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EFFECT OF SOIL PHYSICAL PROPERTIES ON GROUNDNUT PRODUCTION UNDER DRIP IRRIGATION WITH BLACK PLASTIC MULCH

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ABSTRACT

The effect of soil physical properties such as bulk density, soil moisture content, soil temperature and water use efficiency on groundnut production under drip irrigation with black plastic mulch was investigated by four treatments namely drip-T_1, drip with mulch-T_2, mulch-T_3 and control-T_4. The obtained results of the bulk density are within permissible limits of 1.3 to 1.6 g cm^{-3} for sandy soil. Compared to all treatments, the drip with mulch treatment reported optimum soil moisture content and s oil temperature. The obtained results of water use efficiency for drip with mulch, drip, mulch, and control were 12.44,9.73, 8.05 and 6.45 kg ha^{-1} mm^{-1} duly. The higher water use efficiency under drip with mulch treatment was reported because of efficient use of application of irrigation water by adopting drip irrigation system in conjunction with black plastic mulch for conserving soil moisture content.

KEY WORDS : Groundnut, Drip irrigation system, Plastic mulch, Bulk density, Soil temperature, Soil moisture content and water use efficiency.

INTRODUCTION

The groundnut (*Arachis hypogaea,* L.) is a prominent food and oilseed crop, which ranked 14th and 4th in the world (Ahmed *et al.,* 2016) and contributes 40% of total national oilseed output (Priya *et al.,* 2013). According to Indian agricultural statistics at a glance 2018, groundnut yields 9.18 million tonnes per year on 4.91 million ha, with an average productivity of 1868 kg ha^{-1}. It generates 1.04 million tonnes per year in 0.74 million hectares in Andhra Pradesh, with an average of 1416 kg ha^{-1} productivity. In terms of both land and groundnut output, India is world's biggest country. After Rajasthan and Gujarat, Andhra Pradesh is 3rd largest producer of groundnuts. Groundnut largely cultivated in Rayalaseema districts of Anantapur, YSR Kadapa, Kurnool, Chittoor, and coastal areas of Andhra Pradesh.

Water is primary source of life for all living organisms in the universe, including plants, animals, and humans. A human also need food, which is produced from volume of water available to cultivate crops. The water availability is critical to the agricultural production system. According to the International Water Management Institute, the amount of freshwater is decreasing each year, and the international ground water resource assessment centre (Central Ground Water Board, 2020) reports that, availability of ground water reserves is decreasing each year by 1 m deep. Some estimations reveal that there will be serious water scarcity in the future throughout the planet. India's population was 1.39 billion in 2021, with a predicted increase of 1.807 billion by 2050 (Anonymous, 2021). As a result, it is a big challenge to produce enough food with available water as the population goes up.

Drip irrigation is application of water to the soil surface or below the root zone of plants at regular

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basis. By distributing little volume of water repeatedly to the perimeter of plant roots, drip irrigation systems can save irrigation water and boost crop output (Wilson *et al*., 2010; Chen *et al*., 2019). Drip irrigation improves crop productivity, application efficiency by reducing the evaporation, runoff, and deep percolation losses. Drip irrigation extremely beneficial where the water availability is scarce or expensive. Excess or insufficient water supply has a negative impact on yield, an optimal water supply can significantly improve the crop productivity.

Mulch defined as a material uniformly spread on soil surface to protect it from evaporation and solar radiation. Plastic mulch helps to keep water in the soil by reducing evaporation, to develop plant vigorously and adjust the soil temperature (Shen *et al*., 2013). Mulch on soil surface lowers evaporation and enhances water storage in the soil profile (Filipovic *et al*., 2016). Plastic mulch has several advantages like moisture conservation, weed control, and regulating soil temperature for better root growth and crop production (Ramakrishna *et al*., 2006).

The combined use of drip irrigation and plastic mulch enables water and fertiliser conservation. Drip irrigation delivers a smaller amount of wateralong with fertilisers at root zone as needed. When compared to broadcasting method, drip fertigation reduces the amount of fertiliser applied. Additional benefits are obtained by combining drip watering with plastic mulch. Previous researchers have found that combining a drip irrigation system with plastic mulch increases yield, (Wang *et al*., 2009); (Wang *et al*., 2011) and (Zhou *et al*., 2012). With the above factors in the view, a study was conducted to determine the impact of soil physical parameters such as bulk density, soil moisture content, soil temperature, and water use efficiency on groundnut production when drip irrigation with black plastic mulch was used.

MATERIALS AND METHODS

Description and selection of experimental field

The Bapatla is located in the south-eastern section of Guntur district of Andhra Pradesh. Because of its proximity to the seaside, the town has hot summers and cool winters. Summer and winter temperatures range from 40 to 50 °C and 18 to 25 °C. The annual rainfall ranges between 700 and 1150 mm, with an average of 940 mm. The field experiment was conducted at College of Agricultural Engineering at field irrigation laboratory. The experimental site is situated at a latitude of 160 N and a longitude of 880 E, at a height of 5 metres above sea level. The chosen field soil is fully sandy in nature, and the irrigation is provided via tube well.

