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Water productivity and yield of baby corn (*Zea mays* L.) as influenced by irrigation levels under subsurface drip irrigation

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Abstract
An experiment was undertaken to estimate yield and water productivity of baby corn (*Zea mays* L.) variety F1 hybrid at varying irrigation water levels under subsurface drip irrigation (SDI) method at ICAR-CIAE, Bhopal in central India, during summer season. The experiment was laid out in randomized block design with five irrigation treatments were considered in the experiment are 100% net irrigation water requirements (NIR), 75% NIR, 50% NIR, 120% NIR and 150% NIR corresponds to T1, T2, T3, T4 and T5 treatments. Each treatment had 4 replications. Irrigation levels markedly influenced growth, yield components and yield of baby corn. Maximum yield of 2.05 t/ha was obtained under T1 treatment, however maximum irrigation water use efficiency (IWUE) was recorded under T3 treatment with value of 25.74 kg/ha-mm and crop water use efficiency (CWUE) under T2 treatment with value of 7.32 kg/ha-mm. No significant difference was observed among the treatments T1, T2 and T4 in terms of yield. Least performance exhibited under T3 treatment with yield of 1.36 t/ha. Quadratic relationship was obtained between grain yield and irrigation rate and increased with irrigation rate from deficit to full irrigation treatments (FIT) and thereafter decreased for the over irrigation treatments. The findings of this study will be helpful for taking decision on how effectively water can be utilized for achieving maximum yield or maximum water use efficiency.

Keywords: Baby corn, crop yield response factor, deficit irrigation, subsurface drip irrigation, water use efficiency

Introduction
Irrigation plays a pivotal role in bringing agricultural, social and economic growth of a country. From time immemorial, civilization has been dependent on the development of irrigated agriculture to provide food and nutrition security to the people of nation. The developed and developing countries across the world are facing acute water shortage due to competitive demand of water in various sectors. Which necessitates adoption of precise method of irrigation. One such practice is the micro irrigation systems such as drip, sprinkler and subsurface drip (SDI) methods of irrigation. Adoption of such systems not only results in enhanced water productivity but also minimizes the environmental pollution occurs in surface irrigation method [1, 2, 3]. Adoption of subsurface drip irrigation (SDI) systems in some of the field crops would enhance the irrigation water use efficiency. These systems apply water directly inside the crop root zone instead of on the surface which reduces soil water evaporation losses from the wet bulb as the soil surface is not wetted and reduces deep percolation beyond crop root zone if designed and maintained properly [4].

Saving of water due to precision irrigation systems over the conventional method of irrigation ranges from 30 to 70 per cent whereas gain in productivity ranges from 20 to 90 per cent for different crops as well as reduces the requirement of labors and fertilizers over the conventional method of irrigation [5]. The on farm water management practices that increases the crop yield and reduces amount of water applied is a priority under declining water table conditions. Subsurface drip irrigation can reduce off-farm movements of fertilizers and pollutants and improve the water productivity of irrigated agriculture. Although, SDIs have been used since long time but in the country like India it is still in infant stage despite having high water productivity and numerous advantages.

Maize is the third most important cereal crop after rice and wheat crops in India. It is cultivated approximately in 8.7 m ha area mainly during *Kharif* season [6]. The average productivity of maize in India is about 2.43 t ha^{-1} which is roughly half as compared to global average productivity (4.92 t ha^{-1}) because maize cultivation is mainly under rain-fed conditions with inadequate irrigation facilities and limited adoption of improved production-protection technology [7]. More than 80% of maize cultivation experience moisture stress at its critical stages of growth viz., flowering and grain formation. Baby corn (*Zea mays* L.) is the ear of maize where cobs are removed within 3 to 5 days after silk emergence are called baby corns. Baby corn (*Zea mays* L.) is one of the most lucrative agriculture product and has established market in European and American countries but it is relatively new addition in India. Since it is a crop of short duration requires about 60-70 days for harvesting so farmer can grow baby corn 3 to 4 times in a year depending upon the agro-climatic conditions and can also be a good substitute at times when other crop fails. Baby corn is not only a 'cash crop' but can be considered as a very good 'catch crop'. In case of baby corn the cobs are not allowed to fertilize and set seed. The nutrient retention in the plant part (stover) makes, baby corn stalks nutritious cattle feed. Thus, the cultivation of baby corn provides avenues for crop diversification, value addition with high export potential and revenue generation.

