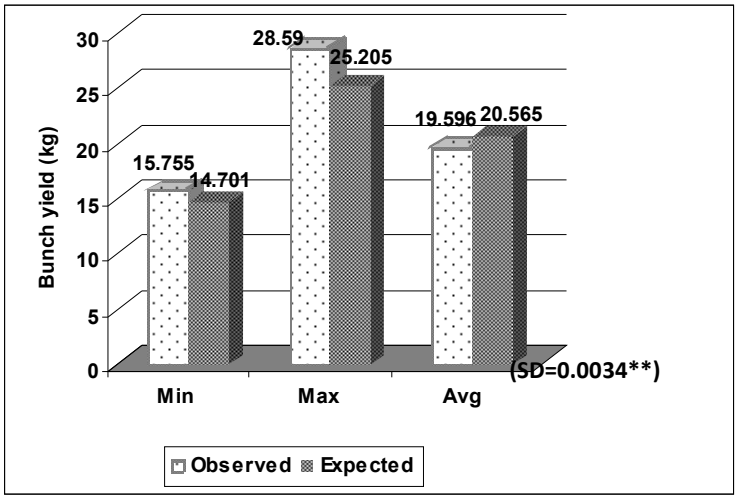
S.N.	Yield attributes	Yield	
		r	R^2
1	Girth (cm)		
	Lower	0.5687**	0.323
	Middle	0.4974**	0.247
	Upper	0.4346**	0.189
2	Bunch length (inch)	0.3226*	0.104
3	No. of hands/bunch	0.5608**	0.315
4	No. of fingers/bunch	0.6520**	0.425
5	Length of fruit (cm)	0.0551	0.003
6	Girth of fruit (cm)	0.0322	0.001

Using the best fit equation as given below, expected fruit yield was calculated and validated for 100 plants (Fig.1). In view of the minimum deviation between predicted and observed yields this equation can very well be used for predicting the fruit yield of banana when crop is six month old.

Y=-23.1121 + 0.70025 X,

Where,
Y= Bunch yield (kg).
X= Lower stem girth (cm).

Fig.1: Comparison between observed and expected bunch yield (kg) of banana (n=100)



Apart from this, yield attributes recorded at harvest can also be used for predicting fruit yield though it is late. However, the attributes *viz.*, length of bunch, number of hands per bunch and number of fingers per bunch recorded at harvesting are going to remain same even 3 to 4 month prior to harvesting *i.e.* complete emergence of bunch. Hence, a multiple regression equation was computed using these attributes.

$Y=3.36031-0.02390X_1 + 0.28456\ X_2 + 0.11338\ X_3$..... ($R^2=0.428$)

Where,
Y= Bunch yield (kg)
X_1= Bunch length (inch)
X_2= Number of hands per bunch
X_3= Number of fingers per bunch

This equation is also showing good fit, so it can be used for predicting the yield of banana 3-4 month before harvesting. Similar findings were also reported earlier by Palkar (2007), Garoli (2004) and Patel (2003).

Conclusion

From the results of present study it is concluded that banana fruit can be predicted precisely well in advance using lower girth at the age of six month or by wing length of bunch, number of hands per bunch and number of fingers per bunch. This will help the farmers in planning the sound marketing strategy.

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15.Drip and Mulching Studies in Gourd Crops under South Gujarat Conditions

B. M. Solia , S.A. Aklade, S.J. Patil, A.P. Patel, M.S. Malik, S.K. Dhimmar and R. G. Patil

Source: Green Farming J. (2010), Vol.: 3, Page:47

Abstract

There was demand from the farmers for appropriate method and schedule of irrigation particularly for gourd crops. Accordingly, systematic field experiments with gourd crops *viz.,* bitter gourd, sponge gourd and little gourd were conducted at Soil and Water Management Research Unit Farm, Navsari Agricultural University, Navsari (Gujarat). In all the above crops, the treatments were consisting of different moisture regimes (0.4/ 0.6 / 0.8 PEF) with drip and surface methods of irrigation in presence and absence of mulching. The experimental results revealed that adoption of drip method of irrigation along with mulching with black plastic (50 micron, 40% coverage) and/or sugarcane trash @ 2.5 t/ha could increase the yield by 18 – 30 per cent along with water saving to the extent of 32 – 57 per cent. This was also reflected on WUE as it was almost doubled with recommended treatments.

Key words: Bitter gourd, drip, little gourd, mulching, sponge gourd

Introduction

South Gujarat is blessed with natural resources which are highly suitable for cultivation of agricultural as well as horticultural crops. In view of this, Government of Gujarat has declared South Gujarat as special Agri-Export Zone for fruit and vegetable crops. As a result of this, farmers are going for cultivation of vegetable crops in a big way. There was demand from the farmers for appropriate method and schedule of irrigation particularly for gourd crops. Drip irrigation with its ability of small, frequent irrigation applications has created interest because of decreased water requirements and possible increased production (Singh and Singh, 1973). Further, mulching along with drip has been found to be more beneficial in increasing productivity (Parikh *et al*., 1996). There was a significant difference in length of vine of bottle gourd grown under micro and surface irrigation (Singh *et al*., 2001). In order to generate information on these aspects, systematic field experiments with gourd crops *viz*., bitter gourd, sponge gourd and little gourd were conducted and the results are presented here.

Material and methods

In all three experiments were conducted at Soil and Water Management Research Unit Farm, Navsari Agricultural University, Navsari (Gujarat). The location lies between 21º N latitude,72º E longitude and altitude of 10 m above mean sea level. The experimental soil belong to Vertic Ustochrepts with low in organic carbon, medium in available P and high in available K content. The soils are non calcareous in nature with no problem of salinity and sodicity. The details of the treatments tested in 3 experiments are furnished in table 1.

Table 1: Treatment details

S.N	Period	Crop/ design/ replications	Spacing (cm)	Treatments	
				Drip (PEF)	Surface (IW/CPE)
1	2000-2001 (2 year)	Bitter gourd / FRBD / 4	50x50x150 (paired row)	0.6 and 0.8 Mulch : No mulch and black plastic	1.0 (IW=50 mm) Mulch : No mulch and black plastic
2	2003-2004 (2 year)	Smooth gourd / FRBD / 4	100 x 200	0.4 and 0.6 Mulch : No mulch, trash and black plastic	1.0 (IW=60 mm) Mulch : No mulch, trash and black plastic
3	2004-2006 (3 year)	little gourd / FRBD / 4	250 x 250	0.2 ,0.4 ,0.6 and 0.8	0.2 ,0.4 ,0.6 and 0.8 (IW=80 mm)

In all the experiments lateral lines of 16 mm diameter with on line drippers of 4 lph capacities were kept along with crop row. The system was operated at 1.2 kg/cm^2 pressure which gave uniformity co-efficient of about 89 to 91 per cent. Irrigation was applied every alternate day in drip irrigated crop based on two days cumulative pan evaporation.

Results and discussion

The results presented in tables 2 and 3 revealed that only mulching effect was found to be significant on fruit yield of bitter gourd and smooth gourd. In case of bitter gourd, mulching with black plastic recorded significantly higher fruit yield (25.3 t/ha) as compared to unmulched control (21.57 t/ha). Whereas, in smooth gourd, mulching with sugarcane trash performed better than no mulch and plastic mulch treatments. However, the latter two treatments were at par with each other (Table 3). The beneficial effect of mulching either with trash or black plastic on fruit yield of bitter gourd and smooth gourd could be attributed to the better moisture and nutrient availability as well as effective weed control. Similar beneficial effects of mulching on yield of different crops have been reported by Parikh *et al.* (1996).

With respect to fruit yield of little gourd, it was affected significantly due to individual as well as interaction effects of methods and levels of irrigation (Table 4). Between the two method tried, drip (23.3 t/ha) performed significantly better than surface method of irrigation (9.3 t/ha). The results are in conformity with the results earlier reported by Singh and Singh (1973). Among the ratios of irrigation scheduled at 0.6 ratio recorded significantly higher fruit yield (23.2 t/ha) of little gourd as compared to 0.2 (19.1 t/ha) and 0.4 (21.2 t/ha), but it was at par with 0.8 ratio (21.7 t/ha). A combination of irrigation with drip at 0.6 PEF recorded conspicuously more fruit yield of 27.8 t/ha than rest of the combinations.

Considering the yield advantage and statistical significance, economics along with other relevant parameters were computed only for the recommended treatment (Table 5). In the cases of bitter gourd and smooth gourd, though, net profit is less with drip because of system cost (without subsidy) than surface method of irrigation, yet considering additional area that can be irrigated with saved water, net profit increased considerably. This implies that in water scarce area, with drip method of irrigation these crops can be grown successfully. This is also substantiated by enhanced water use efficiency. Whereas, in case of little gourd, drip method recorded significantly higher fruit yield and ultimately the net profit along with water saving to the tune of 32 per cent in comparison to surface method of irrigation.

Conclusion

The results of present studies indicated that drip method was found suitable for irrigating gourd crops with the advantages of higher yield as well as water saving. These beneficial effects can be further enhanced in presence of mulching particularly in water scare area.

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Table 2: Effect of drip and mulching on fruit yield (t/ ha) of bitter gourd (pooled)

Treatments	Mulching (M)		Mean
Irrigation (I)	No mulch	Black plastic (50 µ)	
0.6 PEF drip	23.45	24.95	24.20
0.8 PEF drip	21.22	25.65	23.44
1.0 IW / CPE surface	20.04	25.51	22.78
Mean	21.57	25.37	
	Irrigation (I)	Mulch (M)	I X M
S. Em ±	0.88	0.72	1.24
C. D. at 5 %	NS	2.06	NS
CV %	15		

Table 3: Effect of drip and mulching on fruit yield (t/ ha) of smooth gourd (pooled)

Treatments	Mulching (M)			Mean
Irrigation (I)	No mulch	Trash (2.5 t/ha)	Black plastic (50 µ)	
0.4 PEF drip	8.51	11.04	9.33	9.63
0.6 PEF drip	9.85	10.60	10.13	10.19
1.0 IW / CPE surface	9.49	11.66	9.00	10.30
Mean	9.28	11.10	9.48	
	Irrigation (I)	Mulch (M)		I X M
S. Em ±	0.338	0.338		0.585
C. D. at 5 %	NS	0.96		NS
CV %	17			

Table 4: Effect of drip and surface method of irrigation on fruit yield (t/ ha) of little gourd (pooled)

Treatments	Ratio (PEF, IW/CPE)				Mean
Irrigation method	0.2	0.4	0.6	0.8	
Surface	17.5	19.5	18.7	21.4	19.3
Drip	20.7	22.8	27.8	22.0	23.3
Mean	19.1	21.2	23.2	21.7	
	Surface (S)	Drip (D)		S X D	
S. Em ±	0.50	0.72		1.01	
C. D. at 5 %	1.4	2.0		2.8	
CV %	16				

Table 5: Comparative economics of drip and surface method of irrigation in gourd crops

Sr. no.	Particulars	Bitter gourd		Smooth gourd		Little gourd	
		Recommended treatment of drip (0.6 PEF)	Surface method with mulch	Recommended treatment of drip (0.4 PEF)	Surface method with STM	Recommended treatment of drip (0.6 PEF)	Surface method (0.8 IW/CPE)
1	Fixed cost (Rs. ' 000 / ha)	18.0	11.0	19.2	9.8	26.6	17.8
2	Variable cost (Rs. ' 000 / ha)	28.4	31.7	8.6	13.1	34.9	38.7
3	Total cost (Rs. ' 000 / ha)	46.4	42.7	27.8	22.8	61.5	56.5
4	Yield (t/ ha)	25.37 *	25.37 *	11.04	11.66	27.8	21.4
5	Income (Rs. ' 000 / ha)	152.2	152.2	66.24	69.96	166.2	128.4
6	Net income (Rs. ' 000 / ha)	105.8	109.5	38.43	47.06	104.2	71.9
7	Water applied (mm)	479	802	480	111.0	626	917
8	Water saving over surface(%)	40	-	57	-	32	-
9	Possible additional area with saved water (ha)	0.67	-	1.31	-	-	-
10	Fixed cost (Rs. ' 000 / ha)	176.7	-	116.6	-	-	-
11	Water use efficiency (Kg/ha.mm)	53	32	23	11	44	23

***** Due to non significant difference average yield was considered.

16. Studies on Efficient Use of Water and Nutrients in Banana under South Gujarat Conditions

B. M. Solia , S.A. Aklade, S.J. Patil, A.P. Patel, M.S. Malik, S.K. Dhimmar and R.G. Patil

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Abstract

In order to find out agro techniques for enhancing the productivity of banana, studies involving drip irrigation, fertigation, mulching and intercropping were conducted with different planting geometry in South Gujarat. The soils of experimental sites are clay in texture, slightly alkaline, normal with respect to salinity, low in organic carbon, medium in available P and high in available K content.

The results of first two studies indicated that increase in banana yield due to either black plastic mulch (BPM) or sugarcane trash mulch @ 5 t/ha (STM) was more pronounced in narrow spacing (1.5 x 1.5 m) than wider spacing. The magnitude of increase in yield with STM was slightly higher as compared to BPM. The extent of water saving with drip + BPM or STM was almost similar and it was also true for WUE. Inspite of almost identical advantages of BMP and STM, farmers have showed interest in BPM due to induction of early maturity by 35 to 40 days with BPM. These enable the farmers to fetch higher prices of banana. Similarly, BPM has more weed control efficiency than STM. The results of fertigation study showed 40 per cent saving in fertilizer without any reduction in banana yield. For increasing the net profit per unit of input use, an inter cropping with bottle gourd in banana under drip irrigation was tried. Apart from increase in yield and water saving, the WUE was almost doubled with inter cropping as compared to sole crop of banana. In view of advantages of different technologies, a package demonstrations comprising drip irrigation, fertigation, mulching, desuckering, bunch covering *etc*., were arranged on the farmers' fields and the response is highly encouraging.

