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Assessment of Cob Characteristics of Sweet Corn on Sandy Soils under Different Irrigation Methods

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Drip irrigation is an incredibly efficient watering method that slowly delivers water directly to a plants root system, through a network of small pipes. This minimizes conventional losses such as deep percolation, runoff and soil erosion. A few low cost automation systems were developed and evaluated their performance with drip irrigation on sweet corn. Compared to flood irrigation and paired row drip irrigation, single row drip irrigation produced better results. The results indicated that the number of kernel rows per cob, number of kernels per cob, length and diameter of the cob and individual fresh cob weight were observed to be more in single row as compared to flood irrigation and paired row drip irrigation systems. The yield response was also observed to be best in soil moisture sensor based irrigation with single row spacing.

Keywords: *Drip irrigation; conventional losses; soil erosion; automation systems; flood irrigation; soil moisture sensor.*

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1. INTRODUCTION

Drip irrigation is an incredibly efficient watering method that slowly delivers water directly to a plants root system, through a network of small pipes [1]. This minimizes conventional losses such as deep percolation, runoff and soil erosion. Agriculture marks the beginning of civilized or sedentary society. India had a stagnant performance of agriculture during the colonial period which turned into a sustained growth then with a stronger performance in India especially in terms of per capita food production the Indian Agricultural Industry grew. Irrigation has long been regarded as essential to agricultures rapid expansion, which absorbs 80 percent of the countrys usable water resources.

Agriculture, industrial production and domestic purposes, account for the majority of water consumption apart from fisheries, hydropower generation, transportation, and sustaining bio-diversity and ecological balance. Depending on the lifestyle, the proportion of water utilised for agriculture and industry differs from country to country. Indias per capita water use will rise from 99 litres per day today to 167 litres per day in 2050, making it the worlds most water-demanding country, requiring 2413 billion litres per day [2]. Land and water are essential for the countrys agriculture and economic development. According to a research by the International Water Management Institute (IWMI), enhancing the efficacy of irrigation can meet about half of the increase in water demand by 2025 [3]. Plants and animals cannot survive without water and water is required to ensure food security, feed livestock, maintain organic life, expand industrial production, and protect biodiversity and the environment. As a result, there can be no life without water. Water is becoming a scarce commodity in India, despite the fact that it is not a water-scarce country. This is due to the rising human populations terrible disregard and overexploitation of this resource.

Micro irrigation technology is now widely accepted by most of the farmers in the world. In this system water is applied close to the root of the plants which provides right amount of water required for the growth of the plant and avoids excessive wastage of water, unlike surface and flood irrigation, which wets the whole soil profile and sometime causes soil erosion and soil nutrient loss. Improved irrigation water efficiency, according to the FAO, is required to boost irrigations contribution to food production [4]. Water-saving technology, notably drip irrigation, has the added benefit of increasing yields while also reducing the rate of salinization. Furthermore, since neither system brings water into contact with foliage, they can be used with brackish water for crops that are not too sensitive to salinity [5]. Considering irrigation efficiency and environmental issues, micro-irrigation which is the precise application of water on or below the soil surface at low pressure using small devices that spray, mist, sprinkler or drip water, is becoming more attractive [6]. In order to reduce water use in agriculture, drip irrigation is often preferred over other irrigation methods because of high water application efficiency on the account of reduced losses, limited surface evaporation and reduction in losses due to percolation [7]. With drip irrigation water applications are more frequent than with other methods and this provides a very favourable high moisture level in the soil in which plants can flourish. There are lots of benefits of automation in drip irrigation- the real time useful controlling system for monitoring and controlling all activities of drip irrigation more efficiently. Drip method helps in achieving saving in irrigation water, increased water-use efficiency, higher quality products, decreased tillage requirement, increased crop yields and higher fertilizer-use efficiency [8,9]. There are lots of benefits of automation in drip irrigation- the real time useful controlling system for monitoring and controlling all activities of drip irrigation more efficiently. Drip irrigation by automation helps the farmers to apply the right amount of water at right time, regardless of availability of labour. This reduces the wastage of water and improves the crop performance and help saving time in all aspects.