Irrigation strategies for maize under Sub-surface Drip Irrigation (SDI) can provide invaluable data and information for water management options. It can help for decision making on water availability objectives in terms of yield target versus water productivity and environmental protection regarding conservative agriculture. The effect of different controlled deficit-irrigation strategies on the crop yield was reported in few studies [8, 9, 10]. Many authors have reported that deficit irrigation strategy may improve water use efficiency under water scares condition.

(Irmak *et al*., 2016) [10] reported that irrigation frequencies have no significant impact on the maximum grain yield but irrigation rate significantly affect grain yield. According to them grain yield had quadratic relationship with irrigation rate and increased with irrigation rate from rainfed to full irrigation treatments (FIT) and thereafter decreased for the over irrigation 125% FIT. Similarly several authors have reported the quadratic relationship between water use efficiency and amount of water applied in different crops [11, 12]. It has been reported by several authors that maize yield linearly increases with increasing actual evapotranspiration (Eta) and total water supply [13, 14], however, with over-irrigation, the relationship may become curvilinear [15], because an increase in water supply not increases potential yield.

Indiscriminate availability of water to the crop would adversely influence its productivity. Baby corn is very sensitive crop to waterlogging conditions. Thus potential impact(s) of different irrigation strategies under SDI on baby corn yield, water productivity and crop yield response factors are need to be evaluated experimentally. Therefore, a field experiment was carried out to evaluate the performance of subsurface irrigation system on water productivity and yield of baby corn under different quantities of irrigation water applied.

Material and Methods

Experimental Site details

An experiment was undertaken for estimation of yield and water productivity of baby corn (*Zea mays* L.) variety F1 hybrid at varying irrigation water level under subsurface irrigation method at the Precision Farming Development Centre (PFDC) of ICAR-Central Institute of Agricultural Engineering, Bhopal (M.P.), in central India, during *summer* season. The experimental farm is situated between 23° 18' 22" to 23° 20' 00" N latitude and 77° 24' 45" to 77° 25' 24" E longitudes with an average elevation of 490 m above mean sea level. This area has a humid subtropical climate, with cool, dry winters, hot summer and humid monsoon season, receives average annual rainfall of 1146 mm. *summer* starts in late March and go on till mid-June with temperature exceeds up to 40 °C (104 °F) in the month of May. The meteorological observations during baby corn growth period were acquired from the observatory, located near the experimental site. Weekly weather parameters are presented in Figure 1. During crop establishment period temperature was above 40 °C for most of the time and recorded maximum temperature was 46.5 °C in late June and lowest daily temperature was 23.5 °C during mid of July month. The average relative humidity values were very high at a later stage of crop growth with the advancement of monsoon. Total rainfall received during crop growth period is 285.96 mm which occurred in late June (45.36 mm) and July (240.60mm).

The soils of research farm is black soil having clayey texture with prominent montmorillonite clay mineral. The soil is very sticky, soft and swells on wetting and develops cracks on drying. Due to presence of comparatively hard pan at 1.8-2.5m depth, movement of water beyond root zone is restricted after heavy rainfall or over irrigation. Data of different soil physical, hydraulic and chemical properties of the experimental site are presented in Table 1, and 2.

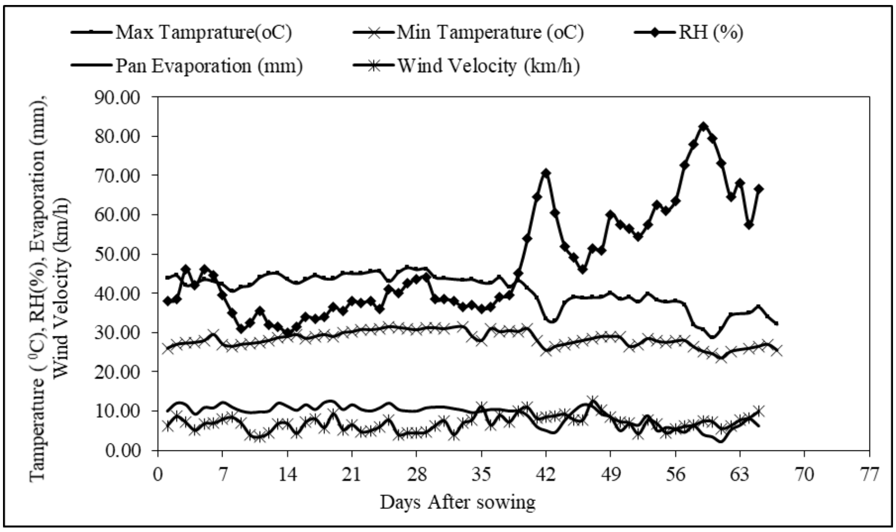

Fig 1: Weakly weather parameters variation during crop growth period.