Key words: Banana, drip, fertigation, geometry, intercrop, mulch

Introduction

Banana provides more balanced diet than any other fruit and is also considered as poor man's fruit. It is rich source of energy, carbohydrates and various vitamins like A, B, etc. In India, banana is cultivated over an area of about 6.47 lakh ha with production of about 232.05 lakh tones and average productivity of 35.9 t/ha. In Gujarat, it occupies about 0.57 lakh ha area with production of 31.577 lakh tones and productivity of 54.8 t/ha (Anon., 2007-08). Further there is wide scope for increasing productivity of banana in Gujarat by adopting proper water and nutrient management practices, planting geometry, soil type *etc.* Keeping soil type in mind, appropriate scientific water and nutrient management including mulching technologies for banana have been developed at and popularized by NAU, Navsari which are being discussed in present paper.

Materials and methods

For developing scientific water and nutrient management technologies, in all 4 experiments comprising 3 at Soil and Water Management Research Unit Farm, NAU, Navsari and one at Fruit Research Station, NAU, Paria were conducted. In experiment No.1, 10 treatments comprising 3 levels of each of irrigation and mulching along with one surface control were compared in RBD with 3 replications for three years. Whereas in experiment No. 2, set of 8 treatments consisting of drip methods of irrigation with 1.8 and 1.5 m geometry in presence (sugarcane trash and black plastic) and absence of mulching along with two surface controls *i.e.* 1.8 and 1.5 m geometry were compared in RBD with 4 replications for three years. Another experiment was conducted with 6 treatments consisting of 2 frequency and 3 levels of fertigation in RBD with 4 replications for two years. The 4th experiment was conducted at Fruit Research Station, Paria for studying the feasibility of

intercropping in drip irrigated banana. This experiment was conducted for two years with 12 treatment combinations comprising of 4 irrigation levels (3 drip at 0.6, 0.8, 1.0 PEF and 1 surface at 1.1 IE/CPE ratio) and 3 intercrops in factorial RBD replicated 4 times.

The soil of Soil and Water Management Research Unit Farm, Navsari is clay in texture, low in organic C and available N, low to medium in available P and high in available K content. Whereas, the soil of Fruit Research Station, Paria is loam in texture, low in organic C and available N, medium in available P and high in available K content. The soils of both the locations are normal with respect to salinity and sodicity.

Results and discussion

The results presented in table 1 clearly indicate that banana fruit yield of 59.3 t/ha with drip + black plastic mulch and 64.1 t/ha with drip + sugarcane trash mulch could be achieved as against 55 t/ha in surface control along with water saving of 43 per cent (0.6 PEF). The extent of increase in fruit yield was more with trash mulch (16 %) than black plastic mulch (9 %). This could be due to earliness in maturity by 35-40 days with black plastic mulch and delayed maturity by 10-15 days with trash mulch in comparison to unmulched control. The results of another study (Expt. #2) revealed that 1.5 X 1.5 m planting geometry recorded higher fruit yield of banana as compared to 1.8 X 1.8 m. The fruit yield was further increased with back plastic mulch and trash mulch by about 50 and 60 per cent, respectively over control at 1.5 X 1.5 m spacing (Table 2). The results of an experiment conducted for knowing the level and frequency of fertigation for drip irrigated banana revealed that 40 per cent saving in fertilizer could be achieved along with water saving up to 30 per cent without adversely affecting the yield. This is also evident from the improvement in WUE (Table 3). The results further showed that frequency of fertigation had not effect on fruit yield of banana. Similar beneficial effects of drip irrigation, fertigation and mulching in banana were also reported by Savani *et al*., 2002 and Srinivas *et al.,* 2001 for drip + fertigation, by Parikh *et al*., 2002 for drip + mulch + geomatry and by Deshmukh and Badgujar, 2002 and Pandey *et al*., 2002 for fertigation + geometry.

Apart from water and nutrient management, feasibility of intercropping in drip irrigated banana was also studied (Table 4). The results revealed that drip irrigation scheduled at 0.8 PEF and intercropping of bottle gourd recorded significantly higher net profit as compared to rest of the treatments.

In view of the significant increase in banana productivity with an adoption of drip, fertigation and mulching, a package demonstrations (drip = 0.6 PEF, fertigation 40 % of RD and mulching with black plastic (50 micron) along with chemical desuckering were arranged on farmers' fields and on research farm using Grand Naine variety of banana *vis-à-vis* farmers practices (Table 5). The productivity of banana recorded at both the places clearly shows that an average productivity of about 75 t/ha could be achieved under South Gujarat conditions through efficient utilization of water and nutrient resources.

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Table 1: Fruit yield, WUE of banana under different levels of moisture regimes and mulching (Pooled over 3 years)

Treatment	Fruit yield (t/ha)	Yield increase over control (%)	WUE (kg/ha-mm)
Drip			
0.45 PEF	52.9	- 4	73
0.60 PEF	58.3	6	62
0.75 PEF	58.8	7	51
Drip + BPM			
0.45 PEF	58.0	5	80
0.60 PEF	59.3	8	63
0.75 PEF	60.7	10	52
Drip + STM			
0.45 PEF	58.5	6	81
0.60 PEF	64.1	16	68
0.75 PEF	66.8	21	57
Control (1.10 IW/CPE, D=80 mm)	55.0	-	33

Spacing: 1.8 x 1.8, Water saving (%) over control: At 0.45 = 56, 0.60 = 43 and 0.75 = 30
BPM= Black plastic mulch, STM= sugarcane trash mulch, WUE=Water use efficiency

Table 2: Fruit yield of banana under different treatments of irrigation methods, planting geometry and mulching (Pooled over 3 years)

Method	Spacing (m)	Mulch	Fruit yield (t/ha)	Increase in yield over		WUE (kg/ha-mm)
				1.8 control (%)	1.5 control (%)	
Surface	1.8 x 1.8	-	56.3	-	-	34
Surface	1.5 x 1.5	-	72.4	28.6	-	44
Drip	1.8 x 1.8	-	61.2	8.7	-	53
Drip	1.5 x 1.5	-	82.5	46.5	14.0	71
Drip	1.8 x 1.8	BPM	66.0	17.2	-	57
Drip	1.5 x 1.5	BPM	84.1	49.4	16.2	73
Drip	1.8 x 1.8	STM	68.9	22.4	-	60
Drip	1.5 x 1.5	STM	90.2	60.2	24.6	78
	S.Em+	**C.D at 5 %**	**CV %**			
Treatment	2.10	5.93	10			
Y x T	3.51	NS				

Table 3: Fruit yield of banana under different treatments of level and frequency of fertigation (Pooled over 2 years)

Treatment	Fruit yield (t/ha)	Yield increase over control (%)	WUE (kg/ha-mm)	FUE (kg/kg NPK)
100 % RD + 10 DI	73.5	11	65	37
80 % RD + 10 DI	70.5	6	62	44
60 % RD + 10 DI	65.5	-	58	55
100 % RD + 20 DI	69.5	5	61	35
80 % RD + 20 DI	68.6	3	61	43
60 % RD + 20 DI	68.4	3	60	57
Control	66.3	-	39	33
	S Em±	**C.D at 5 %**	**CV %**	
	2.83	NS	12	

Spacing: 1.5 x 1.5 m, Variety: Basarai, RD: 180:120:180 g NPK/plant, DI:Interval in days, FUE: Fertilizer use efficiency

Table 4: Net income (Rs.' 000/ha) of banana + intercrop (Pooled over 2years)

Irrigation/ Intercrop	Long melon	Bottle gourd	Cucumber	Mean
0.6 PEF (512)	131	170	122	141
0.8 PEF (682)	161	208	146	172
1.0 PEF (853)	141	157	121	140
1.1 IW/CPE (930)	129	154	123	136
	S.Em±	**CD at 5 %**	**CV %**	
Irrigation	4.3	12.2		
Intercrop	3.7	10.6		
Interaction	7.5	NS	14.4	

Spacing: 1.5 x 1.5 m, Variety: Basarai, ( ) = Volume of water applied in mm

Table 5: Fruit yield of banana on research farm and farmers' fields under improved and farmers' practices

Technology	Fruit yield (t/ha)		Increase over control (%)
	On research farm	On farmers' fields	
Drip +BPM	81	68	31-35
Drip + STM	77	64	23-28
Control (Farmers' method)	60	52	-

Spacing: 1.5 x 1.5 m, Variety: Grand Naine

17.Irrigation Management in Pointed gourd under South Gujarat Conditions

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Source: Water Management and Climate Change Seminar at RTTC, JAU, Junagadh (2015), Page: 442

Abstract

Pointed gourd is an important vegetable crop of this zone. This crop is very sensitive to excess water situation which causes wilt disease. The severity of wilt is accentuated in high clay containing soils and more so when conventional method of irrigation is followed. In order to generate information on water management aspects of pointed gourd, field experiments were conducted during 2007 to2009 at Soil and Water management Farm, NAU, Navsari (Gujarat). The experimental soil is clay in texture, low in available N, medium in available P and high in available K with high moisture retention capacity. The results of experiment revealed that the treatment with drip irrigation @ 0.6 PEF(I_2) recorded significantly higher length and average weight of fruit which were closely followed by surface irrigation at 1.0 IW/CPE ratio(I_3). Among the mulching treatments, no mulch (Mo) treatment recorded significantly higher volume of fruit (44.1 ml) as compared to trash mulch (M_T)(40.8 ml) and black plastic mulch(M_B)(38.8ml). Here, the combination I_2 M_T (5.1 %) and I_3 M_B (5.1%) recorded identical values of TSS and both these treatments were significantly higher than I_2M_0 (4.1 %), I_3M_T (4.4%) and I_1M_T (4.3%) treatments. Based on the yield results of the experiments indicated that irrigation through drip @ 0.6 PEF along with black plastic mulching in pointed gourd was found to be the best treatment for getting 47 per cent higher fruit yield and 42 per cent more net income than the surface control without mulch. This treatment could also lead to water saving to the extent of 37 per cent.

Key words: Pointed gourd, Drip, Mulching

Introduction

South Gujarat is blessed with natural resources which are highly suitable for cultivation of agricultural as well as horticultural crops. In view of this, Government of Gujarat has declared South Gujarat as special Agri-Export Zone for fruit and vegetable crops. As a result of this, farmers are going for cultivation of vegetable crops in a big way. There was demand from the farmers for appropriate method and schedule of irrigation particularly for gourd crops. Drip irrigation with its ability of small, frequent irrigation applications has created interest because of decreased water requirements and possible increased production (Singh and Singh, 1973). Further, mulching along with drip has been found to be more beneficial in increasing productivity (Parikh *et al*.,1996). There was a significant difference in length of vine of bottle gourd grown under micro and surface irrigation (Singh *et al*., 2001). Pointed gourd is an important vegetable crop of this zone. This crop is very sensitive to excess water situation which causes wilt disease. The severity of wilt is accentuated in high clay containing soils and more so when conventional method of irrigation is followed. Farmers of this zone approaching us with wilt affected samples of pointed gourd. In view of paucity of information on water management aspects of this crop, it is not possible to give any advice to farmers coming with such problems. In order to generate information on water management aspects of pointed gourd, present study was conducted.

Material and Methods

This experiment was conducted at Soil and Water Management Farm, Navsari Agricultural University, Navsari (Gujarat). The location lies between 21º N latitude,72º E longitude and altitude of 10 m above mean sea level. The experimental soil belong to Vertic Ustochrepts with low in organic carbon, medium in available P and high in available K content. The soils are non calcareous in nature with no problem of salinity and sodicity. In

this experiment 9 treatment combinations consisting of two levels of drip irrigation each of fraction two day cumulative pan evaporation (I_1= 0.4 PEF and I_2= 0.6 PEF), one surface method control (I_3=IW/CPE 1.0, Depth: 60 mm) and three mulches (M_0: No mulch, M_T: sugarcane trash mulch @ 2.5 t/ha and M_B: black plastic mulch: 50 micron) were tried in RBD with four replications. The normal plant spacing of 100 x 200 cm was followed in this study. Recommended dose of fertilizer *i.e.* 90 : 60 : 40 NPK kg/ha were applied in both method. In case of surface method,100 % of PK and 25 % of N were applied as basal and remaining 75 % N was applied in two equal splits *i.e*., before and after monsoon. But in case of drip method, 100 % of PK and 10 % of N were applied as basal and remaining 90 % N was applied in nine equal splits at an interval of 30 days (except monsoonic months). In drip irrigation system, lateral lines of 16 mm diameter with on line drippers of 4 Lph capacity were kept at 1 m spacing along with crop row. The system was operated at 1.2 kg/cm^2 pressure which gave uniformity co-efficient of about 89 to 91 per cent. Irrigation was applied every alternate day in drip irrigated crop based on two days cumulative pan evaporation. All the data recorded in these experiments were analyzed statistically and the results are presented here.

Results and Discussion

Yield attributes and quality parameter

The yield attributes *viz.,* length of fruit, girth of fruit, average weight of fruit and average volume of fruit along with quality parameter *viz.,* TSS content in fruit were determined during the year 2009-10. The length of fruit of pointed gourd was affected significantly only due to main effect of irrigation method (Table 1). The treatment with drip irrigation @ 0.6 PEF recorded significantly higher fruit length which was closely followed by surface irrigation at 1.0 IW/CPE ratio. However, these treatments were significantly higher as compared to I_1, (drip irrigation @ 0.4 PEF). Similar pattern of treatment effect was also observed in the case of average weight of fruit as I_2 treatment recorded significantly heavier fruit (29.4 g) than I_1 (26.2 g) but was at par with I_3 (27.69 g). As far as girth of fruit is concerned, it was not affected significantly due any of the factors or their interaction. The volume of fruit was influenced significantly due to main effect of mulching and its interaction with irrigation methods (Tables 1 and 2). Among the mulching treatments, no mulch (Mo) treatment recorded significantly higher volume of fruit (44.1 ml) as compared to M_T (40.8 ml) and M_B (38.8ml). Among all the combinations, I_2Mo (46.5ml), I_3Mo (46.0ml) and I_1 M_T (46.0 ml) recorded significantly higher volume of fruits as compared to rest of the combinations, but these combinations were at par with each other. With respect to TSS content in fruit of pointed gourd, it was affected significantly only due to interaction effect of I x M (Table 3). The trend of treatment effect was on TSS content in fruit was similar as was observed in volume of fruit .Here, the combination I_2 M_T (5.1 %) and I_3 M_B (5.1%) recorded identical values of TSS and both these treatments were significantly higher than I_2M_0 (4.1 %), I_3M_T (4.4%) and I_1M_T (4.3%) treatments.