Table 1. Details of experimental field

S. No.	Treatment	Method of water application
1	Drip (T_1)	Drip irrigation
2	Drip with mulch (T_2)	Drip irrigation
3	Mulch (T_3)	A small furrow is made along the row i.e., inside of mulch sheet
4	Control (T_4)	Hose pipe

Design of drip irrigation system

Drip irrigation system is efficient irrigation method to saves water by allowing drop by drop near to plant root zone through a serious of network pipes. Paired row method is selected with 16 mm size of lateral with 1m lateral spacing and emitter spacing is 40 cm on drip line. Drip system is operated with a 3 hp motor as water source of 2 inch bore well. The crop water requirement was calculated by using

Fig. 1. Preparation of field with rotovator

Fig. 2. Installation of drip laterals

CROPWAT 8.0 Software, the obtained crop water requirement was 449.1 mm. Based on crop water requirement the irrigation schedule and timings are formulated.

Selection and installation of black plastic mulch

For agricultural production, black plastic mulch is the most common colour. Most UV, visible, and infrared wave lengths of solar radiation are absorbed by black mulch. The absorbed energy is re-radiating as heat or long-wavelength infrared radiation. When compared to bare soil, soil temperatures beneath black plastic mulch are 5ºF higher at 2-inch depth and 3 ºF higher at 4-inch depth during a day. Black mulch increases the soil temperature by transforming heat from mulch to soil. The black plastic mulch film spread at plot rows manually after 10 days of planting with 60 cm width × 15.3 m length for the treatments.

Fig. 3. Installation of black plastic mulch

Fig. 4. Determination of bulk density

Bulk density

The compaction and low porosity are signs for higher bulk density, which results in restriction of root growth, air and water movement, there by leads to poor plant development. The ratio of soil dry weight to unit volume defines the bulk density. Soil samples from four treatments are taken initial and harvesting stage and analyzed as per the standard test procedures.

Formula used for calculation of bulk density

$$\text{Bulk density} = \frac{\text{Mass of dry soil, g}}{\text{Volume of core cutter, cm}^3} \quad .. (1)$$

Mass of wet soil = (Mass of core cutter+Wet soil)– Mass of core cutter

$$\text{Volume of core cutter} = \frac{\pi}{4}(D^2) \times \text{Height}$$

Soil moisture content

The moisture content of soil is stated in two ways: by weight i.e., mass of water available to soil sample dry weight, or by volume i.e., volume of water to soil sample total volume, expressed in percent. In comparison to saturated heavy clay, a sandy soil can hold significantly less water, because a sand granule does not bind water for longer times. Soil moisture is an important factor in determining how much water is evaporated from soil and transpiration from plant to atmosphere. Using a soil auger, soil samples taken daily from eachtreatment before and after irrigation at four depths: 5, 10, 20, and 30 cm, and an average value was computed.

Formula used for calculation of moisture content

$$W = \frac{M_2 - M_3}{M_3 - M_1} \quad .. (2)$$

Where,
W = water content in percentage (%)

Fig. 5. Collection of soil sample

Fig. 6. Soil samples in oven dryer

M_1 = Mass of container (g)
M_2= Mass of container + wet soil (g)
M_3=Mass of container + dry soil (g)

Soil temperature

The soil temperature during sowing time has direct influence on crop yield, for appropriate germination and emergence of any crop, soil temperature is major critical variables. Low soil temperature is a primary factor restricting seedling emergence and growth throughout the winter season. The measurement of soil temperature is more difficult than measuring air temperature, it requires separate thermometers. Daily temperatures are measured at four distinct depths such as 2.5, 5, 7.5, and 10 cm by using soil thermometers and an average value is calculated.

Water use efficiency

The ratio of total yield to amount of water utilised is known as water use efficiency. The yield obtained from each treatment as well as the amount of water consumed for treatment were recorded to calculate the water use efficiency and expressed in kgha^{-1} mm^{-1}.

$$WUE = \frac{\text{Yield (kg ha}^{-1}\text{)}}{\text{Amount of water (mm)}} \quad .. (3)$$

RESULTS AND DISCUSSION

Bulk density at initial and harvesting stage

The average bulk density at initial and harvesting stage was depicts in Fig. 7. Obtained data reveals that relatively higher bulk density was reported in all the treatments at harvest stage. Bulk density in sandy soil reported higher (1.3 to 1.7 g cm^{-3}) compared to fine silts and clays (1.1 to 1.6 g cm^{-3}) because of larger pore spaces. Root growth is restricted by bulk densities more than 1.6 g cm^{-3}. The obtained results are within the permissible limit of 1.3 to1.6g cm^{-3} for sandy soils. results indicates that, the drip irrigation and drip under black plastic mulch with control have no effect on bulk density.