Table 1: Soil Physical properties of experimental farm

S. No.	Parameters		Soil Depth (cm)					
			0-15	15-30	30-45	45-60	60-75	75-90
1.	Soil Texture	: Sand	19.2	18.8	21.4	22.7	19.6	21.2
		: Silt	27.6	27.2	25.4	27.2	28.6	27.4
		: Clay	53.2	54	53.2	50.1	51.8	51.4
2.	Textural Class		clay	Clay	clay	clay	clay	Clay
3.	Bulk Density		1.37	1.42	1.45	1.39	1.51	1.56
4.	Field Capacity (%)		30.6	30.8	31.2	30.9	32.5	32.1
5.	Wilting Point (%)		17.8	18.2	18.5	18.8	19.1	19.2
6.	Soil pH		7.5	7.7	7.5	7.6	7.9	7.4
7.	Electrical Conductivity (dS/m)		0.18	0.21	0.18	0.19	0.25	0.18

Table 2: Hydraulic properties of soil

Drainable porosity (%)	Percolation rate (mm/day)	Hydraulic conductivity (m/day)	Basic Infiltration rate (mm/h)
5.9-6.8	8.1-8.5	0-40 cm depth: 0.22-0.29	11.2- 14.5
		40-100cm depth:0.02-0.023	

Experimental Design

To evaluate the performance of sub-surface irrigation method under varying irrigation levels, an experiment was carried out based on a randomized block design with five irrigation water levels viz., 100% net irrigation water requirements (NIR), 75% NIR, 50% NIR, 120% NIR and 150% NIR corresponds to T1, T2, T3, T4 and T5 treatments. Each treatment was replicated four times. The experimental units were randomly distributed throughout the plot. Size of experimental plot was 30 m× 13m with 20 beds of 15 m length. Size of bed was 60cm and bed to bed spacing was 80 cm. T1 was taken as controlled treatment; T2 and T3 were deficit irrigation treatments whereas T4 and T5 were over irrigation treatments. Soil moisture at different depths were recorded after every two days using gravimetric method for irrigation scheduling. Figure 2 shows the described experimental layout. Other soil and crop parameters *viz.*, plant height, root depth, root volume, no of leaves per plant, chlorophyll content, soil electrical conductivity, pH and bulk density were measured in 15 day interval.

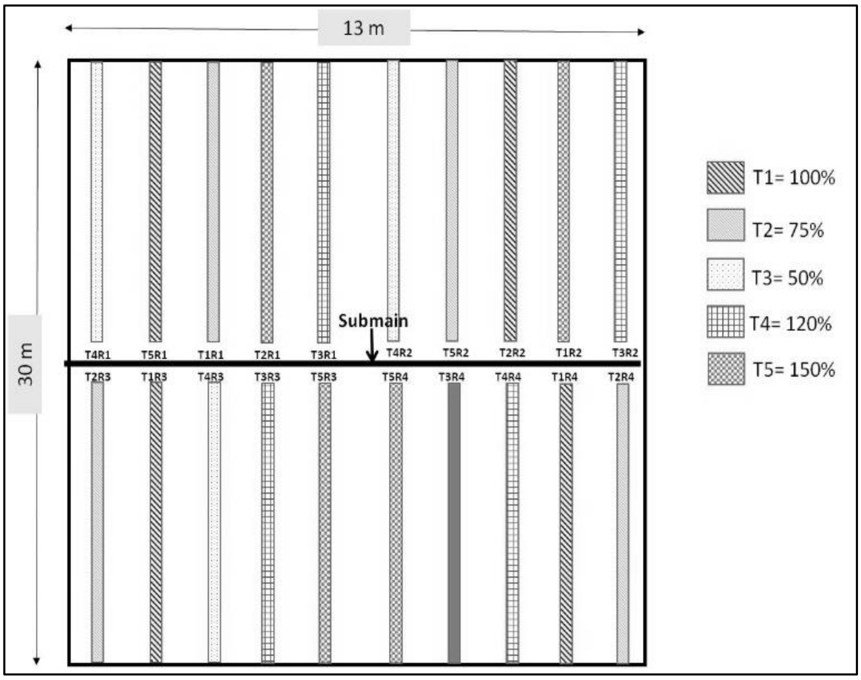

Fig 2: Layout of experimental field.

