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Adoption of drip irrigation and impact on cotton productivity of Aurangabad district of Maharashtra

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ABSTRACT: The water use efficiency is becoming crucial part of crop productivity with limited available natural resources. Cotton crop is mainly dependent on ground water for irrigation. The study evaluated the adoption of drip irrigation (DI) and its impact on cotton productivity of Aurangabad district. There is 29.50 per cent increase in cotton yield with 38.01 per cent water saving due to adoption of DI. There is 228.03 HPh/ha savings in water use and 171.03 kwh/h saving in electricity consumption in DI farmers. The adoption of DI improves cotton productivity by 29.50 per cent with 38.01 per cent water saving and reduction in electricity consumption than Food irrigation (FI). But surprisingly the water use is improved in DI *i.e.* 4432.8 CuM /ha than FI *i.e.* 2846.4 CuM/ha. This additional use of water by DI may be due to the farmers tending to use limited water through DI to cotton crop for getting more yields in water scarce period. Continuous dry spell during critical crop growth stages may affect yield of the crop. The DI play important role in providing protective irrigation in critical growth stages of cotton during long dry spells of rain. The DI improves cotton productivity with reduction in water and electricity use.

Key words : Adoption, cotton productivity, drip irrigation, flood irrigation

The demand for available water resources in the world is fast exceeding. The supply and competition in the several sectors of the economy for scarce water is becoming intense. In recent years there is tremendous pressure on limited water resources due to intensification of agriculture. The annual water requirement of India from all sectors *i.e.* 1447 BCM would exceed the annual utilizable surface and groundwater *i.e.* 1122 BCM by 2050. The water requirement of food and agriculture has been rising because of continuous growth of population of human and livestock (Amarsinghe *et al.,* 2007). As irrigation cause substantial increase to agricultural production, there is increasing demand for water for irrigation. The flood method of irrigation (FI) is traditional method for irrigation throughout the world. It is considered to be inefficient in terms of field application efficiency and water use efficiency as there is heavy losses of water through conveyance and distribution (Postal *et al.,* 2001). Drip irrigation (DI) is method of irrigation to irrigate root zone directly using network of pipe and emitters. DI method enables not only even dispersion of water to crop land but also minimum water loss due to excessive irrigation and conveyance and distribution. The water use efficiency of DI system can be upto 100 per cent as compared 35-40 per cent of FI method. Nearly 1.3 m ha of irrigated land is under DI (Narayanamoorthy, 2004). As in initial stage; DI was the capital intensive; it used on large farms, however, is not affordable and proper for smallholders. Recently, DI technology has gone through technical renovations to immerge as

in input mode (Verma *et al.,* 2004). India is one of the major producers of cotton (*Gossypium hirsutum* L.) in the world with largest acreage *i.e.* 9.59 mha but productivity is only a little above 50 per cent of the world's average productivity of 794 kg lint/ha (Anonymous, 2008). In Maharashtra, cotton productivity is very low *i.e.* 170 kg lint/ha as compared to India *i.e.* 555 kg lint/ha and world's average, because about 77per cent of cotton is cultivated under rain fed conditions. Area under cotton cultivation has increased from 27.21 to 41.60 lakh ha during 1990-1991 to 2013-2014. Change of crops was able to improve the returns and economic status of the farmers but at the same time it has increased water supply demand. Agriculture in Marathwada is predominantly rainfed with only 12 per cent area under irrigation. Therefore, the agricultural progress depends on how efficiently the available water, rainfall and ground water, is managed (Venkateswarlu, 2015). The farmers using micro irrigation sets are 294 at Kadavanchi for cotton and horticultural crops (Pawar *et al.,* 2012).

Application of DI results in saving water and enhances the water use efficiency of cotton to a great extent. Regulated and slow application of irrigation water through emitters/orifices enables the water to reach the root zone of plants at frequent intervals. Cotton plant is very sensitive to both deficient as well as exerts soil moisture conditions. Excessive moisture at early stage is harmful. Similarly inadequate moisture during germination stage will give poor crop stand (Mehetre, 2004). Experimental results have indicated that DI would save water and increase yield in different regions (Sivanappan, 2004). However, not many studies are available focusing on the effectiveness of the DI in the context of the sustainable use of irrigation water. There is an urgent need to increase the existing water use efficiency in Indian agriculture, mainly due to the increasing demand for water from different sectors and the rapid decline of the available potential of water. Water use efficiency under the FI predominantly practiced in India, is very low, facing enormous losses in distribution and evaporation. The DI introduced recently helps to increase water use efficiency significantly, besides increasing the productivity of crops. The specific objective of the study is to estimate water and electricity saving in cotton by using DI and impact of DI on cotton productivity.

