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Assessment of crop water requirement and yield attributes of groundnut under drip irrigation with black plastic mulch

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ABSTRACT

Groundnut *(Arachis hypogaea* L.*)* variety of TAG-24 was selected for the experiment with four treatments namely drip-T_1, drip with mulch-T_2, mulch-T_3 and control-T_4. The research objective is to study crop-water requirement, uniformity coefficient, yield attributes such as yield, plant height, root length, number of pods m^{-2}, seed and shell weight m^{-2}. Crop water requirement (CWR) for groundnut crop was calculated as 449.1 mm by CROPWAT 8.0 Software. Experiments were conducted by supplying different amount of water among various treatments such as 100% of CWR in T_4, 90% of CWR in T_1 & T_3 and 80% CWR in T_2 respectively. Uniformity coefficient was found as 0.86 for drip irrigation. Highest and lowest yield was reported in T_2 as 4.45 t ha^{-1} and 2.89 t ha^{-1} in T_4. Among all the treatments plant height and root length was reported highest as 52 cm and 48 cm in T_2, similarly number of podsm^{-2}, seed and shell weight m^{-2} were reported highest as 583, 0.47 kg and 0.24 kg in T_2 respectively. The yield attributes were observed highest in T_2 because of efficient water application at root zone by drip, controlled weed growth and conserved soil moisture by mulch which creates favorable conditions for plant growth.

***Key words**: Black polyethylene mulch, CROPWAT 8.0 Software, Crop water requirement (CWR), Drip irrigation system, Groundnut and Yield attributes.*

Introduction

The groundnut (*Arachis hypogaea,* L.) is a prominent oilseed and food crop, which ranked 4th and 14th in the world (Ahmed *et al.,* 2016) contributes for 40% of total national oilseed output (Priya *et al.,* 2013). According to the Indian agricultural statistics at a glance 2018, groundnut yields 9.18 million tonnes per year on 4.91 million ha, with average yield of 1868 kg ha^{-1}. It generates 1.04 million tonnes per year in 0.74 million hectares in Andhra Pradesh, with average of 1416 kg ha^{-1}productivity. In terms of both land and groundnut output, India is the 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, and Chittoor, as well as along the Andhra Pradesh coastal lines.

Water is primary source of life for all living or-

(*[1]Ph.D. Scholar, [2]Assistant Professor [3]B. Tech and [4]M. Tech) ganisms 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 groundwater resource assessment centre (Central Ground Water Board, 2019) reports that, availability of groundwater reserves is decreasing each year by 1 m deep. Some estimates predict that there will be sevier 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.

Drought is the outcome of a catastrophic, which means sudden great damage or suffering, whereas water shortage is a regular state that endures for a long time. When yearly water resources fall below 1,700 m^3 per person, an area is suffering from "water stress". The population experiences "water shortage" when yearly water resources fall below 1,000 m^3 per person, and fall below 500 m^3 indicate "absolute scarcity" (Falkenmark and Widstrand, 1992, Nsubuga *et al.,* 2014). Water shortage occurs when demand for freshwater exceeds availability in a certain sector. Water scarcity is defined as an excess of demand for water over available supply (Charrondiere *et al.,* 2012).

Agriculture is the area most affected by water constraint, accounting for 70% of worldwide freshwater consumption. Water rivalry among different industries deprives agriculture of extra resources. The agricultural share of water in arid places is expected to fall to around 50% by 2050 (Boretti and Rosa, 2019). This condition will gravely jeopardise food security, the sustainability of dry-land cultivation, and the region's social and economic growth. Water shortage can be alleviated to some extent by employing the 3'R concept, which stands for reduce, reuse, and recycle. Plastic mulch used in conjunction with a drip irrigation system increases agricultural yields by conserving water (Shirvastava *et al.,* 1994) evaluated the impacts of drip with mulch on tomato production, water usage and weed growth and found that 95% less weed development indrip with black plastic mulch, 53% more output, and 44% lower water usage than surface method.