Sweet corn is cultivated as a popular vegetable whose productivity potential is higher than that of wheat and nutritive value is superior to rice on account of which it will no longer be considered a coarse grain but a nutritious grain [10]. It is a high moisture commodity and sold on the basis of high quality alone. It is very succulent, has a rather shallow root system and does not yield well if adequate soil water is not readily available [11]. Irrigating sweet corn with micro-drip (emitter discharge of less than 0.5l/h) irrigation may improve yield, reduce drainage flux (excess water removal) and affect the water content distribution within the root zone especially within 0.6-0.9 m soil layer when compared with the conventional drip irrigation [12]. The amount of water applied per day, leaf-air temperature and soil moisture content were monitored [13]. The aim of the present work was to evaluate the yield response and cob characteristics of sweet corn under single, paired row and flood irrigation systems.

2. METHODS AND MATERIALS

2.1 Preparation of the Field

The experiment was conducted in the field irrigation laboratory, Department of Soil and Water Engineering, College of Agricultural Engineering, Bapatla. The experimental site lies in humid sub tropical area. The summers are dry and hot, whereas winter is cool. The experimental site consists of sandy soil with well drained conditions. Prior to spreading the sweet corn seeds, the field was prepared with a cultivator and rotavator to soften the soil and to remove the weeds. After a week of spreading about 100 kg of farm yard manure on a 1330 m^2 sweet corn plot, the plot was tilled with a rotavator once more to completely mix the dried farm yard manure into the soil.

2.2 Irrigation Accessories

- **Main pipe:** A PVC pipe with a diameter of 63 mm (Class 2, 4 kgf/cm2) was utilised to convey water from the source to the experimental location through sub mains.
- **Sub main:** A 50 mm diameter PVC pipe (Class 3, 6 kgf/cm2) was utilised as a sub main pipe to transport water from main lines to laterals.
- **Lateral pipe:** A LLDPE pipe was utilised to deliver water directly to the plant root zone from sub main pipes. The laterals are of the inline kind and have the following characteristics.
  Wall thickness - 0.80 mm
  Outer diameter - 16 mm
  Flow rate - 2.00 lph at 1kg/cm^2 pressure
  Spacing of drippers - 40 cm
- **Pump:** A centrifugal mono block pump of 1 hp capacity was used for pumping water.

2.3 Water Source

An existing open well near the trial site was used to supply the water. To determine whether water is suitable for irrigation, the pH and EC of the water were measured and determined to be 7.2 and 4 dS/m, respectively.

2.4 Screen Filter

The screen filter is typically made out of a 120 mesh (0.13mm) stainless steel screen housed in a mild steel body. Filtration is achieved by the movement of water through the stainless steel mesh. Specifications are as follows.
Maximum flow capacity - 27m^3/hr
Nominal size - 50 mm
Nominal pressure - 2 kg/cm^2
Size of aperture - 120 mesh
Clean pressure drop - 0.5 kg/cm^2 maximum.

2.5 Sand Filter

Fine gravel or coarse quartz sand of specific sizes (typically 1.5–4 mm in diameter) free of calcium carbonate are placed in a cylindrical tank as media filters. Light suspended contaminants, including as algae and other organic materials, fine sand and silt particles are effectively removed by these filters. This type of filtration is essential for primary filtration of irrigation water from open water reservoirs, canals or reservoirs in which algae may develop.

2.6 Working Principle Involved in the Soil Moisture Sensor

Electrical conductivity is the main working principle used in the development of soil moisture sensor circuits. The electrical conductivity of the soil increases as the moisture content of the soil increases. The electrical conductivity of the probes can be related to the soil moisture of the soil. Usually the electrical conductivity is read manually from a multimeter.

In this experiment, sensors which detect the soil moisture in the soil (agricultural field) and supply water to the field which requires irrigation water were arranged. The developed sensor as shown in Plate 3.3 is 8051 microcontroller based design which controls the water supply and the field to be irrigated using solenoid valves. The sensor present in each field stops the pump automatically through microcontroller when the field reached to its field capacity. Once the field reaches to 70% of field capacity, sensors sense the requirement of water in the field and send a signal to the microcontroller. Microcontrollers then supply water to that particular field for which water requires, till the sensors are deactivated again.