The study is conducted in 12 villages from 3 blocks of Aurangabad district. The estimation of water and electricity saving is based on in depth study of 12 farmers adopting DI and FI for cotton one from each village. Water and electricity saving occur with drip irrigation as the water is applied directly to root zone. Under experimental based studies, water consumption is usually estimated as per the depth of water applied. But same method is unsuitable for estimation of water consumption at farmer's field as there is variation in horse power of pump set, water levels of well, water lifting machinery, soil quality, terrain, distance between water source and farm to be irrigated etc. For measurement of impact of DI on cotton productivity, 100 farmers using DI and 72 farmers using FI for cotton crop and 58 farmers are not using irrigation water for cotton are selected from 12 villages from 3 blocks of Aurangabad district. The structured questionnaire survey was conducted and the data analyzed using statistical tool SPSS 20. The water consumption is measured in horse power hours of irrigation in present study. The electricity consumption of pump for irrigation can be calculated by using the formula,

Consumption of electricity (kWh /ha) =

HP of pump set x time (h) x 0.750.

The data illustrates that there is substantial water saving in drip irrigation system (DI) in cotton cultivation. The average number of irrigations is 29 for DI cotton and is more as compared with flood irrigation method (FI). The time for irrigation for irrigating one ha is much lower in DI than in FI. It is 3.2 h in DI and 28 h in FI. Therefore total water used for DI is 371.83 HP h/ha whereas it is 599.86 HP h/ha in case of FI. There is 228.03 HP h/ha savings in water use in DI farmers *i.e.* 38.01 per cent of FI. Though the water used by FI is more than DI to irrigate same area, the farmers following FI could not supply water due to frequent interruptions in electricity supply and availability of water; so cotton crop has to face water stress or water lodging throughout cropping season. There is reduction in water consumption with DI system as well as use of electricity. The electricity consumption of irrigation of DI is 278.87kwh/h while it is 449.90 kwh/h in case of FI following farmers. The ecological footprints of FI method is 38 per cent more as compared to DI method (Table 1). The water use is improved in DI *i.e.* 4432.8 CuM /ha than FI *i.e.* 2846.4 CuM / ha. This additional use of water by DI may be due to the farmers tending to use limited water through DI to cotton crop for getting more yields in water scarce period. The irrigation with DI is given up to January and February while only 5 farmers from 12 can irrigate in January with FI. The uniform distribution of water and uniform growth of crop was observed in DI crop. The water distribution in case of DI was even and uniform whereas in case of FI it was uneven. This resulted in even uniform growth of crop in DI whereas it caused uneven growth of cotton crop in FI cotton. The DI enables applying specific quantity of available irrigation water to crop results in long term application of water with saving. As the drip irrigation method follows more crops per drop principle; the use water through drip irrigation is get priority by farmers. This allocation of available water for applying through drip

Table 1. DI and FI method and productivity of cotton

Village	Irrigations		HR/ irrigation		Cotton yield (q/ha)		Electricity consumption (kWh/ha)		Water used (CuM/ha)	
	DI	FI	DI	FI	DI	FI	DI	FI	DI	FI
Charatha	30	6	3.29	30.42	45	32.5	222.19	410.63	4608.3	3285
Selud	32	6	2.76	28.96	48	33	331.25	651.56	4122.2	3909.4
Hatmali	28	5	3.3	29.75	42	32	346.88	557.81	4008.3	2677.5
Naigavhan	28	5	2.5	30	42	32	157.5	337.5	3500	2700
Waghola	27	6	3.7	24.44	38	30	225	330	5416.7	2640
Babhulgaon	28	6	3.39	28.75	42	32	213.75	388.13	5541.7	3105
Gungi Gevrai	28	5	3.15	25.67	45	33	330.47	481.25	5140.6	2310
Lohagad Nandra	28	5	3.45	29	38	30	217.5	326.25	4833.3	2610
Khandala	30	5	3.25	28.67	52	35	366	537.5	3383.5	3225
Bodvad	31	5	3.23	29.5	45	33	375	553.13	4666.7	2655
Mandana	28	5	3.07	26	42	32	321.88	487.5	4005.6	2340
Lihakhedi	28	6	3.79	25	42	32	239.06	337.5	3966.7	2700
Average	**28.8**	**5.4**	**3.2**	**28.0**	**43.4**	**32.2**	**278.9**	**449.9**	**4432.8**	**2846.4**

(DI - Drip Irrigation, FI - Flood Irrigation)

irrigation uses more water for crop for more time.