Mulch functions as a barrier to limit water loss from the topsoil, and soil hold moisture for extended length of time, making it accessible to plants. In groundnut, the polythene mulch plots yielded 94.5% higher than the non-mulched plots, according to the results (Ramakrishna *et al.,* 2006). According to reports, inadequate water delivery during key phases of plant growth is the major reason of low groundnut production in India (Narayana moorthy *et al.,* 2020). With an efficiency of 90 to 95 percent, drip irrigation is effective technique to apply water and fertigation to crops. It prevents overwatering, resulting in fewer weeds, and saves money by delivering water and nutrients directly to the plant's roots zone in the appropriate amounts and at the appropriate time. By considering above aspects in the view, research was launched to examinecrop water requirement using CROPWAT 8.0 Software in conjunction, plastic mulch and drip irrigation system to study the yield and yield attributes of groundnut crop with varied quantities of water applications.

Materials and Methods

Selection of experimental field

The research is carried out at Bapatla, Guntur district of Andhra Pradesh and experimental filed is very close to of Bay of Bengal and town experiences hot summers and cool winters. The maximum and minimum temperature ranges between 40to 50^{0}C and 18 to 25^0 C in summer and winter. The rainfall of 700 - 1150 mm annually with an average of 940

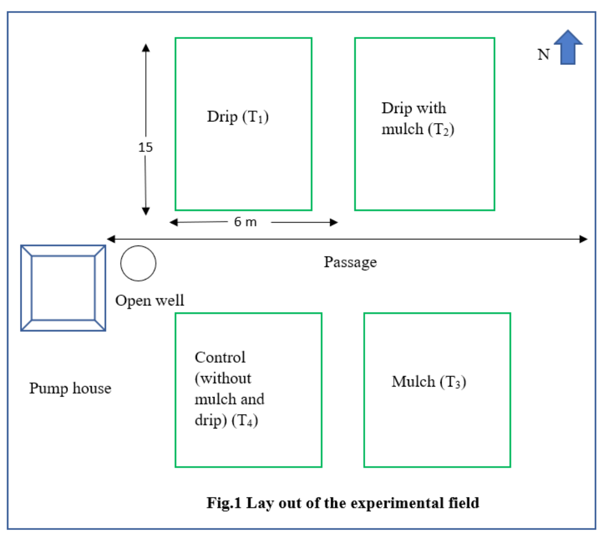


Fig. 1. Layout of experimental field

mm. The site situated geographically 16^0 N latitude, 88^0 Elongitude and 5 m altitude of mean sea level.

The field is sandy loam in nature and irrigation source is bore well. The total area selected for experimental field is 360 m^2 and divided into four plots i.e., Drip irrigation system (T_1), Drip with black mulch (T_2), Black mulch (T_3), and Control (T_4) i.e., without black mulch and without drip irrigation system, it is generally considered as farmers practice. The layout of experimental field is given Figure 1.

Design of drip irrigation system

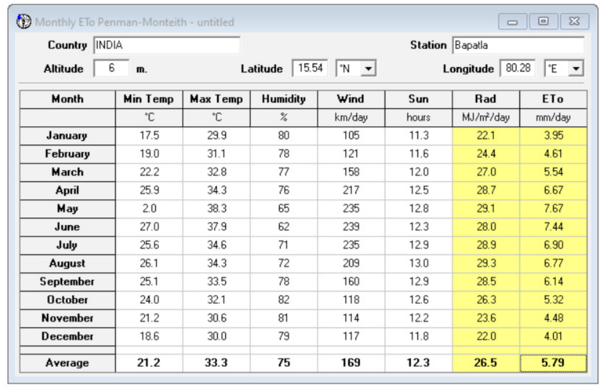
Drip irrigation system is efficient irrigation method to saves water by allowing drop by drop near to plant root zone through a serious of network pipes research conducted by supplying different amount of water among various treatments such as 100% of CWR to control (T_4), 90% of CWR to both Drip irrigation (T_1) and Black mulch (T_3), and 80% CWR to drip with black mulch (T_2) respectively. Drip irrigation system paired row method is selected with 16mm size of lateral with lateral spacing of 1.0 m, drip lateral spacing of 40 cm and drip system operated with a 3 hp motor as water source of 2 inch bore well.

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 incoming solar radiation are absorbed by black mulch, which then re-radiates the absorbed energy as heat or long-wavelength infrared radiation. When compared to bare soil, soil temperatures beneath black plastic mulch are generally 5 ºF higher at a 2-inch depth and 3 ºF higher at a 4-inch depth during the day (Gheshmand Brown, 2020). Black mulch increases the soil temperature improved by transforming heat from mulch to soil (Aniekwe *et al*., 2004). 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 1 and 2 (drip plots) and 30 cm width × 15.3 m length for the treatment 3 as per the design of the field.