Fruit yield

During the first year (2006-07), the fruit yield of pointed gourd was affected significantly due to I, M and their interaction (IxM) also (Table 4). Among the mulches, both *i.e.,* sugarcane trash (10.72 t/ha) and BPM (11.48 t/ha) were statistically at par with each other, but were significantly better than no mulch control (9.43 t/ha). Similarly, the treatment I_2 (11.12 t/ha) and I_3 (10.71 t/ha) were at par with each other, but were significantly higher in comparison to I_1 (9.86 t/ha). Among all the combinations, treatment I_2M_B recorded significantly higher fruit yield (11.95 t/ha) as compared to rest of the combinations. Of course, it was at par with some of the combinations, *viz.*, I_3M_B (11.82 t/ha), I_3M_T (11.72 t/ha) and I_2 Mo (11.01 t/ha). Almost similar pattern of treatment effect was observed on fruit yield

recorded during 2008-09 and 2009-10. Only exception to this pattern was that during 2008-09, interaction I x M effect was not significant on fruit yield.

The trend of treatment effect of fruit yield observed during individual year was also reflected in pooled analysis (Table 4). Here also treatment I_2 (drip at 0.6 PEF) and M_B (black plastic mulch) recorded conspicuously higher fruit yield individually as well as jointly. The I_2M_B recorded significantly higher fruit yield of 12.13 t/ha as compared to rest of the combinations of I and M

Water Use Efficiency (WUE)

The WUE was calculated only for treatments involving irrigation levels/method. Among the irrigation treatments, the WUE recorded with drip @ 0.4 PEF was maximum (15.9 kg/ha-mm) followed by drip @ 0.8 PEF (13.1 kg fruit / ha-mm) and least was with surface method of irrigation (7.52 kg / ha-mm). This implies that drip method of irrigation could almost double the WUE in comparison to surface method of irrigation (Table 5).

Soil respiration (CO_2 content in soil air)

In order to understand the beneficial effects of mulching on crop yield, the CO_2 content in soil air was measured during March of 2009 and 2010 using LC pro-soil respiration chamber (ADC Bio scientific, Landon). The values of CO_2 content in soil air under different treatments are reported in table 6. For clarity, the data were tabulated in two way table. It is interesting to note that at I_1 and I_2 , the net CO_2 content in soil air was almost same, but it declined at I_3 *i.e.,* 0.8 PEF. Similarly, among the mulching treatments, under black plastic mulch treatment, the CO_2 content in soil air was almost double as compared to no mulch and trash mulch treatments. This suggests that the soil microbial and root respiration activities were more profuse under black plastic mulching than no mulch and trash mulch treatments. The higher microbial and root respiration activities lead to higher nutrient availability in soil. This is the main reason for higher fruit yield of pointed gourd recorded with drip + mulch treatment

Economics

As the treatment involving drip irrigation at 0.6 PEF with black plastic mulch out yielded rest of the treatments, economics was computed for this treatment along with surface control. The data presented in table 7 revealed that treatment I_2 M_B (Drip @ 0.6 PEF + BPM) recorded higher net income of Rs. 1.5 lakh /ha along with water saving of 37 per cent over surface control. Even mulching in surface method also realized net income of Rs. 1.38 lakh/ha which is more than un mulched surface irrigation control

Conclusion

Based on the results of three year, it is concluded that irrigation through drip @ 0.6 PEF along with black plastic mulching in pointed gourd was found to be the best treatment for getting 47 per cent higher fruit yield and 42 per cent more net income than the surface control without mulch. This treatment could also lead to water saving to the extent of 37 per cent

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Table 1: Yield attributes and quality parameters of pointed gourd under different treatments (2009-10)

Treatment	Length of fruit (cm)	Girth of fruit (cm)	Average Weight of fruit (g)	Average volume of fruit (ml)	Average TSS (%)
I_1 – 0.4 PEF	7.28	8.79	26.20	41.70	4.51
I_2 – 0.6 PEF	7.93	9.41	29.40	41.93	4.63
I_3 – 1.0 IW/CPE	7.53	9.31	27.69	40.04	4.84
CD @ 5 %	0.46	NS	2.3	NS	NS
Mo	7.52	9.21	27.82	44.13	4.53
M_T	7.72	9.20	28.21	40.78	4.58
M_B	7.48	9.11	27.30	38.75	4.87
SEm ±	0.156	0.209	0.781	1.146	0.112
CD @ 5 %	NS	NS	NS	3.34	NS
I x M	NS	NS	NS	5.79	0.57
CV %	7	8	10	10	8

Table 2: Effect of different treatments on volume of fruit (ml) (2009-10)

Treatments	Mulching			Mean
	Mo	M_T (STM)	M_B (BPM)	
I_1 – 0.4 PEF	39.9	46.0	39.3	41.7
I_2 – 0.6 PEF	46.5	38.7	40.6	41.9
I_3 – 1.0 IW/CPE	46.0	37.7	36.5	40.0
Mean	44.1	40.8	38.8	
	I	**M**	**I x M**	
SEm ±	1.146	1.146	1.985	
C.D. at 5 %	NS	3.34	5.79	
CV %	10.0			

Table 3: Effect of different treatments on TSS content in fruit (%) (2009-10)

Treatments	Mulching			Mean
	Mo	M_T (STM)	M_B (BPM)	
I_1 – 0.4 PEF	4.6	4.3	4.7	4.5
I_2 – 0.6 PEF	4.1	5.1	4.8	4.6
I_3 – 1.0 IW/CPE	4.9	4.4	5.1	4.8
Mean	4.5	4.6	4.8	
	I	**M**	**I x M**	
SEm ±	0.11	0.11	0.19	
C.D. at 5 %	NS	NS	0.57	
CV %	8.0			

Table 4: Effect of different treatments on fruit yield (t/ha) of pointed gourd

Treatments	Mulching			Mean
	Mo (No Mulch)	M_T (Trash mulch)	M_B (Black plastic)	
2006-07				
I_1 – 0.4 PEF drip	8.86	10.05	10.68	9.86
I_2 – 0.6 PEF drip	11.01	10.40	11.95	11.12
I_3 – 1.0 IW/CPE surface	8.58	11.72	11.82	10.71
Mean	9.43	10.72	11.48	
	Irrigation(I)	**Mulch (M)**	**I x M**	
SEm ±	0.305	0.305	0.528	
C.D. at 5 %	0.89	0.890	1.54	
CV %	10			
2008-09				
I_1 – 0.4 PEF drip	9.03	8.82	8.65	8.83
I_2 – 0.6 PEF drip	9.15	11.10	12.98	11.08
I_3 – 1.0 IW/CPE surface	8.06	10.23	10.60	9.63
Mean	8.75	10.05	10.74	
	Irrigation(I)	**Mulch (M)**	**I x M**	
SEm ±	0.407	0.407	0.704	
C.D. at 5 %	1.19	1.19	NS	
CV %	14			
2009-10				
I_1 – 0.4 PEF drip	9.20	8.42	8.23	8.62
I_2 – 0.6 PEF drip	9.11	10.75	11.47	10.44
I_3 – 1.0 IW/CPE surface	8.13	9.89	10.36	9.46
Mean	8.81	9.69	10.02	
	Irrigation(I)	**Mulch (M)**	**I x M**	
SEm ±	0.335	0.335	0.581	
C.D. at 5 %	0.98	0.98	1.69	
CV %	12			
Pooled				
I_1 – 0.4 PEF drip	9.03	9.10	9.19	9.10
I_2 – 0.6 PEF drip	9.76	10.75	12.13	10.88
I_3 – 1.0 IW/CPE surface	8.26	10.61	10.93	9.93
Mean	9.01	10.15	10.75	
	Irrigation(I)	**Mulch (M)**	**I x M**	
SEm ±	0.203	0.203	0.352	
C.D. at 5 %	0.57	0.57	0.99	
CV %	12			

Interactions: *Yx I: NS, Y x M : NS, YxIxM : NS and Y : Sig.*

Table 5: WUE as influenced by different treatments of pointed gourd (Pooled)

Treatments	Mulching			Mean
	Mo	M_T (STM)	M_B (BPM)	
I_1 – 0.4 PEF	15.76	15.88	16.04	**15.9**
I_2 – 0.6 PEF	11.77	12.97	14.63	**13.1**
I_3 – 1.0 IW/CPE	6.26	8.04	8.28	**7.52**
Mean	**11.26**	**12.30**	**12.98**	

Table 6 : The CO_2 content in soil air (difference between atmosphere and soil air) under different treatments (Pointed gourd)

Treatments	Mulching			Mean
	Mo (No Mulch)	M_T (Trash mulch)	M_B (Black plastic)	
I_1 – 0.4 PEF drip	107	142	234	161
I_2 – 0.6 PEF drip	123	138	245	169
I_3 – 1.0 IW/CPE surface	94	109	178	127
Mean	108	129	219	

Table 7: Economics of different treatments

Sr. No.	Particulars	Unit	Drip at 0.6 PEF with BPM	Surface irrigation with mulch	Surface irrigation without mulch
1	Fixed cost	’000 Rs/ ha	28.6	15.5	15.5
2	Variable cost	’000 Rs/ ha	40.6	43.0	28.0
3	Total cost	’000 Rs/ ha	69.2	58.5	43.5
4	Yield	t/ha	12.13	10.93	8.26
5	Income	’000 Rs/ ha	218.3	196.7	148.7
6	Net income	’000 Rs/ ha	149.1	138.2	105.2
7	Water applied	mm	829	1320	1320
8	Water saving over surface	%	37		
9	Net income over surface without mulch	%	42		

* Selling price of pointed gourd @ 18 Rs/kg

18.Experiences of Farmers about Drip Irrigation in Gujarat- A Survey

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Source: Indian Society of Water Management J. (2007)

Abstract

In present study, two survey were conducted *i.e.,* one was related to advantages of drip irrigation method realized by the farmers (n=150) *vis-a-vis* conventional method of irrigation and another was with special reference to the problems encountered by the banana growers (n=89) who have adopted drip system. In both the surveys, standard questionnaires were formulated and farmers were interviewed personally. The information thus obtained was tabulated and interpreted. In general, farmers opined that they could save water above 25 per cent, weed control expenses by 51 to 75 per cent and labour charges to the extent of 26 to 50 per cant along with increase in the crop yields. Whereas, the results of crop specific survey revealed that the major problems faced by banana growers with drip method of irrigation were unassured power supply, inadequate availability of quality planting material and variable prices of banana. The farmers were of the opinion that though, higher fruit yield of banana with drip method was obtained in comparison to surface method, yet there is still scope to increase the fruit yield of banana.

Key words: Drip irrigation, fertigation, problems

Gujarat being water scarce state, concerted efforts are made by state and centre governments to popularize the pressurized methods of irrigation among the farmers. As a results of this, the area under drip method of irrigation in Gujarat has increased from 1600 ha during 1986 to 50260 ha in the year 2007-08 (Anonymous, 2008). The drip system has been adopted by the farmers on large scale in agricultural crops like cotton and horticultural crops in North Gujarat and Saurashtra. Whereas in South and middle Gujarat, it has been adopted in horticultural crops like mango, sapota, banana *etc*. in addition to cash crop like sugarcane. With the increase in area under drip method of irrigation owing to its advantages in terms of water and fertilizer saving as well as increase in crop yield, the extent of problems related operation and maintenance of drip system are bound to increase. In order to understand the experiences of the farmers with drip method of irrigation in different crops and the problems encountered by the banana growers two systematic surveys were taken up and the information generated is presented here.

Methodology

The first survey was conducted covering 13 districts of Gujarat. These districts were selected considering the criteria that it should have more than 3 per cent of the total drip holders of the state. Subsequently, from each district drip holders were identified randomly ensuring the proportional allocation to the total size of drip holders in respective district with a minimum number of eight farmers. The total numbers of farmers selected were 150 (Table 1).

Table 1. District wise distribution of the farmers

Sr.No.	District	Predominant crops	No. of selected farmers
1	Junagadh	Mango, Cotton	20
2	Rajkot	Cotton, G'nut	17
3	Bhavnagar	Cotton, Pomogranate	17
4	Amreli	Cotton, G'nut	15
5	Surendranagar	Cotton	11
6	Valsad	Vegetables	11
7	Amdavad	Citrus, Vegetables	11

8	Sabarkantha	Citrus	8
9	Kutch-Bhuj	Mango, Datepalm	8
10	Banaskantha	Potato, Castor	8
11	Jamnagar	Cotton, Onion	8
12	Mehsana	Cotton, Vegetables	8
13	Vadodara	Cotton, Vegetables	8
Total			**150**

For obtaining reliable information, ex-post-facto design was used and the selected respondents (farmers) were interviewed personally with a standard set of questionnaire. The questionnaire was so designed that the information related to resultant changes due to adoption of drip irrigation method *i.e.,* saving in water, fertilizer, cost of plant protection, cost of weeding and labour charges along with increase in crop yield could be obtained.

