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Short communication

Water productivity of spring maize under modified soil microenvironment

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The state of Punjab is facing a serious threat of fast depleting ground water resources (Hira, 2009). This has prompted the state to plan diversification of higher water guzzling crops like rice and wheat to lower water requiring crops like maize. In this context, the spring maize needs to be water-efficient so as to fulfill the objectives of crop diversification. In addition to warming scenarios, the state of Punjab is suffering from limiting water availability for agriculture as the water table is depleting at an alarming rate in most parts of the state. Thus, a dual challenge of warming climate and low input water availability is being faced while popularizing spring maize in the state. Under such conditions, soil and agronomic interventions leading to modification of soil micro-environment need to be studied for improving the crop and water productivity of spring maize. Keeping this in view, the present investigation was conducted to manage the climate variability effect on evapotranspiration requirement of spring maize to explore management options for improving its water productivity by modification of soil microclimate under Punjab conditions.

The present study involved two locations, namely Ludhiana and Ballowal Saunkhari representing two agroclimatic zones of Punjab.The region is characterized by a sub-tropical and semi-arid climate with a hot dry summer (March–June), wet monsoon season (late June–mid September) and a cool, dry winter (October–February). Ludhiana, representing the central plain agroclimatic region, is situated at 30^{o} 54' 33" N latitude, 75^{o} 48' 22" E longitude and 247 m altitude above mean sea level. It experiences average annual maximum temperature of 29.8^{o}C, minimum temperature of 16.6^{o}C, annual rainfall of 753.3 mm and annual potential evapotranspiration of 1898.0 mm. Ballowal Saunkhari, representing the sub-mountainous undulating north-eastern agroclimatic region of Punjab, is situated at 31^{o} 6' 5" N latitude, 76^{o} 23' 26" E longitude and 355 m altitude above mean sea level. The region experiences average annual maximum temperature of 30.0^{o}C, minimum temperature of 16.3^{o}C, annual average rainfall of 1025.4 mm and potential-evapotranspiration of 1802.0 mm.

Open pan evaporation was recorded daily at 0830 hrs from the open pan evaporimeter installed in the observatory with the help of fixed-point gauge during the crop growing period.Daily values of open pan evaporation were added during different phenophases of the crop at obtain crop water requirement for during different phenological stages.

A field experiment was conducted to manage the climatic variability impact on water productivity of spring maize (var. PMH-7) during spring 2014 at the Research Farm, Punjab Agricultural University, Ludhiana on sandy loam soil.The experiment was laid out in factorial randomized block design with 3 replications comprising 3 irrigation levels and 4 manuring treatments. The irrigation scheduling was applied based on IW/CPE ratio of 1.25 (I_1), 1.0 (I_2) and 0.75 (I_3) respectively. The manuring treatments comprised of surface application of FYM (M_1), subsurface manuring at the depth of 15-25 cm in between the crop rows (M_2), digging alone and refilling (M_3) and control with neither digging nor farm yard manure application (M_4).

Water used by the crop during its entire growing period was calculated by soil moisture depletion method by taking soil moisture observations with gravimetric method at 15 days interval starting from sowing till harvesting as well as before and after each irrigation. After taking fresh weight, the samples were oven dried at about 110^{o}C for 48 hours and the weight of moist and dry soils were recorded for the calculation of soil moisture percentage (Dastane, 1967). The depth of water was obtained as under:

$$P_v = \frac{P_w \text{ x BD x d}}{100}$$

where,

P_v = Depth of water in cm

P_w = Percent moisture on weight basis

Table 1: Open pan evaporation at differentphenological stage of spring maize at Ludhiana and Ballowal Saunkhari during spring 2014

Phenological stage	USDA open pan evaporimeter (mm)	
	Ludhiana	Ballowal Saunkhari
Sowing to 2 leaves emergence	14.5	20.9
2 leaves emergence to 5 leaves emergence	17.6	17.7
5 leaves emergence to knee high	50.7	44.7
Knee high to 12 leaves emergence	34.1	36.8
12 leaves emergence to 16 leaves emergence	136.9	105.0
16 leaves emergence to beginning of Silking	96.0	69.1
End of Silking	89.4	62.1
Silking to physiological Maturity	366.0	287
Total PET during crop season	805.2	643.3