(a) Microcontroller based soil moisture sensor (b) Soil moisture aluminium probes

Fig. 1. Soil moisture sensor with microcontroller

2.7 Scheme of the Experiments

Sweet corn (*Zea mays*) of variety sugar 75 was chosen as the test crop. The plot was prepared for sowing the sweet corn seed by applying the needed farm yard manure at the recommended amount. During sowing, the plot was thoroughly wetted for two days. To conduct research, the 1330 sq m plot is divided into three sub plots of 12x35 m each.

3. RESULTS AND DISCUSSION

3.1 Yield Response of Sweet Corn with Different Irrigation Treatments

The total yield of sweet corn for different experimental plots was calculated and presented in Table 1. The yield from the plot-1 (flood irrigation), plot-2 (single row drip), plot-3 (paired row drip) was observed as 7.43 t/ha, 7.93 t/ha and 6.48 t/ha respectively. The yield of the plot-2 was observed to be higher when compared to the yield obtained from the other experimental plots. The higher yield can be obtained due to the efficient application of water at correct time near the root zone by low cost microcontroller based soil moisture sensor which is present in the field and supplies water automatically whenever there is need of water to the plant which helps for the favourable conditions for growth of the plant.

Yield values of sweet corn were compared against different irrigation systems as shown in Fig 2. The yield of sweet corn for single row drip is 6.72% more as compare to flood irrigation.

3.2 Cob Characteristics

In each treatment, 1 m^2 area was selected to evaluate the sweet corn cob characteristics. The number of kernel rows per cob, the number of kernels per cob, the cob length and diameter, and the fresh cob weight were all observed. The number of cobs in a 1 m^2 area is counted, and the average is displayed below.

3.2.1 Number of kernel rows per cob

It was discovered that the cob properties of sweet corn differed depending on the irrigation treatment. The number of kernel rows per cob is 16.8 in single row drip irrigation, followed by flood irrigation, and finally paired row drip irrigation. Fig 3 depicts the relationship between the number of kernel rows per cob and various irrigation regimes.

3.2.2 Number of kernels per cob

As far as the number of kernel rows per cob goes, the single row drip method has 755.2, followed by flood irrigation with 656.8, and finally the paired row drip method with 558.8.

3.2.3 Cob length

The length of sweet corn cobs varied depending on irrigation treatment. When compared to flood irrigation and paired row drip irrigation, single row drip approach produced longer cobs. The vernier callipers were used to measure the cob length from below the shank position to the bottom of the cob. Fig. 5 depicts the relationship between cob length and irrigation treatment.

Table 1. Yield of the sweet corn under the different irrigation systems

S.No	Type of irrigation system	Plot size	Yield per plot (kg)	Yield (kg/ha)	Yield (t/ha.)
1.	Flood	12m x35m	312	7429	7.43
2.	Single row drip	12m x35m	333	7929	7.93
3.	Paired row drip	12m x35m	272	6476	6.48