Another survey was conducted in phased manner to know the crop production related problems faced by the banana growers who have adopted drip method of irrigation *vis-à-vis* conventional method of irrigation. For this purpose 89 banana growers spread over six talukas *i.e.,* two each of Surat and Narmada districts and one each of Navsari and Bharuch districts were selected randomly (Table 2). All the respondents were interviewed personally during 2002-03 and 2003-04 using a set of standard questionnaire. The whole population was divided into two groups *i.e.,* adopted drip and surface method of irrigation and the information thus obtained was interpreted accordingly.

Table 2. District and talukawise distribution of the farmers

Sr. No.	District	Talukas	No. of selected farmers
1	Surat	2	33
2	Narmada	2	37
3	Navsari	1	10
4	Bharuch	1	19
Total		**6**	**89**

Results and discussion

Survey 1

The information given in table 3 revealed that majority of the farmers (43 %) were of the opinion that water saving to the extent of 26 to 50 per cent could be achieved with an adoption of drip method of irrigation and about 28 per cent experienced saving of water more than 75 per cent. About 57 per cent farmers opined that weeding cost could be reduced by 51 to 75 per cent. As regard the saving in labour cost, about 59 per cent farmers experienced saving between 26 to 50 per cent. The benefit in terms of increase in yield irrespective crop with drip method of irrigation was experienced by most of the farmers (57%) in the range of 51 to 75 per cent. This implies that besides saving in water, weeding cost and labour charges, drip method of irrigation also enhanced the crop yield. For saving in fertilizer and plant protection expenses, five classes of magnitude of saving were made. The values reported in table 4 clearly indicate that majority of the farmers (57 %) realized saving in fertilizer expenses more then 45 per cent, of course, out of 150 respondents only 47 farmers followed fertigation and they empathetically stated that there is saving in fertilizer expenditure. While in curtailment of plant protection expenditure only 53 per cent farmers could experience saving in between 16 to 30 per cent.

Apart from the above benefits, farmers were also asked questions like improvement in quality, earliness in maturity and getting premium prices due to adoption of drip irrigation in different crops. Here the answers were obtained only in terms of yes or no. With respect to quality of produce, 85 per cent of the farmers observed improvement in the quality of

produce. As a result of this, they (83 %) fetched higher prices up to Rs. 200/q. Not only this, but some farmers (19 %) also observed prepondment in maturity by 15 days in drip irrigated crops. The results of present survey clearly brought out the fact that those who adopted drip irrigation method could realize the advantages of the method. Similar benefits of drip irrigation have also been reported by Desmukh (1989) and Nagare (1989) from Maharashtra, Rao (1989) from Tamilnadu , Thorat and Bhoite (1992) from Maharashtra and Chaudhari (1995) from Gujarat.

Table 3. Distribution of farmers in to different classes of benefit (n=150)

Class (%)	Saving of			Yield increase
	Water	Weeding cost	Labour cost	
< 25	21 (14)	06 (4)	49 (33)	04 (3)
26 to 50	64 (43)	57 (38)	89 (59)	52 (35)
51 to 75	22 (15)	85 (57)	10 (7)	86 (57)
>75	43 (28)	02 (1)	02 (1)	08 (5)

( ) = values in parenthesis indicate per cent of total farmers.

Table 4. Distribution of farmers in to different classes of benefit (n=150)

Class (%)	Saving in	
	Fertilizer	Plant protection cost
No saving	*	56 (38)
<15	00 (00)	08 (5)
16-30	07 (15)	79 (53)
31-45	13 (28)	05 (3)
>45	27 (57)	02 (1)
Total	**47 (100)**	**150 (100)**

***** 103 farmers (69 %) did not adopted fertigation *i.e.* only 31% farmers adopted irrigation which were categorized farmer (n=47)

Survey 2

In order to know the crop specific reaction of the farmers with drip irrigation, a special survey considering banana as test crop was conducted vis-*a-vis* surface method of irrigation. Of the total 89 respondent, about 57 per cent farmers had adopted drip irrigation and rest followed conventional method of irrigation.

The distribution of farmers in to land holding classes revealed that large farmers are growing banana more than small and marginal farmers. Similarly, adoption & drip technology was also more with large farmers (Table 5). In general, drip owners allocate more area to banana than farmers adopting conventional irrigation method. The yield obtained with drip irrigation was about 50 per cent higher as compared to surface irrigation. This could be the reason for allocation of more land to banana crop by drip owner.

Table 5. Distribution of banana growers in to different land holding classes (n=89)

Particulars	Drip (51)			Mean	Surface (38)			Mean
	S	M	L		S	M	L	
No. of farmers	6	14	31	-	5	8	25	-
Yield of banana (t/ha)	51	51	60	53	29	42	42	35
% of land holding under banana	79	53	35	56	58	36	26	40

S= small (< 2 ha), M= medium (2-4 ha) and L = large (> 4 ha)

The major problems faced by the banana growers were classified in to infrastructural, soil and water management, crop improvement and protection and others. The drip and surface method of irrigation wise responses of the farmers to differentiate problems are given

in table 6 in descending order. Among the problems, majority of the farmers faced infrastructural problems like unassured power supply (28), inadequate availability of quality planting material (26), fluctuation in prices (25) *etc*. particularly by drip owners.

Table 6. Farmers (Nos.) response to different problems

Problems	Methods of irrigation	
	Drip	Surface
(A) Infrastructural problems		
- Unassured power supply	28	15
- Inadequate availability of quality planting material	26	14
- High fluctuation in price of banana	25	14
- High cost of fertilizer	18	4
- Labour shortage at peak period	14	12
(B) Soil and water related problems		
- Inadequate knowledge about fertilizer management	11	7
- Inadequate knowledge about drip system	8	-
- Poor after sale service	2	-
(C) Crop improvement and plant protection		
- Infestation of disease	22	10
- Stunted growth during winter	12	13
- Need to develop new variety	9	3
- Early flowering	7	3
- Fruit scorching during summer	6	3
- Lodging of banana	5	3
(D) Others		
- High cost of planting material	18	9
- Quality of water	4	1

Conclusions

Based on the information obtained through survey, it is concluded that though farmers are realizing major benefits in term of saving in water, labour cost and weeding expenses along with increase in yield, yet there is need to train the farmers in fertigation and maintenance of system so as to derive maximum possible advantages of the system simultaneously. There is need to take necessary steps by government for assured power supply and timely availability of quality planting material. This will enable to raise the area under drip method of irrigation and enhancing crop productivity as well.

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19. Fertigation and planting geometry studies on tomato

N. D. Desai, A. M. Bafna and R. G. Patil

Source: Green farming J. (2012)

Abstract

A field experiment was conducted at soil and Water Management Farm, N.A.U., Navsari during the late *Rabi* season for two years on fertigation and planting geometry of tomato (*Lycopersion esculentum* Mill). The treatment comprising of ten combinations of two planting geometries (G_1-normal and G_2-pair row planting) and four levels of drip fertigation *viz.*, F_1-100, F_2-80, F_3-60 and F_4-40 per cent of recommended doses of NPK (RDF) with one control for each geometry ($G_1F_1(C_1)$ and $G_2F_1(C_2)$, surface irrigation with 100 per cent RDF) were tried in a RBD with four replications. The soil of the experimental plot was clay in texture, low in available N, medium in available P and high in available K. Of the two systems evaluated, drip emerged more productive and efficient as it significantly enhanced the fruit production and marketable yield, besides saving 33 per cent water, achieving higher fertilizer use efficiency and recording less competition from weeds. Economically also, drip showed 41 per cent higher net return over surface irrigation. The comparison between the planting geometries indicated paired row significantly superior over the normal planting in respect of almost all the growth, yield attributes as well as tomato yield. The gain in fruit yield under the former over latter was 4.62 t/ha. Paired row planting registered additional net income of about Rs. 22,000/- /ha. over normal planting. Reduction in fertilizer level from 100 to 60 per cent RDF restricted the plants from excessive vegetative growth and, in turn, enhanced the reproductive growth as well as fruit yield. Lowering the dose to 40 per cent RDF resulted in the lowest values of all the vegetative and reproductive growth parameters, however, fruit yield was at par with 100 per cent fertigation level, All the fertigation treatment recorded significantly higher fruit yield as compared to control (Surface irrigation with 100% RDF). The net realization obtained under different treatments followed the same trend as that of fruit yield. Thus, 5.3 per cent higher yield and Rs. 13460 ha more net realization can be obtained with 40 per cent saving in fertilizer as compared to 100 per cent RDF.

Key word: *Drip v/s Surface, Economics, Fertigation, Planting geometry, Tomato yield.*

Introduction

The major reasons for the negligible share of India in the world tomato exports are i) high domestic demand ii) low productivity (14.5 t/ha) and iii) non confirmation of the produce to international quality standards. As far as Gujarat is concerned, tomato is grown on 15 thousand ha with a production of 1.80 lakh tones but the productivity is low being 11.7 as against the national average of 14.5 and the world average of 27.2 t/ha.

High yielding and input responsive varieties/hybrids possessing superior quality fruits are now available in the country in good number but their production potential has remained unrealized due mainly to inefficient system of irrigation. Inadequate use of fertilizer and low fertilizer use efficiency. There is enough research evidence available from foreign journals indicating superiority of drip over the furrow and other surface methods of irrigation. However, drip has not favour among the Indian farmers because of the high initial investment involved in its installation.

The cost of drip can be minimized by changing the planting geometry of crop *i.e.* irrigating two or more plant rows per lateral or more than two plants per dripper. But such studies has been rare and non in Gujarat on tomato. The relevance of a study on planting geometry for a drip based cropping system which much more for a state like Gujarat. Where,

the water is scare and evapotranspiration losses are high. Besides water, fertilizer is the another major important input required for raising a good crop. The fertilizer use in India is low in almost all crops as compared to developed nations. It is so because of the high prevailing prices of fertilizers except nitrogenous, which makes it out of the reach of the farmers especially the vegetable grower who in most cases are marginal and poor. Low fertilizer use efficiency in surface irrigated fields also erodes farmers profit. In order to achieve higher returns from the investment made in fertilizer it is always advisable to split the dose in to as many installment as possible and make spot application but this physically unfeasible and costly, when done manually. The problem of low fertilizer use efficiency can be best tackled by drip fertigation, which enables us to apply as much as quantity as and when required. The present study was undertaken to study the effect of fertigation and planting geometry on growth yield attributes and yield of tomato under South Gujarat condition.

Materials and methods

A field experiment was conducted at soil and Water Management Farm, NAU, Navsari during the late *Rabi* season for two years on fertigation and planting geometry on hybrid tomato (*Cv. Avinash-2*). The treatment comprising of ten combinations of two planting geometries (G_1-(1.0m x 0.50m) normal and G_2-(0.50m x 1.50m) pair row planting) and four levels of drip fertigation *viz.* F_1-100, F_2-80, F_3-60 and F_4-40 per cent of recommended dose of NPK (250-125-125 NPK kg/ha) with one control for each geometry ($G_1F_1(C_1)$ and $G_2F_1(C_2)$, Surface irrigation with 100 per cent RDF) were tried in a RBD with four replications. The statistical analysis was carried out by RBD for comparing drip with surface (control) and by factorial randomized block design (FRBD) considering treatments T_1 to T_4 and T_6 to T_9 (Except treatments T_5 and T_{10}, control plots) to study the various levels of geometry and fertigation singly and in combination (G x F). The soil of experimental plot was clay in texture, low in available N (226 kg/ha), medium in available P (26 kg/ha) and high in available K (410 kg/ha). The fertilizer used in study were urea-phosphate (17-44-0 NPK), liquid fertilizer (9-0-9 NPK), urea (46-0-0 NPK) and muriate of potash containing 60 per cent K. The transplanting of seedling was done in first week of January during first year while during second year it was in last week of January. Half of the nitrogen and potash, and whole phosphorus in fertigation levels (F_1 to F_4) were given in four equal splits at weekly interval beginning from 14^{th} day after transplanting during both the years of experimentation. The remaining half doses of nitrogen and potash were applied from 42^{nd} days on wards in 12 equal splits at weekly interval. The treatment wise respective fertilizers were administrated in *venturi* at a specified pressure and discharge rate so as to have uniform rate of application. In surface irrigated plots (control) the entire quantity of P, K and 50 kg N/ha were applied through urea phosphate and muriate of potash after proper establishment of plant (14 DATP) and remaining 200 kg N was given in three splits through urea. The first two splits consisting of 75 kg N/ha were applied at 30 and 50 days after transplanting, where as the third installment comprising 50 kg N/ha was given at 65 DATP.

Irrigation in drip irrigated plots were scheduled on alternate days at the recommended 0.6 fraction of pan evaporation (FPE) The number emitters per plot in paired were half (12 no) than normal planting (24 no.) and hence the drip system was run for double the time in paired row planting than in normal planting to give equal quantity of water in both the planting geometries. In control plots, the irrigations were scheduled at the recommended 0.8 IW/CPE ratio with 80 mm depth. The average total quantity of water applied in drip fertigated plots were 480, 452 and 466 mm, respectively, while 700 mm water was applied in control plots in nine irrigations (second irrigation of 60 mm). A firm support (stake) was given to each plant by staking and tying branches with string to the wire passing above *i.e.* so called telephonic system locally. Fully matured orange to red colored fruits were harvested

(picked) in 17 and 14 pickings during first and second year, respectively. Different observations on growth and yield attributing characters, yield *etc.* were recorded.