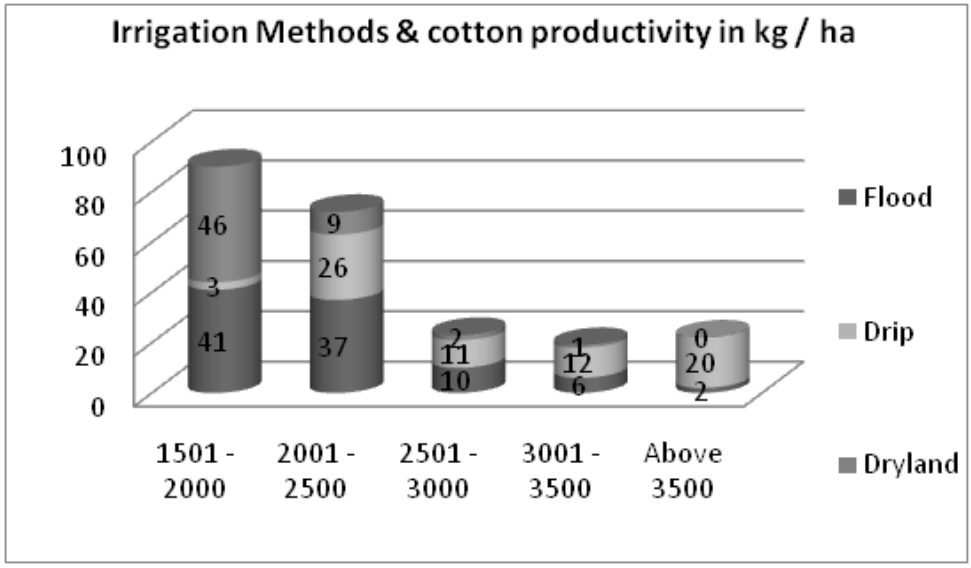
The water saving from DI varies from 12 to 84 per cent/ha for different crops besides increasing the productivity of crops. The core and net potential areas of DI are estimated to be 51.42 million ha (mha) and 21.27 mha, respectively, for the country as a whole. The achievable total saving of water, by utilizing the net potential area of DI, is estimated to be about 11.27 million ha m. From the saving of water, an additional irrigated area of 11.22 mha under FI or 24.12 mha under DI can be created (Narayanamoorthy, 2004).

Irrigation method and productivity : India is one of the major producers of cotton in the world with largest acreage (9.59 mha) but productivity is only a little above 50 per cent of the world's average productivity of 794 kg lint/ ha (Anonymous, 2008). In Maharashtra, cotton productivity is very low *i.e.* 170 kg lint/ha as compared to India *i.e.* 555 kg lint/ha and world's average, because about 77 per cent of cotton is cultivated under rainfed conditions. Area under cotton cultivation has increased from 27.21 to 41.60 lakh ha during 1990-1991 to 2013-2014. Area of cotton in Aurangabad district is maximum *i.e.* 4.03 lakh ha but only 10.8per cent area is irrigated and the average yield is only 345 kg/ha of lint. Under irrigated conditions, it is possible to harvest more than 30-40 q/ha of seed cotton. The cotton under DI is taking up a good shape in the district. (Anonymous, 2013). Experimental results have indicated that DI would save water and increase yield in different regions (Sivanappan, 2004). The Maharashtra state is having largest cotton growing area in India with nearly one third of cotton area *i.e.* 30 lakh ha. Since there are vast tract of shallow soils with poor fertility and also the uneven distribution of rainfall over larger area, the cotton production is low; only around 6-10 q/ha, though there are certain Eco niches having higher productivity (20-30 q/ha) throughout the State (Gopalakrishnan *et al.,* 2007).

There are 226 farmers from 12 villages cultivating cotton as cash crop. The cotton crop needs protective irrigation if there is large dry spell in rain. The study area has to face severe drought since 2011. The farmers have to support cotton crop with protective irrigation in rainy season. There are 42.48 per cent farmers irrigating cotton by FI method and 31.86 per cent farmers using DI for cotton crop while 25.66 per cent farmers are not applying irrigation water for cotton crop. The majority cotton farmers *i.e.* 42.7per cent using FI are getting lowest yield *i.e.* 1501 – 2000 kg/ha. There are 79.3 per cent farmers cultivating rainfed cotton getting yield in range of 1501 – 2000 kg/ha. The farmers using DI are getting good yield. There are 15.3 per cent DI farmers getting yield in range of 2501 to 3000 kg/ha; 16.7 per cent DI farmers are getting yield in range of 3001 to 3500 kg/ha and 27.8 per cent DI farmers are getting cotton yield more than 3500 kg/ha (Fig. 1).