Estimation of crop water requirement

The groundnut crop water requirement is estimated by CROPWAT 8.0 Software. The CROPWAT software works based on Penman-monteith equation. The estimations used for irrigation scheduling calculations and irrigation water requirements based on cropping pattern, various crop stages. The default page with data entered of CROPWAT 8.0 Software shown in Fig. 2.



Monthly ETo Penman-Monteith - untitled

Country INDIA Station Bapatla

Altitude 6 m. Latitude 15.54 °N Longitude 80.28 °E

Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	17.5	29.9	80	105	11.3	22.1	3.95
February	19.0	31.1	78	121	11.6	24.4	4.61
March	22.2	32.8	77	158	12.0	27.0	5.54
April	25.9	34.3	76	217	12.5	28.7	6.67
May	2.0	38.3	65	235	12.8	29.1	7.67
June	27.0	37.9	62	239	12.3	28.0	7.44
July	25.6	34.6	71	235	12.9	28.9	6.90
August	26.1	34.3	72	209	13.0	29.3	6.77
September	25.1	33.5	78	160	12.9	28.5	6.14
October	24.0	32.1	82	118	12.6	26.3	5.32
November	21.2	30.6	81	114	12.2	23.6	4.48
December	18.6	30.0	79	117	11.8	22.0	4.01
Average	**21.2**	**33.3**	**75**	**169**	**12.3**	**26.5**	**5.79**

Fig. 2. Meteorological data entered in CROPWAT 8.0

Meteorological data and Crop data

Meteorological data of the Bapatla collected from agriculture college farm, for the period 2010-2020. The average minimum and maximum air temperature, average relative humidity, sun shine hours, total precipitation and average wind speed were collected. The above average data was entered in CROPWAT 8.0 Software by selecting icon **climate/ ET_o**, which is available at left side of default page.

Figure 2 depicts the entered average data of meteorological CROPWAT 8.0 software by selecting icon climate/ET_o, after selecting, an empty dialogue box is appeared. The following meteorological data was entered in empty fields, such as minimum and maximum temperature, humidity, wind speed, sun shine, ET_c etc., and then click on next icon option crop, after selecting crop option, an empty dialogue box is appeared, which is shown in following Fig. 3.

Figure 3 depicts the entered values of crop coefficient (K_c) in software. By select the crop name and entering the planting date then it automatically displays the harvest date. The K_c values varies with type of crop, K_c values for different stages and rooting depth for different stages was entered. Next select the option soil, which is shown Figure 4, and depicts the entered data of soil in CROPWAT 8.0 Software, after entering all the details, then click the option CWR, i.e., crop water requirement, then it displace the results page which is shown in Figure 5, the crop water requirement is displayed in decade

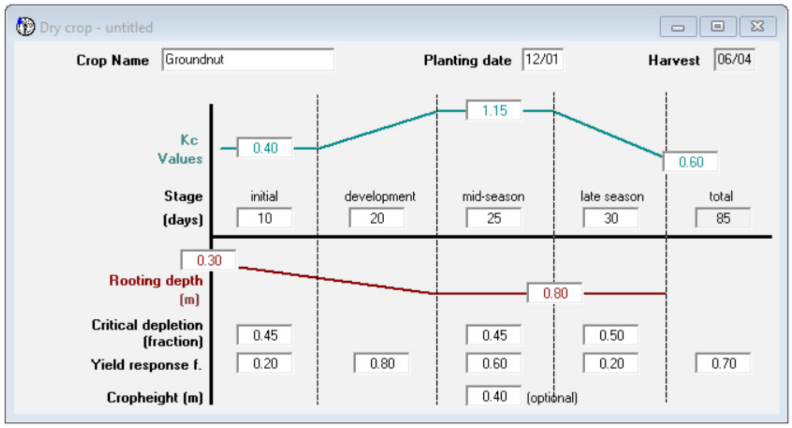


Fig. 3. K_c values entered in CROPWAT 8.0

wise i.e., one-decade equal to 10 days. The amount of water required for the groundnut crop calculated by CROPWAT Software 8.0. Experiments were conducted by supplying different amount of water among various treatments such as 100% of CWR to T_4, 90% of CWR to T_1 and T_3 and 80% CWR to T_2 respectively.

