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# Effect of surface and sub-surface drip irrigation system on seed cotton in *Vertisols* of Malaprabha command in Northern Karnataka

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**Abstract**
A field experiment was conducted during 2015-16 and 2016-17 to compare the surface and sub-surface drip irrigation system on seed cotton in *Vertisols* of Malaprabha command in Northern Karnataka. Drip system with irrigation treatment as 1.0 Etc, 0.8 ETc and 0.6 ETc in surface as well as sub-surface system were considered along with farmers method as check was considered for the study. Sub-surface drip system yields maximum, (20.37 q.ha$^{-1}$) seed cotton which is on par with surface drip system and farmers method. The water use efficiency was maximum, 4.17 Kg. (ha.mm)$^{-1}$ with farmers method but also which is on par with surface and sub surface method of irrigation method. The gross and net income was maximum (Rs 94,051 ha$^{-1}$ and Rs 49,056 ha$^{-1}$) in subsurface drip system also yield was on par with surface and farmers method of irrigation. The B:C ratio was maximum (2.07) in case of surface system. The significantly superior water use efficiency was recorded with 0.6 ETc. Interaction effect between irrigation 0.6 ETc surface drip with and sub-surface system was also recorded significantly superior. The overall water saving was recorded about 12.45 percent, 20.21 percent and 42.34 percent with 1.0 ETc 0.8 ETc, and 0.6 ETc respectively when compared with farmers method.

**Keywords:** Subsurface and surface drip irrigation, irrigation water depths, seed cotton yield, water use efficiency, water saving

## Introduction
Cotton (*Gossypium hirsutum* L.) is one of the major cash crops of India, sustaining country's largest organized industry, textile industry and is popularly known as White Gold for its role in national economy in terms of foreign exchange earnings and employment generation. India has the credit of larger area under cotton with 11.7 million hectare and ranks second in cotton production with 29.0 million bales and the average yield of cotton is 540 kg ha$^{-1}$. In Karnataka state, cotton is grown both as rain fed and irrigated crop. Karnataka ranks 4th in area with 5.78 lakh ha and 6th in total production with 16.90 lakh bales of lint and the average yield is 529 kg ha$^{-1}$ (Anon., 2013) [2].

Increasing cotton production in India is of prime importance to satisfy the native mill consumption and to fetch higher foreign exchange. The productivity of cotton in India is low as it is grown under rain fed conditions where lack of proper distribution of rains or heavy rains and terminal moisture stress occurs. Water, being the prime natural resource for assured crop production, has to be used judiciously and in scientific manner. Day by day the competition for water is increasing from industry, domestic and agriculture sectors. The estimated cotton requirement by 2020 is around 230 lakh bales with a share of 65 to 75 per cent in textiles. Drip irrigation system is one of the advanced methods of irrigation. The system is popular in arid and semi arid regions with high evaporation losses. In drip irrigation water is conveyed through network of pipes up to root zone of crop and applied through emitters, frequently and with a volume approaching the consumptive use of plants and thereby minimizing conventional losses as deep percolation and evaporation from soil which give better water use efficiency. Drip irrigation can save water up to 40 to 70 per cent as well as increasing the crop production to the extent of 20 to 100 per cent.

Drip irrigation permits more efficient use of irrigation water as compared to other irrigation methods. Average water saving by drip irrigation in cotton is up to 57.8, 52.8 and 47.5 per cent at 0.6, 0.8 and 1.0 ETc respectively as compared to conventional furrow irrigation method in cotton at Coimbatore (Nalayini *et al*., 2006) [5]. In addition, in recent years sub surface drip irrigation is also gaining importance due to reduced evaporation losses with higher water use efficiency. Sub surface drip irrigation (SDI) is the irrigation of crops through buried plastic tubes containing embedded emitters located at regular spacing which provides the ultimate in water use efficiency for open-field agriculture, often resulting in water savings.

The extent of water saved in sub surface drip is by 20 per cent over surface drip irrigation (Martinez and Reca, 2014) [4]. The information is meagre hence the study was initiated.