Though cotton is predominantly cultivated as rain fed crop, 33 per cent cotton is cultivated under surface irrigation in India. Because of water scarcity, the cotton crop faces moisture stress in critical stages result in low cotton productivity even though use of required yield increasing inputs. The cotton productivity is increased by 25 per cent with 60 per cent water saving in DI method.

The average yield of cotton farmers adopting FI is 2177.08 kg/ha and of dry land cotton is 1887.93 kg/ha whereas for DI it is 2819.44 kg/ha. There is 15.32 per cent increase in average yield when we apply water through flood irrigation to cotton crop as compared with



Fig,. 1. Irrigation method and cotton productivity

yield of dry land cotton. There is 29.50 per cent increase in average yield of cotton with FI as we apply water through drip irrigation. The average yield of cotton in Aurangabad district is 932.67 kg/ha (Anonymous, 2013). DI recorded significantly higher seed cotton yield in all the 3 years (2.24, 2.32 and 2.18 t/ha, respectively) as compared to other. However drip irrigated treatments were superior to surface irrigation methods, *viz.,* broad bed furrow and farmer's practice of flooding (Ramamurthy *et al.,* 2009). Patil *et al.,* (2004) also indicated that drip irrigation is more beneficial in improving cotton productivity. DI treatments recorded 31per cent higher seed cotton yield over broad bed furrow and 59 per cent over farmer's practice. The agricultural sector in India consumes about 85 per cent of the available fresh water and has one of the lowest water use efficiency ratios. Among agricultural commodities, cotton is highly water intense, using around 30 per cent of the water for irrigation, in India. Traditional water irrigation systems, such as FI result in significant loss of water, with pesticides and fertilizers draining into water resources. There is adoption of water conservation techniques like DI and other innovative techniques, such as watering plant rows in pairs. In the micro irrigation system, water use efficiency varies from 70 to 95 per cent, compared with 35 to 40 per cent in FI due to significant seepage, evaporation, distribution, conveyance losses, etc. The 'r' value of Pearson Correlation equation is 0.005 suggest that the correlation in DI and cotton productivity is significant at the level of 0.01. As the cotton is irrigated with drip irrigation gives better result than flood irrigation and dry-land cultivation of cotton.

CONCLUSION

The study evaluated the adoption of DI and its impact on cotton productivity from Aurangabad district of Marathwada. Cotton crop is mainly dependent on groundwater for irrigation in Aurangabad district. The water use efficiency is becoming crucial part in increasing productivity of crop with limited available natural

resources. The study was carried out with 226 cotton farmers from 12 villages from Aurangabad, Phulambri and Sillod blocks; out of them 42.48 per cent use FI method, 31.86 per cent farmers use DI while 25.66 per cent can not apply irrigation water for cotton cultivation. There is 228.03 HPh/ha savings in water use and 171.03 kwh/h saving in electricity consumption which is 38.01per cent in DI farmers. The ecological footprints of FI method is 38per cent more as compared to DI method. The reduction in water use is coupled with reduction of electricity use ultimately reduction in economic footprint by adoption of DI. The average yield of cotton farmers adopting FI is 2177.08 kg/ha and of dry land cotton is 1887.93 kg/ha whereas for DI it is 2819.44 kg/ha. The result suggest that adoption of DI improves cotton productivity by 29.50 per cent with 38.01 per cent water saving and reduction in electricity consumption than FI. But surprisingly the water use is improved in DI *i.e.* 4432.8 CuM /ha than FI *i.e.* 2846.4 CuM / ha. This additional use of water by DI may be due to the farmers tending to use limited water through DI to cotton crop for getting more yields in water scarce period. The uniform distribution of water and uniform growth of crop was observed in DI crop. The water distribution in case of DI was even and uniform whereas in case of FI it was uneven. The DI work on principle of more crops per drop of water. Continuous dry spell during critical crop growth periods of squaring, flowering and boll development may affect yield of the crop. Water logging coupled with drought may induce reddening in *Bt* cotton. The DI play important role in providing protective irrigation in critical growth stages of cotton during long dry spells of rain. The DI improves cotton productivity with reduction in water and electricity use.

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