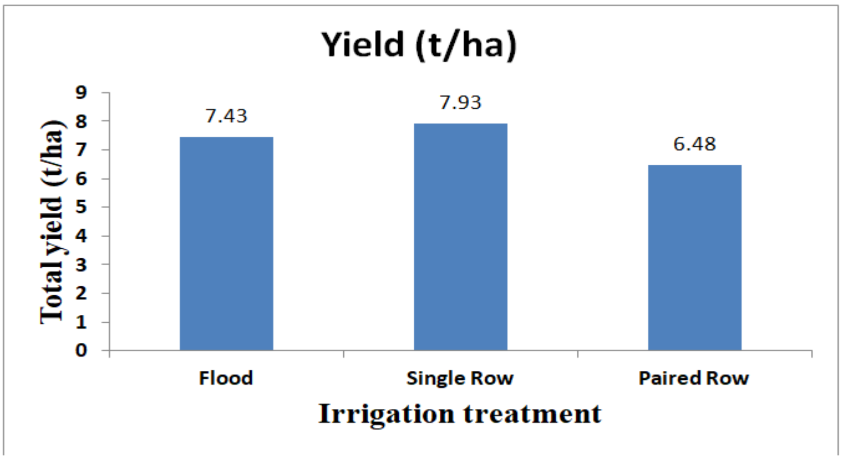

Fig. 2. Relationship between total yield and irrigation treatment

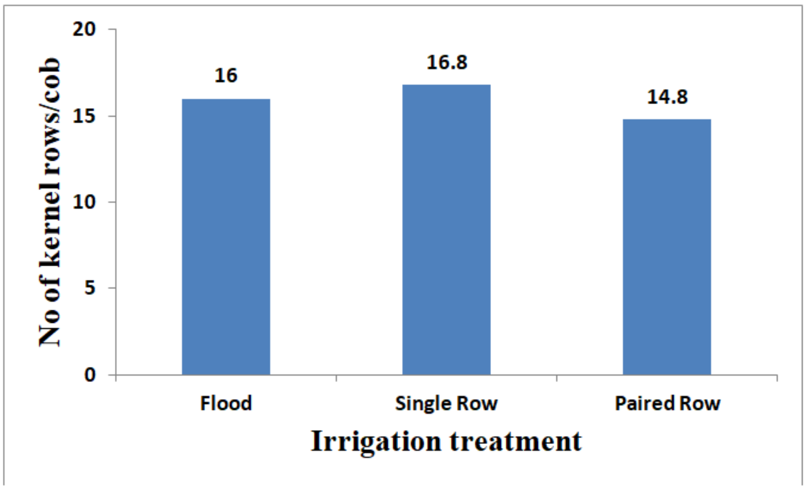

Fig. 3. Relationship between number of kernel rows per cob and Irrigation treatment

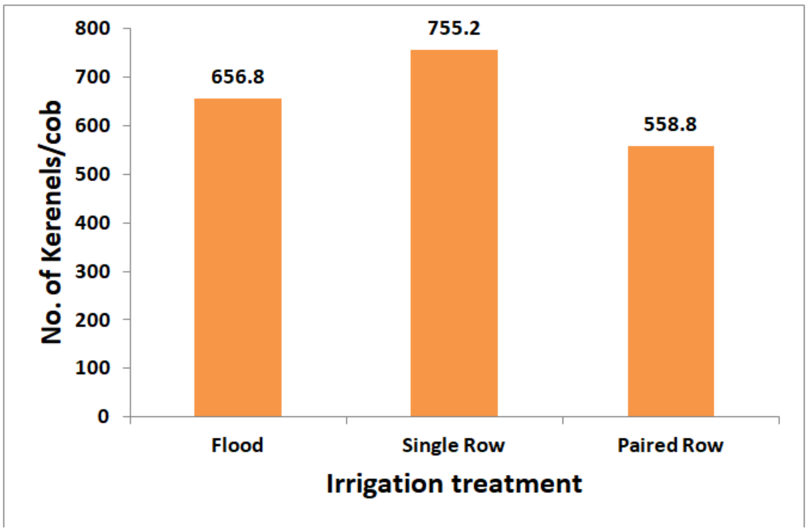

Fig. 4. Relationship between no. of kernels per cobs vs. irrigation treatment

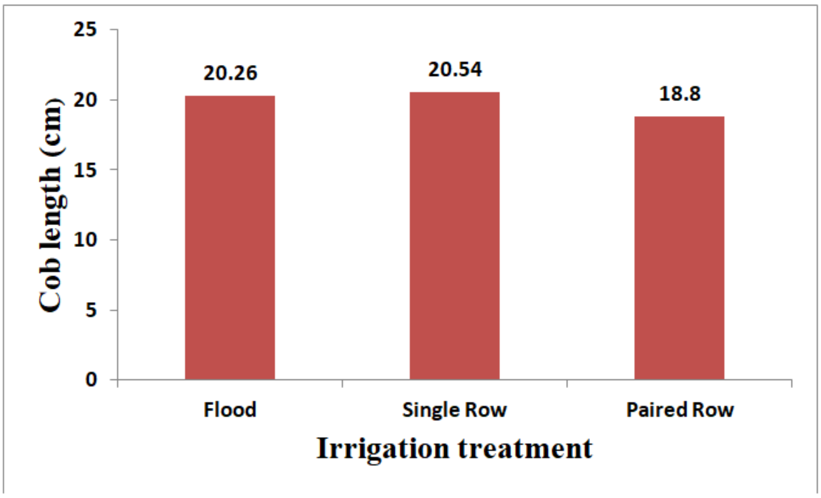

Fig. 5. Relationship between cob length and irrigation treatment

3.2.4 Cob diameter

The diameter of sweet corn cobs varied depending on irrigation treatment. When compared to flood irrigation and paired row drip irrigation, the single row drip approach produced a larger cob diameter. The diameter of the cob was measured using vernier callipers at the centre of the cob.