**Materials and Methods**

A field experiment was conducted at Irrigation Water Management Research Centre, Belvatagi during *kharif 2015-16 and 2016-17*. The centre comes under Northern dry zone of Karnataka. The soil type is clay in texture with pH of 8.20, organic carbon 0.45 per cent and. EC 0.27 dS/m. The initial available N, $P_2O_5$ and $K_2O$ of the soil were 220, 34.5 and 710 kg $ha^{-1}$, respectively. The values of field capacity and bulk density were 40.5 per cent and 1.35 g/cc, respectively. Split plot design was adopted with four replications. In the main plots two irrigation methods ($M_1$ = surface drip and $M_2$ = sub surface drip) and in sub plots three ETc levels ($I_1$ = 1.0 ETc $I_2$ = 0.8 ETc and $I_3$ =0.6 ETc) along with control (surface irrigation at 0.6 IW/CPE ratio) were included. Bt cotton hybrid Brahma (BG II) was sown with spacing of 60 cm x 120 cm Scheduling of irrigation was done at three days frequency based on ETc levels. The volume of water was calculated as: $Q = Ep \times Kp \times Kc \times S_1 \times S_2$ where, Q, quantity of water to be given/dripper (litres); Ep, pan evaporation (mm); Kp, pan co-efficient (0.7); Kc, crop co-efficient; $S_1$, lateral spacing (0.9 m) and $S_2$, dripper spacing (0.6 m). In cotton Kc values considered were 0.45, 0.75, 1.15 and 0.70 for initial (0–25 DAS), development stage (26–70 DAS), boll development (71–120 DAS) and maturity stage (121-harvest) respectively as per FAO Irrigation Water Management Training Manual No. 3 (1986). Time of irrigation was as per the discharge of water per dripper. In control, six cm depth of irrigation was given on the basis of cumulative pan evaporation (100 mm CPE). The control treatment was compared with the treatment combinations of main and sub plots by using Randomized Block Design.

**Results and Discussion**

**Crop Yield And B:C Ratio**

Seed cotton yield did not differ significantly due to method of irrigation (Table 1). The sub surface drip irrigation recorded numerically higher seed cotton yield 20.37 q. $ha^{-1}$ than surface drip irrigation 18.21 q. $ha^{-1}$. The corresponding gross income, net income and B:C ratio were Rs.94051 $ha^{-1}$, Rs.49056 $ha^{-1}$ and 1.974 respectively These results were on par with the surface drip system. However, sub surface drip irrigation increased the seed cotton yield by 9.81 per cent over surface drip irrigation. These results are in conformity with Kalfountzos *et al*. (2007) [3]. In the present investigation year 2015 at IWMRC Belavatagi, rainfall of 392.6 mm can be considered as wet year for cotton cultivation. These contrasting results were mainly attributed to variation in the rainfall pattern during the reproductive stages of the crop (51.2 mm during developmental stage (26-70 DAS), 291.6 mm during boll development stage (76-120 DAS) and it coincided with high effective rainfall of 151 mm throughout crop growth period. Similar results were observed by Nalayini *et al*. (2006) [5] at Central Institute for Cotton Research, Coimbatore. It was recorded highest cotton yield (19.96 q.$h^{-1}$) and the corresponding gross income (Rs 91935 $h^{-1}$), net income (Rs 50854 $h^{-1}$) and the B:C ratio (1.99). All these are on par with the other irrigation treatments (Table.2). Interaction effect of method of irrigation and ETc levels was found significant (Table.3). Scheduling of irrigation at 1.0 ETc with sub surface drip irrigation recorded significantly higher seed cotton yield 23.08 q. $ha^{-1}$. These results recorded on par with surface as well as subsurface drip system with 0.6 ETc. The treatment recorded an increase of 23.08, 21.3, 29.4 and 19.54 per cent over surface drip irrigation with 1.0 ETc, surface drip irrigation with 0.8 ETc, and farmers method of irrigation respectively.

**Total Water Use and Water Use Efficiency**

The total water depth used by the crop (Table.4) was higher in farmers method using furrow irrigation (612.77 mm) as against drip irrigation regimes under 1.0 ETc, (536.45mm) under 0.8 ETc and (488.91 mm) under 0.6 ETc (353.27 mm). The amount of depth of water required for cotton ranges from 660 to 1,145 mm for different places or different varieties, depending on duration, soil and climatic conditions. As the seed cotton yield was comparable with furrow irrigation, considerable saving in water use was possible by adopting drip irrigation. The water saving in 1.0, 0.8 and 0.6 ETc levels were 12.45, 20.21 and 42.34 per cent respectively compared to furrow irrigation.