Irrigation System Description

Non pressure-compensating emitters embedded in laterals with a working interval ranging from 50 to 400 kPa with 4 l/h flow rate were installed in the field to irrigate the experimental crop. Laterals were placed at 15 cm depth from bed surface. Before installing some samples of these laterals were tested for assessing their manufacturing variability. A manufacture's coefficient of variation of 2.27% was obtained experimentally, indicated that the uniformity coefficient is high. By using, Christiansen (1942) [16], the statistical uniformity coefficient (EU) of these laterals were assessed and was found high during both cases (0.97 at the beginning of the experiment and 0.89 at the end). Irrigation system comprised of main line, submain line and laterals were connected to submains through control valve. Both submain and lateral pipes were made up of polyethylene. There was one lateral per paired crop row, spacing between laterals was 80cm. Lateral was of 16mm diameter with in-line emitters placed in it at the spacing of 4 cm. Field evaluations of uniformity of the irrigation subunits were conducted at the beginning and at the end of the experiment. Irrigation water was supplied from tubewell and used to pass through disk and gravel filtration units. Irrigation and leaching water quality parameters are given in Table 3.

Table 3: Chemical properties of irrigation and leaching water

	pH	EC (μS)	TDS (ppm)	Turbidity (NTU)	Hardness (ppm/l)	CO_3^{-2} (meq/l)	HCO_3^{-2} (meq/l)	$Ca^{++}+Mg^{++}$ (meq/l)	Cl^- (meq/l)
Irrigation Water	7.7	906.5	410	1.03	2.1	0.8	4.2	7.3	3.4
Leaching water	7	793	530	0.42	3.84	0	7	9.4	2.6

Irrigation Scheduling

Soil moisture contents up to the crop root zone (90 cm) were monitored at alternate days using gravimetric soil sampling method for irrigation scheduling *i.e.* to decide the date and quantity of irrigation water during the crop growth period. This technique is the most accurate and reliable method of soil moisture measurement. The date of irrigation was decided when the soil moisture in the root zone got depleted to 50% of the difference between the permanent wilting point (PWP) and the field capacity (FC) *i.e.* the total available water (TAW) in the root zone depth of soil profile. Irrigation timings were based on weekly θ_v data for each treatment (average soil water content for each treatment was used). The quantity of irrigation water applied to each treatment was calculated based on the soil moisture content before irrigation and the root zone depth of the plant using the Equation 1.

$$SMD = (\theta_{Fc} - \theta_i) \times D \times Bd \times f \qquad (1)$$

Where:

SMD: Soil moisture deficit (mm), θ_{Fc}: Soil water content at field capacity, θ_i: Soil water content before irrigation (weight percent basis), D: Depth of root zone (mm), Bd: Bulk density of the particular soil layer as per root depth (g cm^{-3}). f: coefficient for each irrigation treatment levels in the experiment *i.e.* f = 1 (full irrigation (T1)), f = 0.75 (75% of FC (T2)), f = 0.5 (50% of FC (T3)), f = 1.2 (120% of FC (T4)) and f = 1.5 (150% of FC (T5)) were used for different treatments to estimate the quantity of irrigation water.

Under the fully irrigated maize, targeted irrigation strategy was to replenish the available soil water in the major root zone to approximately 90% of FC and the maximum allowable depletion, therefore was set to approximately 45-50% of the total available water (TAW).

In the irrigation treatments, water used to apply on the same day but irrigation depths were adjusted by regulating the timing of irrigation through control valves. Irrigation timings were based on average soil water content data for each treatment and based on this, treatments were irrigated approximately twice a week. In the later stage of plant growth, all treatments were at nearly same and uniform soil moisture condition as a result of arrival of monsoon and rainfall. Fertilizer dozes were kept equal for all treatments. Fertilizer schedule is presented in Table 4.

The time interval between irrigations was recalculated weekly using actual climatic data with the aim of matching the applied irrigation water to the crop water requirements. Crop evapotranspiration (ET) was estimated by using field water balance Equation 2.

$$ET = I + P \pm \Delta S - R - D \qquad (2)$$

Where, ET is evapotranspiration (mm), I is the irrigation water (mm), P is the precipitation (mm), ΔS is the change in soil water storage (mm), R is the runoff, and D is the deep percolation below the root zone. Change in the soil moisture content was calculated from soil moisture data recorded during experiment. Deep percolation was measured by recording change in soil moisture content data beyond root zone (90-120 cm depth). Deep percolation and runoff was occurred during excess rainfall, runoff values assumed to be zero as measured amount of water was applied. Deep percolation was also observed during irrigation in treatments *viz.* T4 and T5.