3.2.5 Individual fresh cob weight

The cobs produced in single row drip method has the most weight (405.2 gm), followed by flood irrigation (367.6 mg), and finally the paired row drip method (226.6 gm).

The sensor using washed sand as the porous medium was found to be the most efficient, and the leaf and air temperature sensors for the research region were made from a low-cost, commercially available button type thermistor. The amount of water applied per day, the temperature of the leaf-air and the moisture content of the soil were all measured [13]. In comparison to flood irrigation and paired row drip irrigation systems, the number of kernel rows per cob, number of kernels per cob, length of the cob, diameter of the cob and individual fresh cob weight were observed to be more in single row drip irrigation system. Overall, soil moisture sensor-based irrigation with single row spacing had the best yield response.

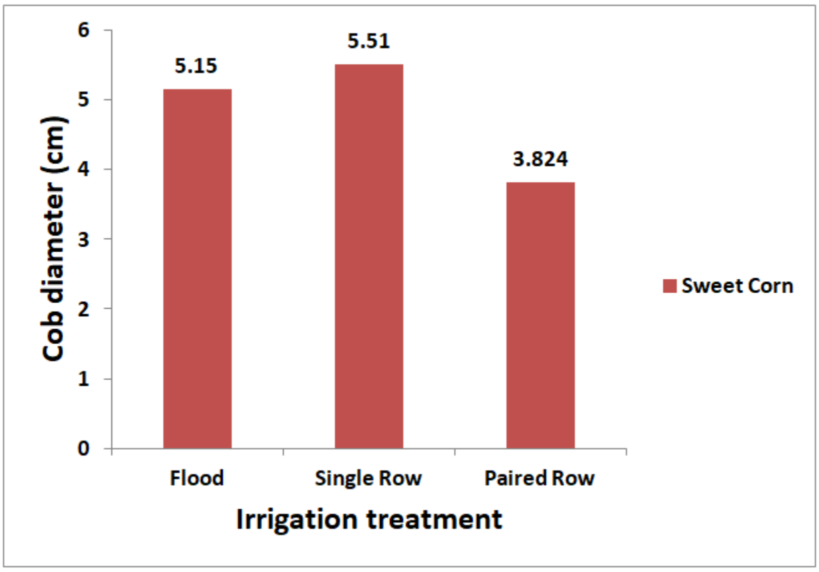

Fig. 6. Relationship between cob diameter and Irrigation treatment

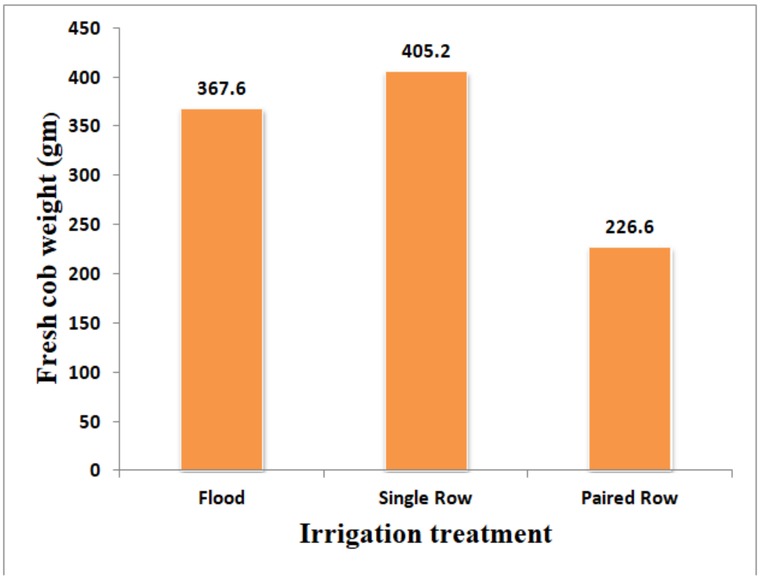

Fig. 7. Relationship between fresh ear weight and Irrigation treatment

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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