Results and discussion

Drip Vs Surface

It is evident from the data presented in **Table 1** that irrespective of crop geometry and fertigation levels, the tomato yield under drip irrigation was significantly higher over surface method (C_1 and C_2). In general drip irrigated plants were taller than surface irrigated. The result of pooled analysis indicated that among the various drip treatments the plant grown under G_2F_1 recovered significantly taller plant height and number of leaflets per plant but it was at par with G_1F_1, G_2F_2 and G_2F_3 and significantly taller compared to those under control (C_1 and C_2). Among the difference treatments combinations which showed significantly higher number of branches per plant and yield per plant over surface (C_1 and C_2) were G_2F_3, G_2F_2 and G_2F_1. The yield attributing parameters like mean weight of tomato fruit, number of fruit per plant and yield per plant were also significantly influenced due to drip fertigation treatment and proved its superiority over surface method except in G_1F_1 and G_1F_4 in all most all yield attributes. Thus, the tomato yields under drip irrigation was significantly higher over surface method (C_1 and C_2). The mean increase recorded by drip treatment over controls ranged from 10.58 to 37.45 per cent.

Drip irrigated tomato plants (at all the four levels of fertigation) recorded significantly more plant height, number of leaflets, number of branches, mean weight of tomato fruits and numerically number of fruits and yield in kg per plant and eventually the fruit yield than control plot (surface irrigated with 100 per cent RDF as band placement). These results are in agreement with the findings of Dhake (1995) and Lara *et al.,* (1996). Better growth and higher yield under drip irrigation could be attributed to i) steady availability of soil moisture to the plant throughout its growth period ii) consistent and uniform availability of nutrient as reflected by higher N, P and K uptake iii) Comparatively less competition of weeds and probably better soil aeration and prevention of leaching losses of nutrients. Similar reasons have also been advocated by Ahulwalia *et al.,* (1993), Bafna *et al.,* (1993) and Shrivastava *et al.,* (1994). Over all the drip system enhanced the fruit yield by 23 per cent and saved 33 per cent water. Thus, water saved can be utilized for bringing additional area under irrigation and in turn more benefit.

Fertilizer use efficiency (FUE) under drip fertigation was significantly higher than band application combined with surface irrigation except, G_1F_1 and G_2F_1. Dry weight of weeds was significantly less under drip than surface irrigation, except under G_1F_1. Drip fertigation treatments recorded significantly higher net realization over their counter parts *i.e.* surface irrigation with 100 per cent fertilizer as band placement. The average gain *i.e.* additional net realization ranged from Rs. 24777 to 52998/ha. These results substantiate the findings of Jadhav *et al.,* (1990) and Anonymous, (1997), who also reported that drip was more economical than surface method of irrigation. There are reports to this effect from studies under taken by the farmers them selves conforming the superiority of drip in economic terms over surface method (Gala, 1992).

Effect of Geometry

It is seen from the data in **Table 2** that, of two geometries tried, paired row planting significantly registered higher growth and yield attributes and eventually the tomato production as compared to normal planting. The mean increase in tomato yield recorded by paired row planting over normal planting was 4.62 t/ha. The results are in consonance with those of Frost and Kretchman (1988) and Satpute and Pawade (1992). The fruit yield per plant is, in turn governed by the mean fruit weight and number of fruit per plant, both of which recorded significantly higher values under paired row than normal planting. The growth characters (Plant height , No. of leaflets, branches/plant) registered significantly

higher values under paired row planting as compared to normal planting substantiate the superiority of the former over the latter in regards to plant development. Higher plant growth and yield under paired row planting could be attributed to lower evapo-transpiration and volatilization losses and there by greater availability of water and nutrients (Singh,1978). Greater canopy coverage as reflected by increased leaflet number and in turn higher light interception and markedly lower growth could have also contributed for superiority of twin over single row system. Marked differences was observed in net income between paired row and normal planting geometries. The magnitude of increase in net return was 19.8 per cent. Similarly higher return under paired row planting was also reported by Singh (1978) and Anonymous (1999). The reason for higher net return under paired rows are apparently the higher yield and 50 per cent saving in the cost of lateral line.

Effect of Fertigation

The perusal of data presented in **Table 1** indicated a gradual increase in yield with the decrease in the rate of fertilizer application from 100 to 60 per cent. However, further reduction in fertilizer dose decreased crop yield as F_4 recorded the lowest production. On the whole F_3 with 64.21 t/ha recorded the highest yield but it was at par with F_2 (62.38 t/ha) and significantly superior to F_1 (60.98 t/ha) and F_4 (58.62 t/ha). The superiority of F_3 in terms of percentage over F_1 and F_2 was 5.30 and 2.93, respectively. These results are in conformity with those obtained at PDC, Rahuri, where 80 per cent fertilizer dose yielded higher and 60 per cent equal to 100 per cent RDF under Fertigation. (Anonymous, 1998). Like wise, Singh *et al*., (1989) found 100, 75 and 50 per cent fertilizer doses statistically at par in fruit yield under fertigation.

The pattern of response in all the yield attributing parameters was identical. These results illustrate luxury consumption of N, P and K by plant when fertigated with levels above 150-75-75 N, P_2O_5 and K_2O kg/ha. Higher fruit yield under 80 and 60 per cent fertilizer dose could be arrived to greater diversion of photosynthesis to the development of sink than towards the vegetative growth as reflected by relatively lower plant height and leaflet number under these treatments vis-à-vis 100 per plant RDF. The lower yield under 100-50-50 N, P_2O_5 and K_2O kg/ha (F_4) seems to lie in general reduction in plant growth and yield attributing characters due to short supply of nutrients. The fertilizer use efficiency significantly increased with decrease in fertilizer dose, highest being under 40 per cent RDF.

The net income was highest under 60 per cent RDF being Rs. 1,37,374/ha but it was at par with 80 per cent RDF recording Rs.1,30,016/ha and significantly higher than 100 per cent (Rs.1,23,914) and 40 per cent RDF (Rs.1,19,675/ha). Income wise 100 and 40 per cent RDF were statistically at par showing same trend as fruit yield. These results are in agreement with Ibrahim (1992) who reported significant reduction in cost of crop production under fertigation. Greater net income under 60 per cent RDF *vis-à-vis* 100 per cent fertilizer dose was facilitated by the significantly higher fruit yield on the hand and 40 per cent saving in fertilizer on the other hand.

Conclusion

Based on the results of two years study, it can be concluded that drip fertigation in twin row (paired row) system is more efficient, productive and cost effective as it enhanced the fruit yield by 23 per cent, saved 33 and 40 per cent water and fertilizers, respectively than surface method of irrigation with 100 per cent RDF as band placement.

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Table 1. Growth, yield attributes and other characters as influenced by various treatments (pooled data of two years)

Treatments	Plant height at 90 DAT (cm)	No. of leaflets /plant 90 DAT	No. of branches / plant at 90 DAT	Mean weight of tomato fruit (g)	No. of fruit / plant	Yield / plant (kg)	Fruit yield (t/ha)	FUE (kg fruit / kg of NPK)	Dry weight of weed (kg/ha)	Net income (Rs/ha)
1	2	3	4	5	6	7	8	12	13	14
G_1F_1	69.61	60.73	13.00	40.23	61.04	2.82	58.93	117.87	649	113644
G_1F_2	68.65	59.23	13.32	42.53	61.93	3.06	59.36	148.39	577	116339
G_1F_3	67.51	58.80	13.95	43.89	63.80	3.23	61.81	206.02	433	125893
G_1F_4	64.57	53.87	13.07	38.19	60.04	2.68	56.85	284.26	376	110367
$G_1F_1(C_1)$	60.97	50.17	11.65	35.36	55.72	2.28	48.47	96.93	968	85590
G_2F_1	72.27	63.71	14.45	45.20	63.99	3.30	63.03	126.07	462	134183
G_2F_2	71.02	62.85	14.82	47.23	65.52	3.50	65.40	163.47	382	143693
G_2F_3	69.54	60.68	15.77	48.81	66.21	3.68	66.62	222.06	356	148855
G_2F_4	67.55	56.99	13.32	42.15	62.12	3.05	60.39	301.93	351	128982
$G_2F_2(C_2)$	64.76	54.06	11.95	37.27	57.56	2.43	51.41	102.81	725	95857
S.Em ±	1.08	1.51	0.54	1.60	1.44	0.10	1.31	7.42	26	5239
C.D. at 5%	3.07	4.26	1.52	4.52	4.08	0.33	3.70	23.73	82	14811

Table 2. Growth, yield attributes and other characters as influenced by planting geometries and fertigation (Pooled data of two years)

Treatments	Plant height at 90 DAT (cm)	No. of leaflets / Plant at 90 DAT	No. of branches / plant at 90 DAT	Mean weight of tomato fruit (g)	No. of fruit / plant	Yield / plant (kg)	Fruit yield (t/ha)	FUE (kg fruit / kg of NPK)	Dry weight of weed (kg/ha)	Net income (Rs/ha)
1	2	3	4	5	6	7	8	12	13	14
Planting Geometry (G)										
G_1=Normal	67.58	58.16	13.34	41.21	61.70	2.95	59.24	189.13	509	116561
G_2=paired	70.09	61.06	14.59	45.85	64.46	3.38	63.86	203.38	388	138928
Level of fertigation (F)										
F_1 : 100% RD	70.94	62.22	13.73	42.71	62.52	3.06	60.98	121.97	555	123914
F_2 : 80% RD	69.83	61.04	14.08	44.88	63.72	3.28	62.38	155.93	480	130016
F_3 :60% RD	68.52	59.74	14.86	46.35	65.00	3.46	64.21	214.03	395	137374
F_4 : 40% RD	66.06	55.43	13.20	40.17	61.08	2.86	58.62	293.09	363	119675
S.Em ±										
G	0.52	0.79	0.29	0.70	0.77	0.03	0.62	2.21	26	2480
F	0.71	1.10	0.40	0.99	1.09	0.08	0.86	8.56	41	3427
G x F	0.99	1.54	0.57	1.40	1.55	0.06	1.21	4.42	20	4854
C.D. at 5%										
G	1.48	2.26	0.81	2.00	2.21	0.08	1.77	6.31	NS	7078
F	2.04	3.14	1.15	2.83	NS	NS	2.44	38.50	NS	9767
G x F	NS	NS	NS	NS	NS	NS	NS	NS	57	NS

20.Water management technology for higher productivity of castor (*rabi*) on clay soil

N. D. Desai, V. R. Naik, N. G. Savani and R. G. Patil

Source: Green farming J. (2012)

Abstract

Castor is *kharif* season crop but it can be grown successfully during *rabi* season after *kharif* paddy with a very small amount of water. In order to enhance the productivity of *rabi* (Oct-May) through appropriate water management technology, three field experiments were conducted at Soil and Water Management Farm, NAU., Navsari (Gujarat) with the objectives to find out schedule of irrigation through drip as well as surface methods of irrigation along with fertigation and mulching . The experimental soils are clay in texture, low in available N, medium in available P and high in available K with high moisture retention capacity. The results of first experiment on drip irrigation and ferigation revealed that irrigating the crop at 0.4 PEF resulted in 38 per cent saving of water as compared to surface method of irrigation. Similarly, fertilizing with drip could save about 40 to 60 per cent fertilizer. The results of another study indicated that irrigating *rabi* castor at 0.6 IW/CPE ratio and mulching with sugarcane trash gave significantly higher seed yield of (3 t/ha) as compared to control. Similarly, mulching with sugarcane trash @ 5 t/ha could enhance the seed yield by 15 per cent and that with black plastic mulch 25 per cent. Another study involving drip method of irrigation under constraint of irrigation water showed that castor sown in paired row (60 x 60 x 120 cm) along with adoption of drip method of irrigation could save 39 per cent water and 40 per cent fertilizer. From the results of different studies, it is concluded that *rabi* castor seems to be more remunerative than existing crops in general and than summer paddy in particular.

Key words: *Castor, Fertigation, Irrigation (surface + drip), Mulching*

Introduction

As the problems of water logging and salinity are on the rise in South Gujarat owing to high rainfall, high clay containing soils and adoption of high water consuming crops like sugarcane, paddy, banana *etc*. Among these crops, paddy crop requires about 2000 mm water (*kharif* + summer) which aggravate the problems of water logging and salinity (Raman and Desai, 1997). Castor is basically *kharif* season crop, but it can be grown successfully during *rabi* season after *kharif* paddy with small amount of water (300-400 mm). The low water requirement coupled with higher net profit with *rabi* castor in comparison to the prevailing *rabi* and summer crops under South Gujarat situation resulted in adoption of this crop on large scale. However, still there is good scope to enhance castor productivity under South Gujarat situation through adoption of appropriate water management practice including methods of irrigation, fertigation and mulching. The results of some of the experiments conducted on these aspects are presented in this paper.

Materials and methods

For enhancing the productivity of *rabi* (Nov.-May) castor (cv: GCH-4), three field experiments were conducted at Soil and Water Management Farm, NAU, Navsari (Gujarat). The first experiment was conducted to study response of drip irrigation and fertigation during *rabi* seasons of 1996-97 and 1997-98. In all, 13 treatment combinations consisting of three levels of drip irrigation each of fraction cumulative pan evaporation (FCPE, 0.4, 0.6 and 0.8) and four fertigation levels (100, 80, 60 and 40 % of recommended dose of fertilizer *i.e.* 100-50-00 NPK kg/ha) were tried in RBD along with one surface method control (IW/CPE 1.0 and Depth: 60 mm). The crop was sown in paired row of 60 x 60 x 120 cm. Similarly, second experiment was conducted with three levels each of IW/CPE ratios (R_1:0.4, R_2:0.6 and R_3:0.8) and mulches (M_0:No mulch, M_1: Sugarcane trash @ 5 t/ha and M_2: Black plastic

mulch, 50 micron) in RBD during *rabi* seasons of 2002-03 to 2004-05. The normal plant spacing of 90 x 60 cm was followed in this study.