Table 4: Fertigation schedule of baby corn

Planting Stage	Fertilizers	N(kg)	P(kg)	K(kg)
After planting (03-05-2018)	urea	10.85	0	0
	19:19:19	2.85	2.85	2.85
	kg/ha	20	15	15
After one month planting (04-06-2018)	urea	21.7	0	0
	19:19:19	1.9	1.9	1.9
	kg/ha	20	10	10
Before detaasseling (26-06-2018)	12:61:0	2.40	12.2	0
	0:0:50	0	0	10
	kg/ha	20	20	20
After detasseling (01-07-2018)	12:61:0	2.40	9.15	0
	0:0:50	0	0	7.50
	kg/ha	20	15	15
Total	kg/ha	80	60	60

Statistical Analysis

Analysis of variance (ANOVA) was performed using Proc Mixed in Statistical Analysis System (SAS) windows software and means separation was done for significant ANOVA results using Fisher's protected least significance difference (LSD) test at the 95% confidence interval to compare treatment means to identify potential significant differences in grain yields, biomass yields and water productivity between treatments.

Results and Discussion

Irrigation water applied and seasonal evapotranspiration

Irrigation water applied and seasonal evapotranspiration values for different treatments are shown in Table 7. Nine irrigations were applied during total crop growth season. The amount of irrigation water applied varied from 53 mm to 160 mm. Active root depth for baby corn was assumed to be 90 cm, and therefore, deep percolation measurements were done for 90–120 cm soil depth. Result indicated that percolation occurred only with T4 (125% NIR) and T5 (150% NIR) treatments of about 8% and 11% of total water applied. Effective rainfall amount of 189.1 mm was received during crop development stage and this rainfall had significant contribution in crop water demand. Thus total water applied (irrigation+ effective rainfall) varied from 262 to 368 mm. The seasonal values of baby corn ETc varied from 254 to 315 mm. As expected, the highest seasonal ET occurred in the T5 treatment and the lowest ETc occurred in T3 treatment. Regression analysis indicated a linear relationship (R^2=0.98) between seasonal ET and irrigation water applied (Figure 3). A unit increase in irrigation resulted in a smooth increase in Etc. The obtained relationship in this study are in agreement to those reported in the previous literature for corn [17, 10]. Baby corn ETc varied from 254 to 315 mm. Roy *et al*., (2015) [18] reported that ETc value of baby corn varied from 279 to 355 mm from rainfed to full irrigation condition.

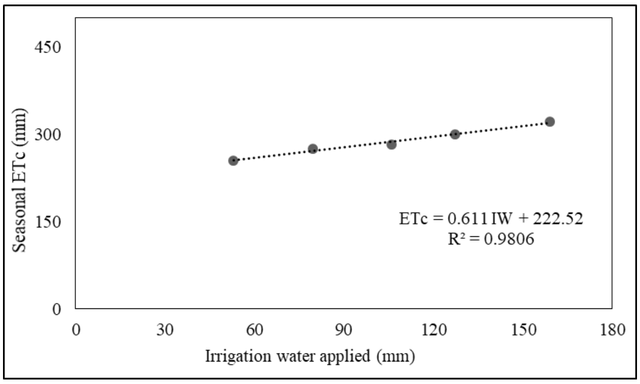

Fig 3: Relationship between irrigation amount and maize seasonal evapotranspiration (ETc).

Variation of different crop growth parameters of baby corn

The plant height, root length, number of leaves and root spread for each treatment were recorded once in two weeks interval during the entire cropping season and presented in Table 5. Visible effect was observed in root length, root spread and plant height whereas number of leaves were almost same for all treatments. Plant height increase with increasing amount of irrigation water applied but highest was found under T4 treatment whereas lowest was found under T3 treatment. No significant difference was obtained in the maximum plant height of treatments T1, T4 and T5, these were nearly in the same range whereas average reduction in plant height of treatments T2 and T3 was about 5.72 and 13.14% as compared to controlled treatment T1. For measurement of total root length, rough trenches were dug and roots were traced up to the bottom by using a sickle. Plants were dug out along with huge mass of soil. Roots were washed properly with tap water under constant pressure. The root systems were placed on a clear plastic sheet and the effective root length was determined. The result showed significant increase in total root length in water deficit treatments as compared to non-deficit regime, and highest was found for T3 treatment. Similar results have been reported by several authors for different crops [19, 20]. Similarly, root spread was significantly more in water deficit treatments as compared to non-deficit regime, however number of fine roots were less in T2 and T3 treatments. The highest root density was found 10-20 cm (49%), then for 20-30 cm (31%), 30-40 (13%) and lowest for 40-50 cm (7%) below from the soil surface.