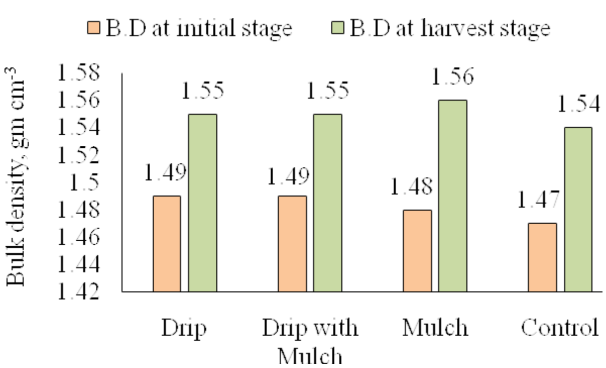

Fig. 7. Comparison of average bulk density at initial and harvest stage

Effect of soil moisture content on soil temperature before irrigation and after irrigation

The effect of soil moisture content on soil temperature before irrigation was shown in Fig. 8. The higher moisture content was observed under mulch treatments. Black plastic mulch reduces soil water evaporation, which helps to retain soil water available up to the next irrigation. The moisture conservation helps plant to develop and utilize soil nutrients, there by increases the final yield of groundnut. Drip treatment were also reported the performance in-between mulch and control in the view of soil moisture conservation, beside that soil temperature plays a major role to alter the soil moisture content. Soil is directly exposed to sun rays in control and drip treatments, which results in quick evaporation of water from soil surface. Under plastic mulch the soil temperature rises by absorption of more solar radiation, as a result

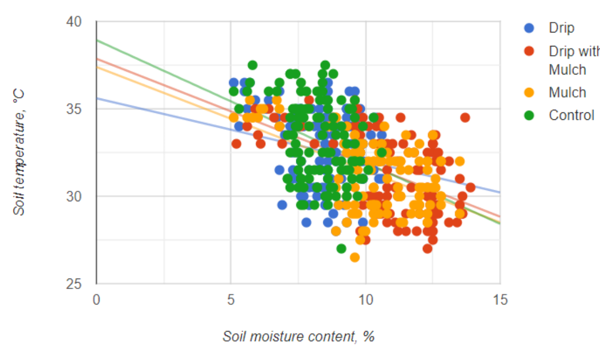

Fig. 8. Effect of soil moisture content on soil temperature before irrigation

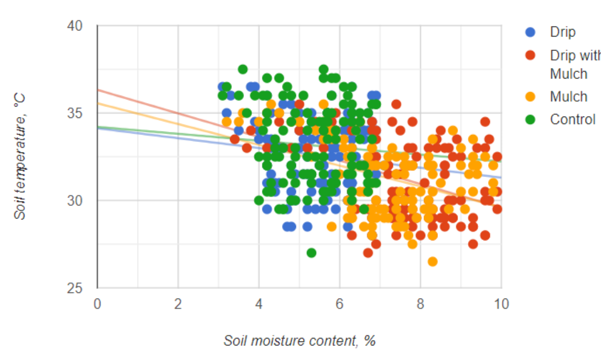

Fig. 9. Effect of soil moisture content on soil temperature after irrigation

evaporated water condensed inside plastic sheet and soil temperature reduces. However, drip with mulch treatment was maintain the optimum moisture conservation and soil temperature by using drip irrigation and black plastic mulch. Fig. 9 depicts the effect of soil moisture content on soil temperature after irrigation. Higher moisture content was reported in control and mulch treatments compared to drip and drip with mulch treatments, because method of water application is furrow irrigation for mulch treatment, for control the method of water application given with hose pipe.

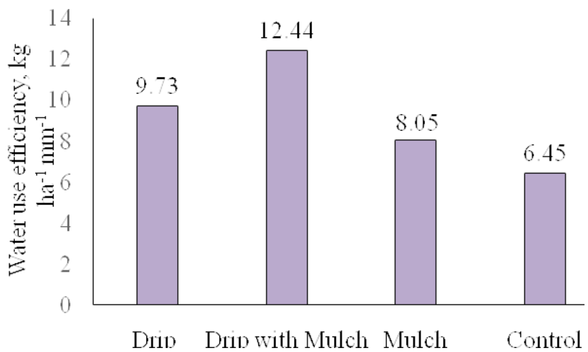

Fig. 10. Comparison of water use efficiency

Water use efficiency of groundnut crop under different treatments

From the graphical representation Fig.10 the water use efficiency reported highest as 12.44 kg ha^{-1} mm^{-1} was depicted in drip with mulch treatment because efficient use of application of irrigation water under drip system in addition to that a moisture conservation through black polyethylene mulch. The water use efficiency for drip, mulch, and control treatments are 9.73, 8.05 and 6.45 kg ha^{-1} mm^{-1} respectively.

CONCLUSION

The obtained results of the bulk density are within the permissible limit of 1.3 to 1.6 g cm^{-3} for sandy soils, it indicates the drip irrigation and drip under black plastic mulch with control have no effect on bulk density. Compared to other treatments, drip with mulch treatment reported the optimum soil moisture content and soil temperature. The obtained results of water use efficiency for drip with mulch, drip, mulch, and control were 12.44, 9.73, 8.05 and 6.45 kg ha^{-1} mm^{-1} duly. The higher water use efficiency under drip with mulch treatment was reported because of efficient use of application of irrigation water by adopting drip irrigation system in conjunction with black plastic mulch for conserving soil moisture content.

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