Uniformity coefficient (C_u)

The uniformity coefficient describes how evenly water is applied to a specific region. Uniformity equation is often used to estimate the design emission uniformity in point source and line source drip irrigation systems, and was first to define an empirical design emission uniformity for evaluation of drip irrigation system performance (Karmeli and Keller, 1975).

Formula for calculating the uniformity coefficient

$$EU = 100\left[1.0 - \frac{1.27C_u}{\sqrt{n}}\right] \times \frac{q_m}{q_a} \quad \text{.. (1)}$$

Where,

EU = Design emission uniformity, %

C_u = Manufacturer's coefficient of variation for emitters with a point or line source,

n = Number of emitters per plant,

q_m= Minimum emitter discharge rate with minimum pressure in the section, (Lh^{-1})

q_a = Average or design emitter discharge for the section, (Lh^{-1}).

Yield measurement

It is important to harvest groundnut crop at right time for obtaining higher yields. With finger pressure, a fully grown pod will be tough to separate. This stage is reached when the vine's leaves become yellow and inside shell turns to black. Leave the harvested groundnut plants in small heaps for two to three days for curing. After curing, threshing can be done either by manual or machines. The final yield of groundnut is determined by calculating corresponding total weight yield obtained from respective treatments per unit area and is expressed in kg ha^{-1}.

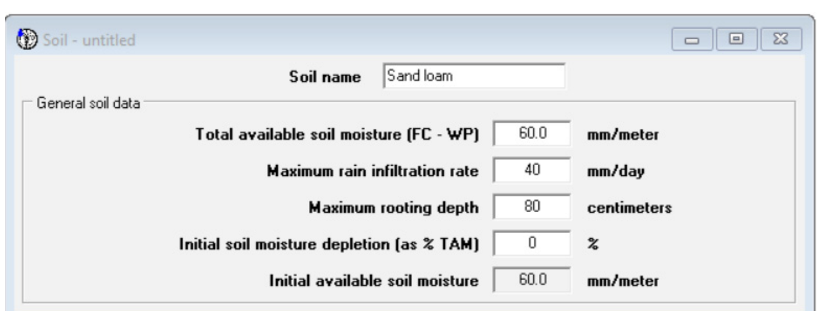


Fig. 4. Soil data entered in CROPWAT 8.0

Table 1. Irrigation time and scheduling

S. No.	Treatment	Crop water requirement (CWR)	Irrigation time	Method of water application
1	Drip (T_1)	90% of total CWR i.e., 404.19 mm	31 minutes	Drip irrigation
2	Drip with mulch (T_2)	80% of total CWR i.e., 359.28 mm	27 minutes	Drip irrigation
3	Mulch (T_3)	90% of total CWR i.e., 404.19 mm	35 minutes	Hose pipe at head of furrow
4	Control (T_4)	Total CWR 449.1 mm taken as 100%	39 minutes	Hose pipe

Calculation of uniformity coefficient of drip irrigation systemby usingequation(1)

Yield attributes

The yield attributes of groundnut such as plant height, root length, number of pods per plant and quality parameters like seed and shell weight are studied. To study the yield attributes randomly chosen a one square meter area and measured the yield attributes.

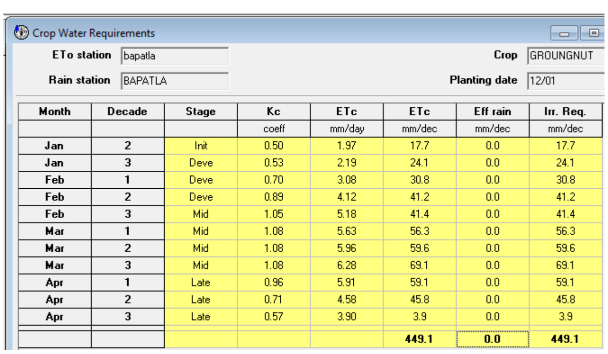
Results and Discussion

Estimated result of crop water requirement

The crop water requirement for groundnut was estimated using CROPWAT 8.0 Software as shown in Fig. 5. The estimated CWR was 449.1 mm for entire crop period. The meaning of the 1 decade is 10 days, for example in January month, decade 2 means, calendar daysfrom 11 to 20 days, similarly decade 3 means calendar days from 21 to 31 days. The irrigation requitement for the January decade 2 is 17.7 mm/decade means 17.7 mm divide with 10 days gives 1.77 mm/day, which means water application for groundnut per day is 1.77 mm.