Table 5: Mean values of plant growth parameters of baby corn

Treatments	Plant height (cm)				Root length (cm)				Root spread (cm)				Number of leaves			
	15 DAS	30 DAS	45 DAS	60 DAS	15 DAS	30 DAS	45 DAS	60 DAS	15 DAS	30 DAS	45 DAS	60 DAS	15 DAS	30 DAS	45 DAS	60 DAS
T1	31.9b	44.7a	95.8c	161.7a	11.8cd	14.9e	31.3cd	45.7c	5.5c	10.3c	15.2c	25.2d	7.5	8.7	12.2	11.7
T2	28.6d	42.5bc	92.5d	152.5ab	15.7b	17.9b	34.9b	47.7b	5.5bc	11.1b	16.1b	28.9b	6.2	7.2	12.2	12
T3	27.7e	37.0d	90.1e	140.5b	17.9a	19.3a	37.8a	51.8a	7.0a	11.7a	18.1a	30.3a	6.7	7.7	12	11.7
T4	30.9c	40.9c	110.6b	168.5a	13.3c	16.9c	30.7d	44.0d	4.7d	9.5d	15.2c	26.1c	6.5	7	12.2	12.7
T5	33.1a	43.5ab	116.6a	165a	10.5d	15.75d	32.2c	46.2c	6b	8.6e	14.2d	25.1d	6.7	6.25	12.5	13.2
CV	0.93	2.84	1.56	0.74	9.62	1.87	2.83	1.51	5.06	2.71	1.41	1.22	-		-	-
CD (0.01)	0.61	2.56	3.42	2.53	2.88	0.69	2.05	1.58	0.63	0.6	0.48	0.72	NS	NS	NS	NS
CD (0.05)	0.44	1.83	2.44	1.80	2.05	0.49	1.46	1.10	0.45	0.42	0.34	0.51	NS	NS	NS	NS

Means with the same letter are not significantly different, DAS= Days After Sowing

Effects of water stress on leaf temperature

Day leaf temperature values at different growth stages of plant were measured using Dickson's D182 non-contact infrared thermometer and it was compared with ambient temperature under different treatments for baby corn. It is a hand-held device used for the rapid, accurate and non-destructive measurement of leaf temperature. To ensure accuracy in collected data IR meter was held with a horizontal angle of 45˚ and measurements were taken on clear sky condition. Sensing canopy temperature using infrared thermometers or thermal cameras has shown good potential to estimate plant water status for irrigation scheduling in various crops [21, 22]. Treatments T1, T4 and T5 maintained the temperature around 35 °C to 41 °C, whereas T2 recorded an elevated temperature of 36 to 42 °C during the growth period and treatment T3 recorded the highest temperature of about 38-43 °C (Figure 4). Mean temperature values under T4 and T5 treatments were statistically similar to T1 treatment, however values recorded under T2 and T3 treatments were significantly high and differed from controlled treatment (Table 6). Increasing leaf temperature and decreasing the difference between leaf and air temperature were due to deficit irrigation (Figure 5).

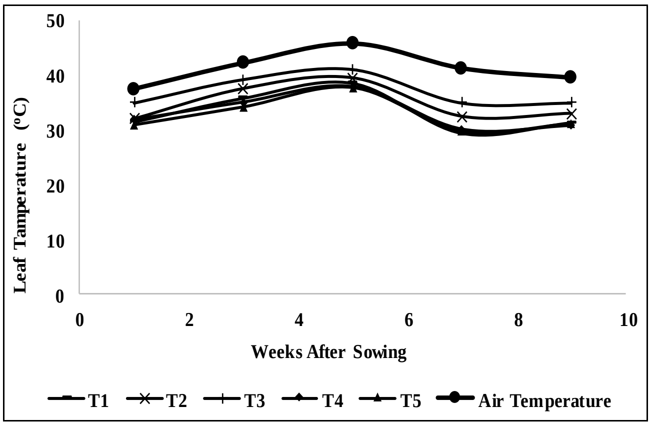

Fig 4: Variation of mean air temperature and mean leaf temperatures under different treatments for baby corn.