Table 2 : Water use efficiency of spring maize under different irrigation levels and manuring treatments during spring 2014

Treatments	Water use (mm)	Straw yield ($kgha^{-1}$)	Grain yield ($kgha^{-1}$)	Water use efficiency ($kgha^{-1}mm^{-1}$)	
				Straw	Grain
I_1M_1	601.9	8791.7	3857.0	14.6	6.4
I_1M_2	738.9	8876.3	3994.7	12.0	5.4
I_1M_3	697.7	8789.7	3653.0	12.6	5.2
I_1M_4	580.9	8761.0	3536.7	15.1	6.1
I_2M_1	617.3	8910.3	4050.3	14.4	6.6
I_2M_2	558.3	9023.3	4226.7	16.2	7.6
I_2M_3	568.3	8892.3	3950.0	15.6	7.0
I_2M_4	602.3	8864.3	3726.7	14.7	6.2
I_3M_1	497.3	8782.0	3526.7	17.7	7.1
I_3M_2	527.3	8866.7	3683.3	16.8	7.0
I_3M_3	543.3	8817.0	3407.3	16.2	6.3
I_3M_4	534.3	8682.3	3296.7	16.2	6.2

BD = Bulk density

d = Depth of soil in cm

Soil water retention in the 120 cm root zone was calculated by adding the by adding the depth of water in different layers as following:

$$\text{Root zone water retention} = \sum_{i=1}^{n} D_j$$

Where 'i' is soil depth interval (0-15, 15-30, 30-60, 60-90 and 90-120 cm) and D_j is the depth of water retained in the respective soil depth intervals.

To compute soil water use by the crop, the difference in soil water retention for the two successive samplings was taken as soil water use by the crop, assuming that no deep drainage (or percolation) occurred below the root zone. From the date of each irrigation to the day of next soil moisture sampling, the daily rate of pan actual evaporation was considered. Total water use during growth season of the crop was obtained by adding depletion of root zone soil moisture between successive sampling intervals.

Grain and straw yield from net plot was recorded at the time of harvesting and was converted from kg per plot to kg per hectare. The water use efficiency (WUE) of the crop under different treatments was calculated by using the following formula:

$$\text{WUE} (kgha^{-1}mm^{-1}) = \frac{\text{Grain / straw yield} (kg\ ha^{-1})}{\text{Water use (mm)}}$$

Open pan evaporationduring the growing period of spring maize for Ludhiana and Ballowal Saunkhari recorded with USDA open pan evaporimeter has been presented in Table 1. The total evaporation during the crop season was higher for Ludhiana (805.2 mm) as compared to Ballowal Saunkhari (643.3 mm). At Ludhiana, lowest evaporation was observed during emergence stage (14.5 mm) whereas highest was observed during physiological maturity stage (366.0 mm). For Ballowal Saunkhari, the lowest evaporation was observed during two leaves emergence stage to five leaves emergence (17.7 mm) stage and highest was observed during physiological maturity stage (285.0 mm).

Water use efficiency of spring maize under different irrigation levels and manuring treatments has been presented in Table 2. The crop under I_3M_1 exhibited more water use efficiency (WUE) w.r.t. straw yield (17.7 kg ha^{-1} mm^{-1}) as compared to other treatments and least WUE was exhibited by I_1M_2 (12.0 kg ha^{-1} mm^{-1}). However, WUE w.r.t grain yield the scenarios was completely different. WUE was highest under I_2M_2 (7.6 kg ha^{-1} mm^{-1}) and least WUE was found under I_1M_3 (5.2 kg ha^{-1} mm^{-1}).Thus, the combination of I_2(IW/CPE = 1.0) level of irrigation and sub-surface manuring tends to show higher WUE under ambient water supply. Various other studies have also reported that subsurface application of farmyard manure is useful for improving soil health, water productivity and reducing emission of green house gases to the atmosphere (Dell *et al,* 2011; Maguire *et al,* 2011 and Way *et al,* 2012).Thus, from the study it can be concluded that need based irrigation scheduling and water application (I_2, IW/CPE=1.00) in combination with sub-surface manuring can be helpful in managing crop water productivity in view of limiting water availability and changing climatic scenarios under Punjab conditions.

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