The third experiment was conducted to study the irrigation and planting management during *rabi* seasons of 2004-05 and 2005-06 with FRBD. There were three treatments of method of irrigation (D(p): drip at 0.4 PEF, paired row planting- 60x60x120 cm, Fr(P): furrow, 0.6 IW/CPE, depth=40mm, paired row planting and Fb(N): flatbed : 0.8 IW/CPE, depth-60mm, normal planting: 90x60cm and three mulches (M_0: No mulch, M_T: sugarcane trash mulch @ 5 t/ha and M_B: black plastic mulch: 50 micron). The experimental soil (*Vertic Ustochrepts*) is clay in texture, low in available N, medium in P and high in K with high moisture retention capacity. All the data recorded in these experiments were analysed statistically.

Results and discussion

The results of present studies revealed that interaction effects between irrigation levels either with fertigation (**Table1**) or mulching (**Table 2 and 3**) were not significant on seed yield of castor. However, the seed yield of castor was affected significantly due to fertigation levels (**Table 1**). Here, the seed yield of about 6 t/ha was recorded with the treatments receiving fertilizer through drip at 40 or 60 per cent of recommended dose. This suggests that saving of fertilizer up to 60 per cent and water up to 40 per cent could be achieved. Malavia *et al*.(1999) also reported higher yield of castor under 0.6 FPE with fertigation at 75 kg N/ha. The results of another study indicated significant individual effect of irrigation levels and mulching (**Table 2**). Irrigating *rabi* castor at 0.6 IW/CPE ratio and mulching with sugarcane trash gave significantly higher seed yield of castor (3 t/ha) as compared to control *i.e.* irrigation at 0.4 IW/CPE and no mulch (2.3 t/ha). 25 per cent increase in yield of castor with castor shell mulch was reported by Patel *et. al*. (1999) in rainfed condition at Sardar Krushinagar while 20 per cent higher yield of castor with either black plastic mulch or straw mulch in irrigated castor was recorded at Junagadh (Anonymous,1998). Another experiment was conducted so as to reduce the cost of drip system through modifying planting geometry. The results revealed that drip irrigation scheduled at 0.4 PEF in paired row planted castor recorded almost similar seed yield (2.3 t/ha) which was obtained with surface control with normal planting (2.5 t/ha). This resulted in saving of water to the extent of 39 per cent (**Table 3**). Patel *et. al* (2004) also reported 25 per cent saving of irrigation water under drip irrigation compared to surface irrigation.

The results of all these studies have clearly proved that castor can be grown after *kharif* paddy (*kyari* land) with an average productivity of 2.5 to 3.0 t/ha as against the state average productivity of 1.8 t/ha of *kharif* castor. If the water requirement of existing crops of summer paddy (1200 to 1500 mm) or sugarcane (1400 mm) is considered, then *rabi* castor (360 mm) seems to be a promising option. This is because of the reason that the net profit of Rs. 27,500/ha (seed yield 2.5 t/ha x Rs.15.00/kg =Rs.37,500/ha - cost of cultivation Rs. 10,000/ha) could be obtained with *rabi* castor as against Rs.13250/ha with summer paddy (grain yield 4.5 t/ha x Rs.6.5/kg =29250 - Rs.16000/ha cost of cultivation). So, there is need to popularize cultivation of *rabi* castor among the farmers of South Gujarat as it will not only mitigate the problem of water logging and salinity of soils but will also double the income of farmers.

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Table 1. Seed yield of castor (t/ha) under different levels of irrigation and fertigation (pooled over 1996-97 to 1997-98)

Irrigation levels (PEF)	Fertigation levels (% of RD)				Mean	Quantity of water applied (mm)	Net profit (Rs./ha)
	100 (F_1)	80 (F_2)	60 (F_3)	40 (F_4)			
I_1= 0.40	4.80	5.72	6.09	7.26	5.97	421 (14.18)	48.08
I_2= 0.60	5.58	6.06	6.54	6.87	6.26	540 (11.58)	51.29
I_3= 0.80	5.69	5.86	5.85	6.71	6.03	6.58 (9.16)	45.56
Mean	5.36	5.88	6.16	6.95			
Control	5.49					680 (8.07)	
	I	F	IXF				
CD at 5%	NS	0.73	NS				

( ) = Value in parenthesis are WEE (kg/ha-mm), RD: 100-50-00 NPK kg/ha, N in 6 splits

Table 2. Seed yield of castor (t/ha) as influenced by irrigation levels and different mulches (Pooled over 2002-03 to 2004-05)

Treatment (IW/CPE) D=60mm	Mulches			Mean	Quantity of water applied (mm)	Net profit (Rs./ha)
	M_0	M_T	M_G			
R_1 (0.4)	2.318	2.69	2.82	2.6	300 (8.68)	24290
R_2 (0.6)	2.59	3.16	3.16	3.0	360 (8.25)	30165
R_3 (0.8)	2.78	3.17	3.49	3.1	420 (7.49)	32620
Mean	2.56	3.01	3.16			
	R	M	RXM			
CD at 5%	0.2	0.2	NS			

( ) = values in parenthesis are WEE (kg/ha-mm)

Table 3. Seed yield of castor (t/ha) under different treatment (pooled over 2004-05 to 2005-2006)

Method of irrigation (I)	Mulches			Mean	Volume of water applied (mm)
	M_0	M_T	M_G		
Drip 0.4 PEF (D(P))	2.0	2.4	2.4	2.3	344 (6.88)
Furrow 0.6 IW/CPE D=40mm (Fr(P))	1.7	1.8	1.7	1.8	458 (3.93)
Flat bed (0.6 IW/CPE)	2.5	2.7	2.4	2.5	546 (4.58)
Mean	2.1	2.3	2.1		
	I	M	IXM		
S.Em ±	0.092	0.092	0.159		
CD at 5%	0.3	NS	NS		

( )= data in parenthesis are WEE (kg/ha-mm)

P = Paired row (60 x 60 x 120 cm)

Abstracts

1. Lateral Spacing and Fertigation Study in Sweet corn under South Gujarat conditions

V. R. Naik, R. B. Patel, B. M. Solia, M. R. Gamit, J. M. Patel, and R. G. Patil

Source: Seminar on Recent Outlook on Sustainable Agriculture, Livelihood Security and Ecology of Coastal Region, ISCAR, Goa (2010)

Abstract

A field experiment with sweet corn as a test crop was conducted at Soil and Water Management Farm, Navsari Agricultural University, Navsari (Gujarat). The treatments comprised of three levels each of different lateral spacing (120, 180 and 240 cm) and fertigation (60, 80 and 100 % RDF of N & K) under drip along with surface method of irrigation as control (1.0 IW/CPE, 60 mm depth, RDF=100 %) in FRBD during 2006-07 and 2007-08. The experimental soil is classified as *Vertic Ustochrept*s having no problems of salinity and alkalinity. The soil tested low in organic C, medium in available P and high in available K content. The results indicated that the fresh cobe and fodder yield were affected significantly due to different treatments during individual years as well as in pooled analysis. In all the cases, a combination of 100 % N with lateral spacing of 120 cm *i.e.*, in alternate row of sweet corn planted at 60 cm row spacing recorded significantly higher fresh cobe and fodder yield as compared to rest of the combinations. This also true for the growth and yield attributes. The net realization with this treatment was also more than the remaining treatments.

2. Drip, Mulching and Fertigation studies in Brinjal under South Gujarat Conditions

S. J. Patil, B. M. Solia, N. G. Savani, A. P. Patel, D. R. Prajapati, and R. G. Patil

Source: Seminar on Recent Outlook on Sustainable Agriculture, Livelihood Security and Ecology of Coastal Region, ISCAR, Goa (2010)

Abstract

Large plot experiment was conducted with two treatments *viz.,* i) Improved Practices (IP) - drip @ 0.6 PEF + black plastic mulch @ 45 % area coverage (25 micron) and ii) Conventional practices (CP) – irrigation scheduled at 1.0 IW/CPE, 60 mm depth using brinjal (cv. Surati Ravaiya) as test crop at Soil and Water Management Farm, Navsari Agricultural University, Navsari (Gujarat) during 2004-05 to 2006-07. The experimental soil is classified as *Vertic Ustochrept*s having no problems of salinity and alkalinity. The soil tested low in organic C, medium in available P and high in available K content. The results indicated that an adoption of improved practices (drip irrigation, black plastic mulch and fertigation) recorded higher fruit yield during all the years and ultimately in the average also. On overall basis, the magnitude of increase in fruit yield with improved practices (IP) over conventional practices (CP) was around 40 per cent. This was amply reflected on growth *viz.,* primary branches, secondary branches, height of plant (m), number of leaf /plant and total leaf area/ plant (cm^2) and physiological parameters *viz.,* CO_2 vpm (cref), Qleaf, u, Atmosphere pressure (p), sub stomatal CO_2 vpm (ci), eref, Delta H_2O mBar (^e), Delta CO_2 leaf mBar (^c), Tch, TI, Transpiration rate $m.mol.m^{-2}.s^{-2}$ (E), gs and Photosynthesis rate $\mu.mol.m^{-2}.s^{-2}$ (A). Beside considerable increase in fruit yield, water and fertilizer N saving of the order of 40 and 20 per cent, respectively, was also achieved. Not only this, but also adoption of IP realized 44 % higher net profit in comparison to CP.

3. Standardization of Low Energy Drip System for Hilly Regions of South Gujarat

B. M. Solia, N. G. Savani, S. J. Patil, J. M. Patel and R. G. Patil

Source: Seminar on Recent Outlook on Sustainable Agriculture, Livelihood Security and Ecology of Coastal Region, ISCAR, Goa (2010)

Abstract

An experiment was conducted on "Standardization of Low Energy Drip System for Hilly Regions of South Gujarat " with two factors *viz.,* i) crops (Brinjal and chilli) ii) low cost drip, for brinjal A_1 (4.8 x 1.8 m one lateral), A_2 (4.8 x 3.6 m two laterals), A_3 (4.8 x 5.4 m three laterals) and A_4 (4.8 x 7.2 m four laterals) and for chilli A_1 (4.8 x 1.2 m one lateral), A_2 (4.8 x 2.4 m two laterals), A_3 (4.8 x 3.6 m three laterals) and A_4 (4.8 x 4.8 m four laterals) in FRBD with three replications at Soil and Water Management Farm, Navsari Agricultural University, Navsari (Gujarat) during 2001-02 and 2002-03. The results indicated that in both the years, out of two crops tested, growth and yield of chillies was very poor due to heavy pest infestation. Similarly, during both the years, with the same volume of water applied, yield of brinjal crop was found to increase with increase in the area under irrigation *i.e.* increase in WUE. On pooled basis, magnitude of increase in yield of brinjal was 33, 85 and 131 per cent with A_2, A_3 and A_4, respectively, over A_1. The individual effects of area and crops as well as their interaction were significant on the monetary equivalent (ME) during both the years. Among the areas, ME was found to increase significantly with increase in the area under irrigation. Between the two test crops, brinjal showed superiority over chillies in terms of ME. Among the combinations, taking brinjal crop in 34.56 m^2 area *i.e.* with 4 lateral spaced at 1.8 m recorded significantly higher ME values of Rs. 345 and 457 per 5000 liter water during 2001-02 and 2002-03, respectively. Almost similar trend was also observed in pooled analysis.

4. Comparative study of different sleeving materials in banana

Solia, B. M., Usadadiya, V. P., Savani, N. G. and Patel, K. K.

Source: National Conference on Technological Changes and Innovations in Agriculture for Enhancing Farmers' Income held during 28-31/5/2017 at JAU, Junagadh (2017), Page: 65

Abstract

A field experiment in banana (spacing: 2.4 m x 1.2 m) was carried out with five treatments of different sleeving materials (S_1: Blue plastic film, S_2: PP non woven, S_3: Transparent plastic, S_4: News paper and S_5: Control) in RBD design with four replications during 2013-14 to 2015-16. The different treatments were applied just after full emergence of fruits in bunch. The irrigation and fertigation (60 % of N and K of RDF:300:90:200 g NPK/Plant) were applied through drip (0.6 PEF at alternate day). Effect of yield attributes and yield under different treatments was found not significant. Microbial loads were observed minimum under sleeving with plastics and non-oven film as compared to control treatment and it effect on market value. Net income was found Rs. 35112/ha more under treatment transparent plastic followed by treatments blue plastic film and PP non woven film compared to control treatment *i.e.,* without sleeving. The other observation *viz.,* maturity days of bunch after emergence of inflorescence, ripening days of fruit after harvest and weight loss in fruit under different treatments were found narrow in range nearer to its average values.

The adoption of innovative technology *i.e.,* sleeving as a transparent or blue plastis or PP non oven after full emergence of fruits in bunch of banana, the income of the farmer's enhance from banana cultivation under South Gujara condition.

5. Irrigation Management in Pointed gourd under South Gujarat Conditions

Savani, N. G., Solia, B. M.,Patil,S.J.,Patel, R. B. and Patil, R. G.

Source: National Conference on Technological Changes and Innovations in Agriculture for Enhancing Farmers' Income held during 28-31/5/2017 at JAU, Junagadh (2017), Page: 85

Abstract

Pointed gourd is an important vegetable crop of this zone. This crop is very sensitive to excess water situation which causes wilt disease. The severity of wilt is accentuated in high clay containing soils and more so when conventional method of irrigation is followed. In order to generate information on water management aspects of pointed gourd, field experiments were conducted during 2007 to 2009 at Soil and Water management Farm, NAU, Navsari (Gujarat). The experimental soil is clay in texture, low in available N, medium in available P and high in available K with high moisture retention capacity. The results of experiment revealed that the treatment with drip irrigation @ 0.6 PEF(I_2) recorded significantly higher length and average weight of fruit which were closely followed by surface irrigation at 1.0 IW/CPE ratio(I_3). Among the mulching treatments, no mulch (Mo) treatment recorded significantly higher volume of fruit (44.1 ml) as compared to trash mulch (M_T)(40.8 ml) and black plastic mulch(M_B)(38.8ml). Here, the combination I_2 M_T (5.1 %) and I_3 M_B (5.1%) recorded identical values of TSS and both these treatments were significantly higher than I_2M_0 (4.1 %), I_3M_T (4.4%) and I_1M_T (4.3%) treatments.