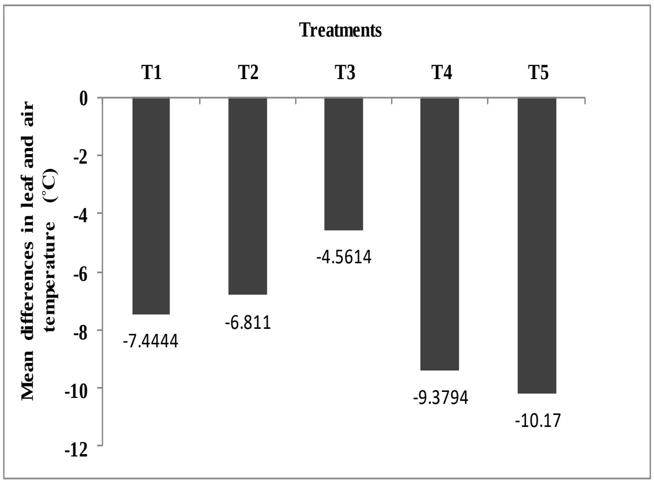

Fig 5: Mean difference between leaf temperature and air temperature under different treatments for baby corn.

Table 6: Mean values of leaf Temperature under different irrigation treatments of baby corn

Treatments	Leaf temperature (˚C)				
	12 DAS	24 DAS	36 DAS	48 DAS	60 DAS
T1	30.933c	34.7cd	38.13c	29.84cd	31.09cd
T2	32.2b	37.475b	39.213b	32.865b	33.025b
T3	35.925a	39.5a	41.175a	35.2a	35.75a
T4	31.815b	35.225c	37.21d	30.238c	30.825d
T5	30.49c	34.125d	36.8d	29.255d	31.775c
CV	1.549	1.732	1.477	1.432	1.83
CD(0.01)	1.08	1.354	1.228	0.961	1.285
CD(0.05)	0.77	0.966	0.876	0.685	0.916

Means with the same letter are not significantly different

Water productivity and yield under different treatments

In order to evaluate the influence of irrigation treatments on grain yield, two important indices crop water productivity (CWP) and irrigation water productivity (IWP) response of baby corn were calculated (Table 7). CWP was computed as the ratio of total grain yield to actual crop evapo-transpiration ETa (mm) and expressed in kg per ha on a unit amount of water applied. IWP can be defined as the grain yield of baby corn per unit of irrigation water use and it is a measure of the productivity of the irrigation water. Besides this yield response factors (Ky) was also evaluated for different treatments.

Irrigation amount significantly impacted grain yield. Highest yield with value of 23.65 t/ha (with husk) and 2.05 t/ha (without husk) was observed in T1 treatment, whereas least performance exhibited under T3 treatment with yield of 17.11 t/ha (with husk) and 1.36 t/ha (without husk). Grain yields of T2 and T4 treatments were obtained statistically equal with grain yield of T1 treatment. There was a decrease in grain yield with the T5 (150% NIR) as compared to the T1 (FIT), which had statistically similar yield as 50% FIT this may be due to lack of aeration in the crop root zone and sensitivity of baby corn for water logging condition. However, fodder yield increase with increase in irrigation amount and highest fodder yield (28.25 t/ha) was observed in case of T5 treatment and lowest fodder yield (24.67 t/ha) was observed in T3 treatment. The maximum plant height was observed in T4 treatment (168.5 cm) which was statistically similar to T4 (165 cm) and T1 (152.50 cm) treatments, whereas lowest plant height was observed in T3 (140.50 cm) treatment. Crop water use efficiency (CWUE) and Irrigation water use efficiency (IWUE) increase with decrease irrigation amount. Highest IWUE was recorded under T3 treatment with value of 25.74 kg/ha-mm and crop water use efficiency (CWUE) under T2 treatment with value of 7.32 kg/ha-mm.

Relationship between baby corn yield and irrigation water amount applied was developed. Baby corn grain yield exhibits quadratic relationship with irrigation amount with R^2 of 0.97 and curve becomes curvilinear (Figure 6), because of an increase in irrigation amount for over irrigation treatments without a corresponding increase in crop yield. Ky is an important index to evaluate plant response to water deficit conditions relative to non-water deficit conditions. It was calculated for water deficit irrigation treatments (i.e, T2 and T3) by using following *Equation 3* (Doorenbos and Kassam 1979):

$$K_y = \left[1 - \frac{Y_a}{Y_m}\right] \Big/ \left[1 - \frac{E_a}{E_m}\right] \qquad (3)$$

Where, Ya is actual grain yield (kg ha^{-1}); Ym is maximum attainable yield (kg ha^{-1}) taken as the fully irrigated treatment; ETa is actual crop ET (mm); ETm is maximum crop ET (mm) associated with Ym. Relative yield deficit decreased linearly with increasing relative ETc deficit. Ky values were 3.36 and 0.73 for T3 (50% NIR) and T2 (75% NIR), treatments, respectively.