Irrigation time and scheduling

$$EU=100\left[1-\frac{1.27\left(\frac{6.5}{100}\right)}{\sqrt{0.5}}\right]\left(\frac{1.704}{1.7337}\right)$$



Crop Water Requirements

ETo station: bapatla | Crop: GROUNGNUT

Rain station: BAPATLA | Planting date: 12/01

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Jan	2	Init	0.50	1.97	17.7	0.0	17.7
Jan	3	Deve	0.53	2.19	24.1	0.0	24.1
Feb	1	Deve	0.70	3.08	30.8	0.0	30.8
Feb	2	Deve	0.89	4.12	41.2	0.0	41.2
Feb	3	Mid	1.05	5.18	41.4	0.0	41.4
Mar	1	Mid	1.08	5.63	56.3	0.0	56.3
Mar	2	Mid	1.08	5.96	59.6	0.0	59.6
Mar	3	Mid	1.08	6.28	69.1	0.0	69.1
Apr	1	Late	0.96	5.91	59.1	0.0	59.1
Apr	2	Late	0.71	4.58	45.8	0.0	45.8
Apr	3	Late	0.57	3.90	3.9	0.0	3.9
					449.1	0.0	449.1

Fig. 5. Crop water requirement in CROPWAT 8.0

= 100(0.883)(0.98288)
= 100 (0.86)
= 86.82%

The recommended range of uniformity coefficient is 0.8 to 0.9. The obtained uniformity coefficient is within the recommended range for the field drip irrigation system.

Effect of irrigation levels on groundnut yield

The total yield of groundnut for different experimental treatments was calculated and shown in Table 2. The yield from drip (T_1), drip with mulch (T_2), mulch (T_3) and control (T_4) were observed as 3.93, 4.45, 3.25 and 2.89 tha^{-1} duly. The yield of the

Table 2. Yield of the groundnut under different treatments

S. No.	Treatments	Yield (th^{-1})	% Increase in yield with respect to control treatment)
1.	Drip (T_1)	3.93	26.46
2.	Drip with mulch (T_2)	4.45	35.05
3.	Mulch (T_3)	3.25	11.07
4.	Control (T_4)	2.89	—

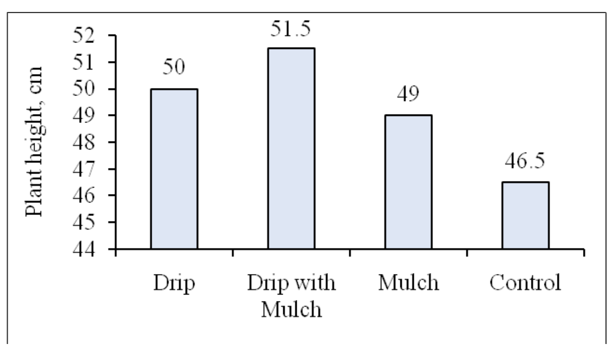


Fig. 6. Comparison of plant height under different treatments

drip was observed to be higher among all the treatments. The higher yield obtained due to efficient application of water, plastic mulch maintains optimum temperature, conserves soil moisture and also controls weed growth under plastic mulch, which helps maintain favourable conditions for growth of plant. From the experimental results shows that with low crop water requirement (i.e., 359.28 mm) under plastic mulch in addition to drip irrigation system reported 35.05% increasing in yield compared to traditional method,thereby it saves 89.82 mm of water.

Comparison of plant height for four treatment plots

Figure 6 depicts comparation of plant height with varies amount of water application, the plant height is reported highest in drip with mulch treatment was 51.5 cm, followed by the drip, mulch and control treatment were 50, 49, 46.5 cm respectively. Higher plant height was reported because of efficient use of application of irrigation water under black plastic mulch compared to farmers practice i.e., T_4.