Based on the yield results of the experiments indicated that irrigation through drip @ 0.6 PEF along with black plastic mulching in pointed gourd was found to be the best treatment for getting 47 per cent higher fruit yield and 42 per cent more net income than the surface control without mulch. This treatment could also lead to water saving to the extent of 37 per cent.

6. Effect of NAA and GA_3 on yield of capsicum grown under poly house conditions

Solia, B. M., Savani, N. G., Patel, A. P. and Patil, R. G.

Source: National Conference on Technological Changes and Innovations in Agriculture for Enhancing Farmers' Income held during 28-31/5/2017 at JAU, Junagadh (2017), Page: 66

Abstract

The experiment was laid out in Completely Randomized Design with factorial concept comprising three different growing conditions *i.e.* i) C_1 = Fan and fad cooling poly house ii) C_2 = Naturally ventilated poly house, iii) C_3 = Open field and five different levels of PGR's *viz.,* NAA 10 mg l^{-1}, NAA 20 mg l^{-1}, GA_3 50 mg l^{-1}, GA_3 100 mg l^{-1} and control (water spray) and repeated five times during 2007–08 to 2009-10. Two sprays were applied first spray at flower initiation and second spray on 10 days after first spray The drip system was operated at 1.2 kg/cm^2 pressure wherein drippers were placed at 100 cm spacing with 8 lph discharge rate. Plants fed with 240:120:120 kg NPK/ha + 10 t biocompost (BC) /ha. N & K was applied through drip in 10 equal splits at an interval of 15 days starting from 15 DAP and whole amount of P was applied as basal at the time of planting in addition to common dose of BC @10 t/ha. The significantly higher fruit yield of 78.64 and 74.27 t/ha was recorded with C_1 and GA_3 100 mg l^{-1}, respectively. As the green houses are generally 100 to 500 m^2 size, the economics was calculated for 100 m^2 green houses. Among the growing conditions, C_1 (fan and pad cooling system poly house) recorded higher net profit of 15026 Rs/100 m^2 with BCR of 1: 1.75. The next in order was C_2 (naturally ventilated poly house) by recording net profit of 12832 Rs/100 m^2 with BCR of 1: 2.66. Out of five PGR treatments, GA_3 100 mg l^{-1} seems to be more remunerative than remaining treatments.

Based on the yield and economics, polyhouse cultivation of capsicum seems to be more profitable than open field cultivation under South Gujarat conditions.

7. Effects of the Modification of Light Intensity in Colour Shade Nets for Growth and Yield of Fenugreek, Coriander and Garlic

C. D. Desai, A. K. Senapati, H. B. Vaidya, C. S. Desai and B. M. Solia

Source: National Seminar on Technology and Sustainability of Protected Cultivation for Hi-Valued Vegetable Crop held during 2-4/2/2018 at NAU, Navsari (2018), Page: 70

Abstract

An investigation on photo selective netting concept was carried out at Soil and Water Management Research Unit Farm, Navsari Agricultural University, Navsari, Gujarat during summer season to study the "Effect of different colour shade nets on biomass yield and quality of fenugreek, coriander and garlic". Plant height was intended to increase with different photo-selective shade nets i.e. highest in red colour shade net (24.76 cm) and lowest open field condition (10.71 cm). The highest plant height was also observed in garlic (22.87 cm) crop as compared to fenugreek and coriander. The growth parameters viz., number of leaves (20.84) and root length (6.78 cm) were significantly higher in red colour shade net treatment in fenugreek crop as compare to other. Number of primary branches was recorded maximum in green colour shade net (6.56) as well as in blue and red colour(6.53) shade net. With the different spice crops i.e. coriander (5.7) had the maximum primary braches and minimum primary branches found in fenugreek (5.5). Minimum days taken for maturity to harvest at green stage of spice crop was found under red (34.2) and green (34.6) colour shade net, while The maximum days taken for harvest at green stage was observed under open field condition (42.3) as well as yellow colour (37.4) shade net.The highest fresh biomass yield of spice crops was registered with red colour shade net (84.31 kg/100 m2) followed by green colour shade net (77.75 kg/100 m2). Lower yield was obtained from open field condition (9.93 kg/100 m2). Higher fresh biomass at green stage was obtained in fenugreek (94.43 kg/100 m2) as compared to remaining crops. The highest dry biomass of spice crop was significantly recorded with white colour (14.4%) shade net which was at par with red colour (13.78%) and green colour (13.49%). Lower dry biomass was obtained in open field condition (10.77) of the spice crops, garlic (16.30%) had higher dry biomass than coriander and fenugreek.

8. Shade Nets Light the Way to Fenugreek, Coriander and Garlic Quality

C. D. Desai, A. K. senapati, C. S. Desai, G. B. Desai and U. I. Patel

Source: National Seminar on Technology and Sustainability of Protected Cultivation for Hi-Valued Vegetable Crop held during 2-4/2/2018 at NAU, Navsari (2018), Page: 93

Abstract

Nets that manipulate light for benefit of the plants grows which is under net is not science fiction. It is a new agro technological concept that is boosting the post-harvest quality of spices crops was carried out at Soil and Water Management Research Unit Farm, Navsari Agricultural University, Navsari, Gujarat during summer season to study the "Effect of different colour shade nets on biomass yield and quality of fenugreek, coriander and garlic". The total sugar content in plant parts of garlic crops grown under white colour shade net (7.7%) recorded significantly the highest value as compared to other growing conditions (6.0%). Starch content was the highest in plants grown under white colour shade net (2.4 %) which was at par with red (2.4%) and green (2.3%) colour shade net. Under net house, higher nitrate content was observed in crop grown in yellow colour shade net (0.1%). Lower nitrate was observed in red, blue and green colour shade net. The highest chlorophyll content was observed from the plant grown under red colour shade net (18.08 mg/g) followed by green colour shade net (17.87 mg/g). Garlic plants recorded the highest chlorophyll content (26.95 mg/g). On the other hand, lower chlorophyll content was observed under the crop grown in open field condition as well as yellow colour shade net.

9. Green Vegetable Garlic Cultivated under Protected Cultivation in off Season

V. P. Usadadia, K. K. Patel, R. B. Patel, C. S. Desai and B. B. Patel

Source: National Seminar on Technology and Sustainability of Protected Cultivation for Hi-Valued Vegetable Crop held during 2-4/2/2018 at NAU, Navsari (2018), Page: 108

Abstract

Garlic (*Allium sativum* L.) is one of the most widely cultivated allium species in the world. There has been immense demand of green garlic and bulb in culinary and medicinal uses. The main therapeutic use of this sulphide rich plant is to reduce the cholesterol and check the cardiovascular problems. Green garlic positioned among the higher remunerative commodity during summer season due to high demand and less availability. Recently the protected cultivation is a trend to produce more yield and quality vegetables in off season. Different colors of shade nets are now use to eliminate the adverse climatic situation for raising crops in protected cultivation. The experiment was conducted during summer seasons of 2014 to 2016 by using 50% shade nets of different color *viz.,* Yellow, Red, White, Blue and Green. The green vegetable garlic cultivated in different five colored shade net house with open field condition. The results obtained from the present findings revealed that the yield in terms of plant height, number of leaves and green biomass of green vegetable garlic were found significantly higher under red color shade net house followed by green color shade net house, while the maximum pungency and chlorophyll content also recorded in the same colored shade net house. In case of economics, net returns and B;C ratio were found higher under the red colored shade net house followed by green colored shade net house during summer season for cultivating the green vegetable garlic under protected cultivation.

10. Response of Different Color Shade Nets House on Yield and Economics of off Season Cultivated Leafy Coriander

C. S. Desai, J. M. Patel, N. G. Savani, P. S. Mistry and V. P. Usadadia

Source: National Seminar on Technology and Sustainability of Protected Cultivation for Hi-Valued Vegetable Crop held during 2-4/2/2018 at NAU, Navsari (2018), Page: 107

Abstract

Growing under protected condition increases the possibility of making produce available in the market earlier. Growers can cultivate leafy vegetable crops in any seasons under shade net house by adjusting the microclimate. Coriander (*Coriandrum sativum* L.) is one of the most important leafy spices grown across the nation. It is a rich source of Vitamin C and K. It is the most adapted leafy spice in food industries for appetite and garnishing. The coriander leaf during summer plummets and it can be achieved by growing under shade net house during summer to fetch higher market deals. The field experiment was carried out on coriander crop for leafy vegetable purpose during summer seasons of 2014 to 2016 using different color shade nets of 50% shade (Yellow, Red, White, Blue and Green) along with open field condition. Significantly the highest plant height, number of leaves, chlorophyll content and fresh biomass yield of leafy coriander were recorded under red colored shade net house followed by green shade net house. The maximum net returns and B:C ration were accrued under red colored shade net house followed by green colored shade net house for cultivating the leafy coriander during summer season.

11.Impact of Vegetable Cultivation under Low Cost Poly House with Low Energy Drip in Tribal Regions of the South Gujarat

M. A. Patel, S. L. Pawar, B. M. Solia, J. M. Patel, C. R. Patel and R. G. Patil

Source: National Seminar on Technology and Sustainability of Protected Cultivation for Hi-Valued Vegetable Crop held during 2-4/2/2018 at NAU, Navsari (2018), Page:251

Abstract

In eastern tribal belt of the south Gujarat, small land holding and water scarcity particularly during *rabi* and summer seasons are the major problems. Low cost poly house (LCPH) with low energy drip (LED) demonstrations (58 nos.) were implemented by SWMRU, NAU, Navsari under FPARP (Farmers' Participatory action Research Programme) project funded by Central Ground Water Board, New Delhi. Out of these demonstrations, majority were demonstrated specifically for growing vegetable nursery, leafy vegetables *etc.* on the field of tribal farmers. The size of LCPH was 5 x 10 m with 1.5 m height on either side and in middle a dome like structure of 3 m height and the top is covered with UV stabilized plastic and the lower sides are closed with 50 % agri-shade net. The data have been collected along with their feedback. The yield (seedlings per 50 m2) was achieved between 4000 for bitter gourd to 23392 for chillies, and water use efficiency (seedlings/50m2lit) was recorded between 2.2 for bitter gourd to 4.5 for tomato. While in case of leafy vegetables, the yield (bundles per 50 m2) was achieved between 22 for green garlic to 1010 for coriander, and WUE (seedlings/50m2lit) was recorded between 0.01 in case of green garlic to 0.28 in case of coriander. In addition to this, monetary benefits *viz.*, cultivation of seedlings in monsoon for better price and timely sowing, high yield and better quality to fetch good price, higher water use efficiency, uniform and better germination, early maturity and harvesting to facilitate more number of crops within short time, more number of cuts in case of leafy vegetables etc. were also achieved as compared to outside which increased the monthly income and thereby raised the social status of the tribal farmer.

12.Green Leafy Vegetable Fenugreek as Affected By Different Colored Shade Net House in Summer Season under South Gujarat Condition

J. M. Patel, C. S. Desai, B. M. Solia, P. S. Mistry and V. P. Usadadia

Source: National Seminar on Technology and Sustainability of Protected Cultivation for Hi-Valued Vegetable Crop held during 2-4/2/2018 at NAU, Navsari (2018), Page: 79

Abstract

Global crisis due to climate changes have adversely affect the current crop production scenario across the world. Increase temperature have plunged the crop yield and quality in open field condition. Fenugreek (*Trigonella foenum-graecum* L.) is an important leafy vegetable crop, its use throughout the year in Indian diet. Both leaves and seeds of fenugreek have medicinal value. Recent studies indicated that fenugreek substantially contain the steroidal substance dysgenic. It is mainly cultivated in winter season, but during summer season the market price is high due to low production in open field condition at that time high temperature adversely affected on growth and development of fenugreek. Mean while protected cultivation is proving its positive effects on crop production. The experiment was laid out using different colored 50% shade nets house of Yellow, Red, White, Blue and Green comparing with open field condition for growing green leafy vegetable fenugreek during 2014 to 2016 in summer seasons. The results revealed that the growth parameters like, plant height, number of leaves and fresh biomass as well as dry matter yield were recorded significantly higher under red colored shade net house. The quality parameters, chlorophyll content were noted higher under same colored *i. e.* red shade net house. In case of economics, net returns and B;C ratio were found higher under the red colored shade net house followed by green colored shade net house during summer season for cultivating the green leafy vegetable fenugreek.

13.Effect of Different Percentage of Green Shade Net in Growth and Fresh Yield of Leafy Vegetables during Summer Season

H.R. Kotadia, S.J. Patil and B. M. Solia

Source: National Seminar on Technology and Sustainability of Protected Cultivation for Hi-Valued Vegetable Crop held during 2-4/2/2018 at NAU, Navsari (2018), Page: 77

Abstract

The present investigation was conducted at Soil and Water Management Research Farm, Navsari Agricultural University, Navsari- 396 450. The results of present investigation revealed that growing of leafy vegetables in shade net situations favoured plant growth and yield. The leafy vegetables are grown in shade net situation favoured plant growth attributes and gave higher production as compared to open field situation during summer season. Amaranthus and spinach grown in 30% shade net produced vigorous growth in terms of plant height, root length, number of leaves and leaf area. In case of fenugreek and coriander grown in 75% shade net gets maximum growth attributes. The leafy vegetables are grown in shade net situation during summer season gave maximum yield than other situations. Particularly, fenugreek and coriander grown in 75% shade net situation, spinach and amaranthus grown in 30% shade net gave maximum yield.

14.Agro textile – A Key For Improving Crop Production

Solia, B. M. , Pawar, S.L., Patil, S. J. and Patil, R. G.