The data on water use efficiency is also presented in Table 1 & 2. Water use efficiency did not differ significantly due to method of irrigation (Table.1). Water use efficiency was found higher in sub surface drip irrigation (4.17 kg $ha^{-1}$ mm) and increase was by 7.2 per cent over surface drip irrigation. These results are in conformity with Abdrabbo (2013) [1] at Egypt. Irrigation scheduled using ETc level differed significantly as irrigation scheduled at 0.6 ETc (5.65 kg $ha^{-1}$ mm) recorded significantly higher water use efficiency. Next best water use efficiency was in 0.8 ETc (3.77 kg $ha^{-1}$ mm) and was significantly higher than 1.0 ETc (3.04 kg $ha^{-1}$ mm). This might be due to higher seed cotton yield (19.96 q.$ha^{-1}$) and limited quantity of water applied under 0.6 ETc (353.27 mm). Amount of water applied varies based on ETc levels. In surface drip irrigation as well as sub surface drip at 1.0 ETc (536.45 mm), 0.8 ETc (488.91mm) and 0.6 ETc (353.27 mm) of water was applied. Among different treatment combinations (Table.3) significantly higher water use efficiency of 5.67 kg. $ha^{-1}$.mm) was registered with surface drip irrigation with 0.6 ETc. This result also on par with sub-surface drip irrigation with 0.6 ETc Increase in the level of water application by drip irrigation decreased the water use efficiency, while limited quantity of water applied under lower drip irrigation regime increased seed cotton yield, due to higher moisture content at all stages. These results were in harmony with Veeraputhiran and Chinnuswamy (2009) [6]. Lower water use efficiency was recorded in surface drip irrigation with 1.0 ETc (2.93 kg $ha^{-1}$ mm) due to lower seed cotton yield. Surface irrigation at 0.6 IW/CPE ratio recorded significantly lower water use efficiency (3.35 kg ha-1 mm) compared to other treatments except surface drip irrigation with 1.0 ETc (2.93 kg ha-1 mm).

**Table 1:** Effect of method of layout using drip irrigation system on Cotton yield, water use efficiency, gross income, net income and B:C ratio

| Method of Layout | Seed Cotton Yield, (q/ha) | | | WUE Kg/ha.mm | | | Gross Income. Rs.ha$^{-1}$ | | | Net-Income Rs.ha$^{-1}$ | | | B:C ratio | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015-16 | 2016-17 | Mean | 2015-16 | 2016-17 | Mean | 2015-16 | 2016-17 | Mean | 2015-16 | 2016-17 | Mean | 2015-16 | 2016-17 | Mean |
| $M_1$=surface drip system | 18.45 | 17.98 | 18.21 | 3.90 | 3.85 | 3.87 | 83041 | 83555 | 83298 | 42961 | 43699 | 43330 | 2.017 | 2.15 | 2.07 |
| $M_2$=Sub-surface drip system | 20.79 | 19.95 | 20.37 | 4.29 | 3.98 | 4.17 | 93546 | 94556 | 94051 | 49458 | 48654 | 49056 | 1.958 | 1.99 | 1.974 |
| Control / Check AAF 0.6 IW/CPE ratio @ 60 mm depth of water. | 17.85 | 18.56 | 18.20 | 4.09 | 4.25 | 4.14 | 88293 | 86565 | 87429 | 41564 | 42894 | 42229 | 1.880 | 1.96 | 1.92 |
| SEm± | 0.98 | 0.99 | 0.98 | 0.28 | 0.29 | 0.28 | 4437 | 4566 | 4501 | 4437 | 4356 | 4396 | 0.114 | 0.135 | 0.124 |
| CD (0.05) | 4.44 | 4.55 | 4.49 | 0.97 | 0.96 | 0.96 | 19969 | 19663 | 19816 | 19969 | 19956 | 19963 | 0.511 | 0.611 | 0.561 |

**Table 2:** Effect of drip irrigation levels on seed cotton yield, water use efficiency, gross income, net income and B:C ratio

| Treatment Irrigation levels | Seed Cotton Yield, (q.ha$^{-1}$) | | | WUE Kg(ha.mm$^{-1}$) | | | Gross Income. Rs.ha$^{-1}$ | | | Net-Income Rs.ha$^{-1}$ | | | B:C ratio | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015-16 | 2016-17 | Mean | 2015-16 | 2016-17 | Mean | 2015-16 | 2016-17 | Mean | 2015-16 | 2016-17 | Mean | 2015-16 | 2016-17 | Mean |
| $I_1$ = 1.0 ETc | 18.69 | 19.67 | 19.18 | 3.13 | 2.95 | 3.04 | 88505 | 87888 | 88197 | 46421 | 46239 | 46330 | 2.01 | 1.98 | 1.995 |
| $I_2$ = 0.8 ETc | 17.55 | 18.63 | 18.09 | 3.70 | 3.85 | 3.77 | 83807 | 84905 | 84356 | 41723 | 42888 | 42305 | 2.06 | 2.12 | 2.09 |
| $I_3$ = 0.6 ETc. | 19.35 | 20.57 | 19.96 | 5.45* | 5.85* | 5.65 | 92570 | 91300 | 91935 | 50486 | 51222 | 50854 | 1.88 | 2.10 | 1.99 |
| SEm± | 0.83 | 0.82 | 0.825 | 0.17 | 0.18 | 0.175 | 3687 | 3599 | 3643 | 3687 | 3622 | 3655 | 0.093 | 0.088 | 0.091 |
| CD (0.05) | 2.44 | 2.53 | 2.485 | 0.54 | 0.56 | 0.55 | 11364 | 12333 | 11848 | 11364 | 11562 | 11463 | 0.287 | 0.261 | 0.274 |
| ***Significantly superior** | | | | | | | | | | | | | | | |