Comparison of root length for four treatment plots

Figure 7 depicts comparation of root length under different treatment combinations, the root length is reported highest in drip with mulch treatment was 48.5 cm, followed by the drip, mulch and control treatment were 46, 42, 39.5 cm respectively. Higher plant root length was reported due to efficient use of application of irrigation water under black plastic mulch compared to control treatment.

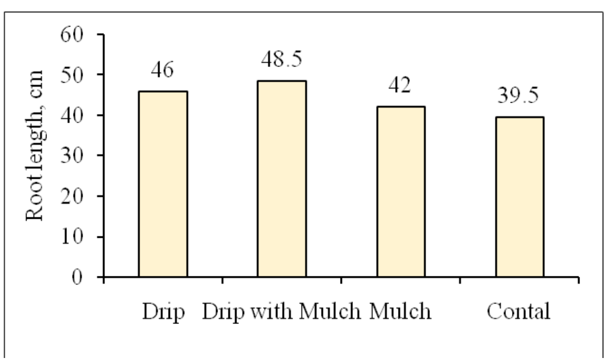


Fig. 7. Comparison of root length of four treatments

Comparison of number of seeds per square meter area of plots

From the above graphical representation Figure 8

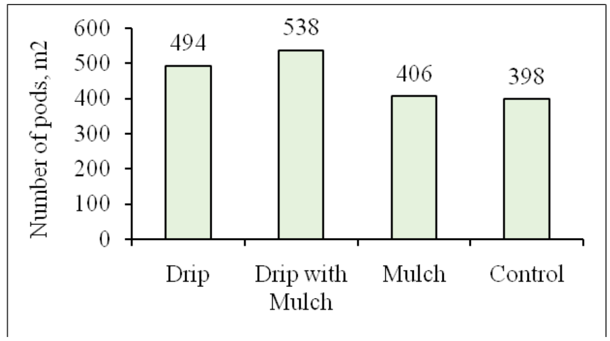


Fig. 8. Comparison of number of pods per square meter area

shows highest number of pods per square meter area is obtained in drip with mulch plot i.e., 538 followed by 494, 406, 398 in drip, mulch and control treatments respectively. The high pods were reported due to the efficient application of irrigation water and use of black plastic mulch reduces weed infestation which results in efficient utilization soil nutrients in given area.

Comparison of seed weight per square meter area of four plots

Figure 9 depicts comparation of seed and shell weight of different treatments, higher seed and shell weight was reported in drip with mulch treatment as 0.476 and 0.244 kg. The lowest seed and shell weight was reported in control treatment as 0.319 and 0.124 kg. The seed and shell weight per square meter area in drip with mulch treatment were reported highest because of efficient irrigation and use of black plastic mulch, the formation of large size groundnut pods is major factor to get more seed weight with use of mulch and drip irrigation.

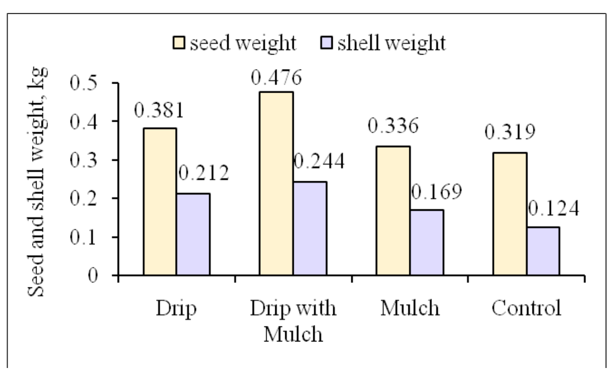


Fig.9. Comparison of seed and shell weight

Conclusion

The obtained results of crop water requirement (CWR) for groundnut crop were calculated as 449.1 mm by CROPWAT 8.0 software. Uniformity coefficient was found as 0.86 for drip irrigation. Highest and lowest yield was reported in T_2 as 4.45 t ha^{-1} and 2.89 t ha^{-1} in T_4. Among all the treatments plant height and root length was reported highest as 52 cm and 48 cm in T_2, similarly number of pods m^{-2}, seed and shell weight m^{-2} were reported highest as 583, 0.47 kg and 0.24 kg in T_2 respectively. The yield attributes were observed highest in T_2 because of efficient water application at root zone by drip, controlled weed growth and conserved soil moisture by mulch which creates favorable conditions for plant growth to increase the productivity.

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