Table 7: Amount of irrigation water applied, total water applied, grain yield, fodder yield and water use efficiency of baby corn under different irrigation treatments

Irrigation Level	Irrigation water Applied (mm)	Etc (mm)	Total Water Applied (mm)	Yield (t/ha)	Yield Without Husk (t/ha)	Fodder Yield (t/ha)	Max Pl Height (cm)	CWUE (Kg/ha-mm)	IWUE (kg/ha-mm)
T1 (100% NIR)	106	282.1	315.1	23.648a	2.05a	26.20bc	161.75a	7.29a	19.410ab
T2 (75%NIR)	79.5	275.6	288.6	21.215ab	2.02a	25.47c	152.50ab	7.32a	25.403a
T3 (50%NIR)	53	254.1	262.1	17.113b	1.36b	24.67c	140.50b	5.36bc	25.740a
T4 (125% NIR)	127.2	294.3	336.3	23.558a	2.05a	27.78ab	168.5a	6.82ab	16.112bc
T5 (150% NIR)	159	315.1	368.1	17.14b	1.57ab	28.25a	165a	4.90c	9.905c
p-value				0.0318	0.0454	0.0022	0.0457	0.0417	0.0007
SE(mean)				1.569	0.175	0.536	6.149	0.607	2.069
LSD (p=0.05)				5.1447	0.5395	1.653	18.946	1.8699	6.3767

Means with the same letter are not significantly different

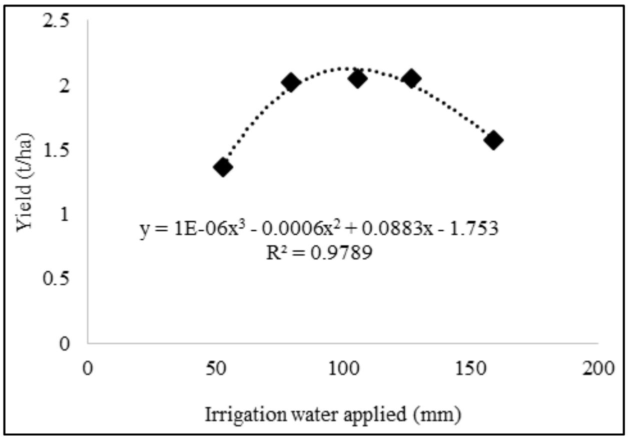

Fig 6: Relationship between maize grain yield and seasonal irrigation water applied.

Conclusions

This study evaluated the effect of different seasonal irrigation amounts on evapotranspiration, grain yield, yield response factors and water use efficiency of baby corn *(Zea Mays* L.) under SDI. Field experiment was conducted at ICAR- Central Institute of Agricultural Engineering, Bhopal, during summer season of 2018. Irrigation levels significantly influenced growth, yield components and yield of baby corn. Maximum yield of 2.05 t/ha was obtained with T1 (100% NIR) treatment, whereas least performance exhibited under T3 treatment with yield of 17.13 t/ha. However maximum irrigation water use efficiency (IWUE) was recorded under T3 treatment with value of 25.74 kg/ha-mm and maximum crop water use efficiency (CWUE) under T2 treatment with value of 7.32 kg/ha-mm. There was a decrease in grain yield with the excess amount of irrigation water under treatment T5 (150% NIR), which had statistically similar yield as T3 treatment (50% NIR), this may be resulted due to sensitivity of baby corn for water logging condition. Results indicated variation in total water demand that ranged from 260 to 368 mm. Baby corn yield response factor, as an indicator of crop sensitivity to water stress, obtained 3.36 and 0.73 for T3 (50% NIR) and T2 (75% NIR) treatment, respectively. The value of ky obtained for this study could be used for the purposes of irrigation management and water allocation scheduling over irrigation schemes under limited irrigation water supply. In this study, higher values of both WUE and IWUE were obtained when irrigation was scheduled at 75 percent available soil moisture depletion (T2). On the other hand, full irrigation (T1) gave the highest net return. Quadratic relationship was obtained between grain yield and irrigation rate and increased with irrigation rate from deficit to full irrigation treatments (FIT). For decision making on water availability objectives in terms of yield target versus water productivity, the best performance was observed with irrigation treatment T2, where only 11.13% reduction in yield was observed with 25% water saving as compared to T1 treatment. The findings of the study recommends cultivation of summer baby corn by providing recommended dose of water and nutrient to achieve maximum production, water use efficiency and yield under sub-surface drip irrigation strategy in black cotton soil region of central India and in locations that have similar soil type, climatic conditions and crop management practices.

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