**Table 3:** Interaction effect between drip and method of layout of irrigation system on Cotton yield, water use efficiency, gross income, net income and B: C ratio

| Method of Layout | Seed Cotton Yield, (q.ha$^{-1}$) | | | WUE Kg. (ha.mm$^{-1}$) | | | Gross Income. Rs.ha$^{-1}$ | | | Net-Income Rs.ha$^{-1}$ | | | B:C ratio | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015-16 | 2016-17 | Mean | 2015-16 | 2016-17 | Mean | 2015-16 | 2016-17 | Mean | 2015-16 | 2016-17 | Mean | 2015-16 | 2016-17 | Mean |
| $I_1M_1$ | 16.80 | 17.36 | 17.08 | 2.67 | 3.20 | 2.93 | 75612 | 76254 | 75933 | 35532 | 34654 | 35093 | 2.22 | 2.31 | 2.26 |
| $I_1M_2$ | 22.53 | 23.64 | 23.08 | 3.58 | 3.85 | 3.71 | 87965 | 89652 | 88808 | 57310 | 54789 | 56049 | 1.80 | 1.95 | 1.87 |
| $I_2M_1$ | 17.97 | 18.36 | 18.16 | 3.57 | 3.47 | 3.52 | 80856 | 78564 | 79710 | 40777 | 42154 | 41465 | 2.05 | 2.10 | 2.07 |
| $I_2M_2$ | 19.28 | 19.65 | 19.46 | 3.84 | 2.84 | 3.34 | 86757 | 84562 | 85659 | 42669 | 46125 | 44397 | 2.08 | 2.56 | 2.32 |
| $I_3M_1$ | 20.59 | 21.56 | 21.07 | 5.46* | 5.89 | 5.67 | 92657 | 91562 | 92109 | 52577 | 52638 | 52607 | 1.77 | 1.84 | 1.80 |
| $I_3M_2$ | 20.55 | 19.58 | 20.06 | 5.45* | 5.65 | 5.55 | 92483 | 91458 | 91970 | 48394 | 46897 | 47645 | 2.00 | 2.15 | 2.07 |
| Control | 18.50 | 18.65 | 18.57 | 3.12 | 3.58 | 3.35 | 83257 | 82456 | 82856 | 39128 | 38546 | 38837 | 1.67 | 1.94 | 1.80 |
| SEm± | 1.36 | 1.34 | 1.35 | 0.29 | 0.31 | 0.30 | 6149 | 6241 | 6195 | 6149 | 5644 | 5896 | 0.16 | 0.18 | 0.17 |
| M X S CD (0.05) | 4.21 | 4.35 | 4.28 | 0.92 | 0.94 | 0.93 | 18953 | 16258 | 17605 | 18952 | 17956 | 18454 | 0.49 | 0.52 | 0.50 |

**Table 4:** Percentage saving of water for the crop seed cotton

| Treatment Irrigation levels | Depth of water irrigated (mm) | | | Effective rainfall (mm) | | | Total Depth of irrigation (mm) | Saving of water (%) |
|---|---|---|---|---|---|---|---|---|
| | 2015-16 | 2016-17 | Mean | 2015-16 | 2016-17 | Mean | | |
| $I_1$ = 1.0 ETc | 474 | 469 | 471.5 | 63.21 | 66.71 | 64.95 | 536.45 | 12.45 |
| $I_2$ = 0.8 ETc | 379 | 389 | 384 | 99.56 | 110.26 | 104.91 | 488.91 | 20.21 |
| $I_3$ = 0.6 ETc. | 284 | 294 | 289 | 65.23 | 63.31 | 64.27 | 353.27 | 42.34 |
| Control / farmers method of irrigation | 540 | 550 | 545 | 68.23 | 67.31 | 67.77 | 612.77 | -- |

## Conclusion

The results of the experiment inferred and was concluded that the adoption of surface drip method of irrigation at 0.8 ETc was proved to be advantageous and resulted in recording higher seed cotton yield, water use efficiency and water saving in comparison surface or farmers method of irrigation under *vertisols*.

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