Source: National Conference on "Agrotech, Meditech and Coating & Laminating held at Ahmedabad (/2010)

Abstract

For feeding the ever increasing population under the situation of declining per capita availability of land and water resources, it is imperative to increase the output per unit area, time and inputs. One of the ways to achieve the higher crop productivity is to use agro textile in agriculture. The economically viable major uses of agro textile in agriculture are mulching (ground cover), shade net house, poly house / green house, canal/ pond lining *etc*. The research work done in India have clearly indicated that mulching with black plastic in crops like banana, brinjal, okra, pointed gourd, bitter gourd, marigold, rose, castor *etc* could increase the yield by 13 to 39 per cent, improves quality and induces early maturity as compared to conventional methods of cultivation. Similarly, cultivation under shade net and poly houses also enables the farmers to grow pre-season or off-season crops along with yield increase by 50 to 300 per cent along with improvement in quality. Apart from yield and quality advantages under mulching and shade net / poly houses, efficiency & inputs like water, fertilizer *etc.* also increased considerably. In the cases of canal and pond lining with plastic certainly prevent the percolation losses, thereby saving the precious water resource. In addition to the above uses, there are number of applications of agro textile in agriculture and fisheries sector is the major consumer.

Though, agro textile has tremendous potential in enhancing the crop production along with resources conservation as evident from its growth rate of 8 per cent, yet the quality standards of different agro textile products except nets used in fisheries are not available in India. This is major concern for the farmers as well as manufactures. In this regard, recently the work related to quality criteria has been initiated jointly by SASMIRA, Mumbai (MS) and MANTRA, Surat (Gujarat) along with NAU, Navsari as a testing partner. Output of this joint venture will be equally beneficial to the farming community as well as agro textile industry.

15.Effect of phasic salinity stress and irrigation water salinity levels in presence and absence of mulch on fruit yield of brinjal and soil salinity

Patel, A. M., Vaghasiya, P. M. and Patil, R. G.

Source: ICPPF seminar at Delhi (2005)

Abstract

A field experiment was conducted at Soil and Water Management Research Unit, NAU, Navsari (Gujarat) during 2003-04 at fixed site with 21 treatment combinations comprising 3 phases (15,30 and 45 DAT) 2 irrigation water salinity (EC 4 and 8 dS/m) and 3 mulches (No mulch, sugarcane trash and black plastic mulch) along with 3 mulch control using best available water (BAW)in FRBD. In present experiment drip method of irrigation was used in test crop of brinjal. The different quality of irrigation water was obtained by diluting sea water.

The results revealed that between the two levels of saline water, lower level (EC 4 dS/m) was comparable with BAW with respect to fruit yield of brinjal. In general, the increase in fruit yield of brinjal with lower salinity level (EC 4 dS/m) was about 22 per cent over higher level (EC 8 dS/m) . This quality of water even recorded 5 per cent higher fruit yield of brinjal as compared to BAW (40 t/ha). Similarly, mulching either with trash or black plastic had significant positive effect on brinjal fruit yield as compared to unmulched control. The magnitude of increase in fruit yield of brinjal with sugarcane trash and black plastic mulch was about 12 and 17 per cent, respectively, over control. Among the three phases tried, late imposition (45DAT) of salinity stress out yielded the remaining two phases *i.e.* 15 and 30 DAT.

Apart from increase in fruit yield of brinjal, soil salinity was also remained lower with the treatments involving late salinity stress, lower salinity level and mulching either with trash or black plastic than early salinity stress, higher salinity level and unmulched control.

16. Transfer of Technologies of Microirrigation in Some Horticultural Crops under South Gujarat Conditions

Solia, B. M., Vaghasiya, P. M., Timbadia, C. K., Savani, N. G., Gohil, K. B., Raman, S. and Patil, R. G.

Source: National Seminar on International for Environmental Moderation at ASPEE at Navsari (2008), Page: 82

Abstract

Under South Gujarat agro climatic conditions, banana, okra and tomato are the important horticultural crops. In view of the poor productivity of these crops under South Gujarat conditions, crop production technologies *viz;* drip irrigation; fertigation and mulching have been developed by Soil and Water Management Research Unit, Navsari Agricultural University, Navsari. In order to popularize these technologies as a package of practices among the farmers, large scale demonstrations on farmers' fields as well as on research farm were arranged for banana, tomato and okra during 2002-04. In the case of banana, an increase in yield on research farm and farmer's field was of the order of 35 and 31 per cent, respectively due to improved practices (drip + black plastic mulch + fertigation) over conventional method. The per cent increase in yield of okra and tomato with improved practices was around 28-44 and 50-58 per cent, respectively under both the situations. With respect to water saving, it was 40 per cent in banana and more so in okra as well as in tomato (60 %). Similarly, fertilizer saving was ranging from 20 per cent in okra and 40 per cent in banana and tomato. An additional advantage of weed control was also observed with drip + mulch technologies in all the crops. In case of banana and tomato, sugarcane trash mulch (STM) was also tested and it was found comparable with black plastic mulch (BPM).

17.Fertigation through Minisprinkler in Onion Grown in *Kyari* Land

Patel, R. B., Solia, B. M., Savani, N. G. Vaghasiya, P.M. and Patil, R. G.

Source: ICPPF seminar at Delhi (2005)

Abstract

Farmers of South Gujarat region take onion crop after *kharif* paddy and the yield level is low. Earlier, it has been established that irrigation with minisprinkler increases the onion yield as compared to surface method of irrigation. In order to know the effect of N fertigation through minisprinkler on onion yield, a field experiment was conducted consecutively for two years at Soil and Water Management Research Unit, Navsari Agricultural University, Navsari. In all five treatments *i. e*. 40, 60, 80 and 100 per cent recommended dose of N (RDN) through minisprinkler along with one control of surface irrigation method were tested in RBD. The pooled results revealed that onion bulb yield was increased by 5, 13, 23 and 26 per cent with 40, 60, 80 and 100 per cent of RDN, respectively over surface method. This implies that significantly higher bulb yield can be obtained along with 20 per cent saving in fertilizer N. Even the bulb yield obtained only with 40 per cent RDN through minisprinkler was equal to that recorded in surface method of irrigation (25.7 t/ha).

18. Problems Faced by Banana Growers Adopting Drip Irrigation in South Gujarat – A Survey

Timbadia, C. K., Solia, B. M., Vaghasiya,P. M., Patel, J. M. and Patil, R. G.

Source: ICPPF seminar at Delhi (2005)

Abstract

In order to get insight in the adoption of improved cultivation practices and constraints experienced by the banana cultivators of South Gujarat, a systematic survey was planned in phased manner during 2002-2003. In all, 89 farmers were personally interviewed through set of standard questionnaire. The whole lot of the farmers was divided into two groups *i.e*. irrigating banana through drip and surface methods of irrigation. The information thus obtained was tabulated and interpreted in the context of land holding groups.

On over all basis, 57 per cent banana growers are adopting drip method of irrigation. The land holding group wise distribution of the banana growers indicated that large farmers prefer banana crop and more so with adoption of drip irrigation. As far as yield of banana is concerned, under drip method of irrigation farmers could get 51 per cent more yield than surface method. Though, farm size wise not much variation was observed in yield, yet, under both the methods of irrigation, large farmers are harvesting more yield than small farmers.

Based on the responses of the farmers, aspect wise problems were prioritized. Among the infrastructural problems, unassured power supply is ranking first and it is followed by inadequate availability of planting material, fluctuation in prices, high cost of fertilizer *etc*. As far as soil and water management related constraints are concerned, nutrient management seems to be a major problem for both the groups of farmers. In the case of drip irrigation, the farmers placed the poor know how and after sale service of system at second place.

Among the crop production related problems, disease is at the top priority and next in order are stunted growth during winter, old variety, early flowering, scorching of fruit during summer and lodging of the plant. In addition to these problems, farmers of both the groups have expressed the concern about higher cost of planting material and quality of water. Of course, the magnitude was higher with drip farmers as compared to the farmers following surface method of irrigation.

19.Micro Irrigation in Fruits and Vegetable Crops – An Experience in Gujarat

Patil, R.G., Vaghasiya, P.M., Solia, B.M., Timbadia, C.K., Patel, A.P. and Raman, S

Source: National Seminar on International for Environmental Moderation at ASPEE at Navsari (2008), Page: 11

Abstract

In Gujarat, fruits and vegetable crops are grown on about 2 to 3 per cent of net cropped area. Though the area under fruit and vegetable crops is increasing, the productivity of most of the crops grown is either stable or declining with time. Considering the agro climatic conditions and available water resources in the state, there is good scope of micro irrigation particularly for fruit and vegetable crops. The scope for increasing area under fruit and vegetable crops with drip/sprinkler irrigation has been zone wise indicated.

Geographically Gujarat is located on West coast of India between 20.1^{O} N to 24.7^{O} N latitude and 68.4^{O} E to 74.4^{O} E longitude with coastline of 1600 km providing semi tropical climatic settings. Agro climatically, Gujarat is divided in to 7 agro climatic zones, *viz*., South Gujarat heavy rainfall zone, South Gujarat zone, middle Gujarat, North Gujarat, North-west, North Saurashtra and South Saurashtra zones .These zones are further sub divided in to agro ecological situations (AES). Under such heterogeneous soil and climatic conditions, wide varieties of crops are being cultivated. With respect to water resources, except South Gujarat heavy rainfall agro climatic zone, rest of the zones are water scare that too with poor quality of ground water in most part of the state. The sources wise irrigated area in different agro climatic zones give an idea about the distribution of water resources across the state.

20.Subsurface Drainage for Rejuvenation of Water Logged and Salt effected Heavy Texture Soils of South Gujarat

A. N. Lad , N. G. Savani , A. M. Patel, N. D. Desai, R. G. Patil and S. Raman

Source: National Seminar on International for Environmental Moderation at ASPEE at Navsari (2008), Page: 40

Abstract

Water logging and salinity / sodicity problems are acquiring menacing proportion in canal command areas of South Gujarat because of high clay containing soils, heavy rainfall , cultivation of high water consuming crops viz paddy, sugarcane, banana and adoption of faulty irrigation practices. In view of severity of these problems, two pilot areas covering 30 ha area under closed sub surface drainage (CSSD) and 20 ha area under open sub surface drainage (OSSD) were established in phased manner during 1998,1999 and 2000 in Surat Branch of Ukai Kakarapar command. The pilot areas were monitored with respect to fluctuation in water table, changes in soil salinity/ sodicity and crop performance.

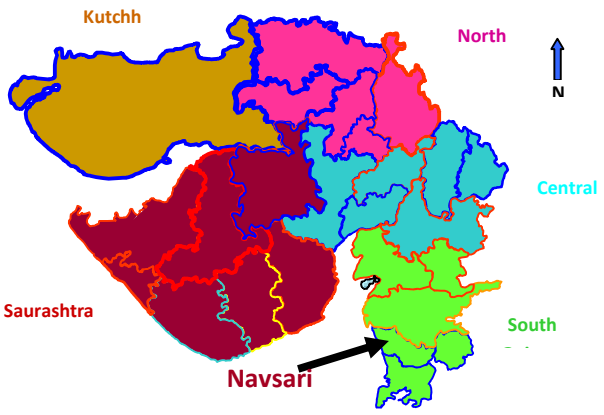
Installation of CSSD (corrugated perforated PVC) at 45 m spacing and at an average depth of 0.90 m could lower down the water table by 31 per cent, decrease salinity by 200 per cent and improved the sugarcane yield by 31 per cent in comparison to control (undrained block). The corresponding percentages under OSSD with paddy crop were 60, 32 and 200. The IRr (Internal Rate of Return) computed for CSSD with sugarcane crop was 58 and that for OSSD with paddy crop was 114 per cent. The payback period of 2 year was recorded for both systems. Looking to the pilot area results, about 10 farmers of this area have already installed CSSD in their fields at their own cost under the technical guidance of Soil and Water Management Research Project, Navsari Agricultural University, Navsari (Gujarat).

About PFDC, NAU, Navsari (Gujarat)

Precision Farming Development Centre, Navsari Agricultural University, Navsari was established during 1988-89 under the banner of Plasticulture Development Centre (PDC) and subsequently modified into the present form. Since its inception, this centre was in forefront in the research related to MIS including fertigation, mulching along with protected cultivation and subsurface drainage. During the first decade, major emphasis was given to the technology development in the field of plasticulture along with some transfer of technology. It was sensitization phase in relation to use of plastic in agriculture. However, since 2002-03 onward, the focus of PFDC has been shifted to transfer of technologies (ToT) with due consideration to technology development and refinement wherever necessary. In view of the availability of sound scientific data base and excellent infrastructure facility, team of PFDC along with experts from other departments / colleges of the university at Navsari are doing all out efforts to transfer the developed technologies to the farmers' fields in most effective way.

Location

Navsari is located at about 12 km East of Arabian sea near historical place Dandi, where Mahatma Gandhi launched the Salt Movement during 1942. Geographically, it lies between $20^0 57'$ N latitude, $72^0 54'$ E longitude and at an altitude of about 10 m.



Climate

Navsari falls under agro-ecological situation III of South Gujarat heavy rainfall zone I. It is characterized by fairly warm summer, mild winter and warm humid monsoon with an average rainfall of 1500 mm. As per the delineation done by NB's and LUP, Nagpur, major part of South Gujarat falls in Agroecological Subregion 19.1 (Coastal ecosystem).

Soil

The soil of research farm is placed under the order Inceptisols and sub group Vertic Ustochrepts. It is deep and moderately drained clay soil containing predominantly montmorillonitic minerals.

DECLARATION

The compilation team of this booklet, declare that the plasticultural related available data and information given in this booklet are based on work done by Precision Farming Development Center, Navsari Agricultural University, Navsari. The PFDC project is financially supported by GoI, MoA, New Delhi and overall looking by NCPAH, New Delhi.

The team hopes that this booklet is useful to the farmers, scientists, extension workers, planners *etc.* in their agricultural activities.

Compilation team