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College of Agriculture and Natural Resources

Department of Plant Science

Effect of watering frequency on germination and early growth of maize (Zea mays) seed on Gurage zone Wolkite University

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LIST OF ABERIVATION

CRD	Completely Randomized Design
LSD	Latin Square Design
N	Nitrogen
**	Highly significant

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Abstract

Maize (Zea mays) is one of the most important cereal crops grown principally during the raining season in Ethiopia which is commonly used for both human consumption and poultry feed. Green house experiment on the effect of watering frequency on germination and early growth of maize was carried out at Ambo Agricultural Research Center using a hybrid maize variety BH661 (Zea mays) from May to June, 2022. The study was conducted to determine the effect of watering frequencies on germination and early growth of maize seed (Zea mays). The highland maize hybrid variety of BH661 was used as a test crop for the experiment. Three watering frequencies one day interval, three days intervals and five days intervals were used as an experimental treatment, and they were laid out in a Completely Randomized Design (CRD) with four replications. The watering frequencies showed statistically significant differences, on plant shoot length and biomass weight, but the treatments didn't reveal statistical difference on seedlings emergence. Therefore, one day watering interval shows better performance on shoot length, fresh and dry biomass.

Effect of watering frequency on germination and early growth of maize (Zea mays) seed in wolkite university,

Keywords: Maize, watering frequency, block, treatment

1. Introduction

Irrigation can be described as the artificial application of water to soil for the purpose of agricultural production. It is primarily considered when there are suspected problems with rained crop production. Rainfall may be unreliable in amount and duration of timing. For instance, rainfall may vary from year to year, or the onset and cessation of the rains may be uncertain (Gevens, 2007). Meanwhile, there may be period of drought during the rainy season itself. Irrigation systems are considered because they solve the problem of food production and the materials needed or used for the practice are not as scarce as they appear to be. Effective irrigation will influence the entire growth and yield process from seedbed preparation, germination, root growth, nutrient utilization, plant growth regrowth, yield and quality. Water is essential for irrigation purposes, but its indiscriminate use can lead not only to shortages, but also to the deterioration of crop yields and soils.

Maize (Zea mays) is one of the most important cereal crops grown principally during the raining season in Ethiopia which is commonly used for both human consumption and poultry feed. The local production of the crop is not sufficient to meet the continuous increase of consumption. Therefore Deborah, et al. compared three methods of irrigations under climatic conditions such as wind, drip and furrow irrigation, then came up with the conclusion that drip and furrow irrigation methods are preferred to sprinkler. Humphreys while comparing the same irrigation methods under slope condition submitted that sprinkler and drip irrigation are preferred to furrow irrigation .Whether sprinkler, drip or furrow irrigation significant effect has been realized on the growth and yield of a crop when a system is properly designed.

Irrigation frequency is the number of days between irrigation periods without rainfall. Crop irrigation requirement is the portion of the water consumptive use of crop, which must be supplied by irrigation to ensure optimal crop growth and development. With the rising human population and resultant increase in daily demand for maize for various uses, it becomes imperative to intensify effort at all year-round Maize Production in the country. Traditional crop of maize is greatly affected by various weather conditions. The rain in the country is very uncertain and may either cause prolonged drought or water-logged conditions. It is, therefore, essential to consider both aspects of water requirement to produce 1 kg of dry matter is the lowest in case of maize. Thus, very high water use efficiency can be achieved by maize as

compared to other cereal crops. Although maize needs less water requirement for germination, it needs 10 to 30 times greater than that of wheat and mustard. According to (Rathore, 2005), it is very critical to have enough moisture for the maize seed, during germination so that successful seed germination may occur. In Ethiopia, there is no adequate information on early time water requirement of maize.

1.1. General objective

- To determine the effect of watering frequencies on germination and early growth of maize.

1.2. Specific objective

- To evaluate the germination and growth of maize in different watering frequency

2. LITERATURE REVIEW

2.1. Origin and Distribution of Maize

Maize is considered to be indigenous to the Americas particularly Southern Mexico. It has been domesticated about 8000 years ago and does not exist in its wild form (Mandal, 2014). The crop is a tropical grass that is well adapted to many climates and hence has varieties which have wide maturity from 70 days to 210 days (Stephanie and Brown, 2008). The name 'maize' is derived from a South American Indian *Arawak* Carib word "*Mahiz".* It was first used for food about 10,000 years ago by Red Indians living in the area now called Mexico. For hundreds of years, the tribal people in the area gathered the grains from wild plants before they learnt to grow maize themselves. Thus, it was also called as "Indian corn" although this did not refer to the Asian country "India" in any way (Usha and Pandey, 2007).

The genus *Zea*is classified in the tribe *Maydeae*of the family *Poaceae*/*Gramineae.* There is only one species, *Zea mays* which is known only in cultivation. Closely related to this genus are two other New World genera, *Tripsacum* (called *gama* grass which is used as fodder in North America) and *Euchlaena* (called *Teosinte,* believed to be the closest wild relative of maize). Some taxonomists do not recognize *Euchlaena*as a separate genus and have transferred all the species of this genus to *Zea* (Usha and Pandey, 2007).

The oldest written record of maize in China appears in *Dian Nan Ben Cao* by Lan Mao in approximately 1492. The original usage of maize was as traditional Chinese medicine. The earliest written record (from 1560) of maize as a food crop mentions that maize was a popular cereal crop cultivated in conjunction with rice, wheat, and millet in Pinliang Fu, Gansu Province, in northwestern China. Records also indicate that maize was used as a tribute to the emperor. Other historical accounts describe the cultivation of maize in the hilly areas of Fujian Province on China's southeastern coast in the 16th century. By the early 20th century, maize had become one of China's major crops. The maize area expanded to 10 million ha, approximately 12% of total cultivated area, between 1900 and 1930 (Erika *et al.,* 2006). Usually Africa in particular Ethiopia, grow mainly white dent or semi-flint white grain maize.

White flint maize is growing in Central America and South America, Asia and Southern Europe. Overall white maize occupies only 10% of the world maize production. The majority of the areas around the world are planted under yellow maize, and a very small fraction to other grain colors such as black, red, violet, green-blue and other grain colors (ATA, 2013).

2.2. Ecology of Maize

Maize is grown globally from 50°N to 40°S, and from sea level up to 4000 m altitude. It is a short-day plant with 12.5 hours/day being suggested as the critical photoperiod. Photoperiods greater than this may increase the total number of leaves produced prior to initiation of tasseling, and may increase the time taken from emergence to tassel initiation (Stephanie and Brown, 2008). Plessis (2003) indicated that maize is a warm weather crop and is not grown in areas where the mean daily temperature is less than 19 ºC or where the mean of the summer months is less than 23 ºC. Although the minimum temperature for germination is 10 ºC, germination will be faster and less variable at soil temperatures of 16 to 18 ºC. At 20 ºC, maize emerges within five to six days. The critical temperature detrimentally affecting yield is approximately 32 ºC. It does not do well when the temperature during the growing cycle averages below 190C or above 400C (ATA, 2013).

It is a warm weather plant that requires high temperature during the growing period. The crop requires an average temperature of about 24C^{o}. Low temperature reduces growth and extremely high temperature may retard germination of seed particularly when it's combined with deficient moisture (Balasubramaniyan and Palanlappan, 2007).

The optimum temperature for maize growth and development is 18 to 32 °C. Temperatures of 35 °C and above considered inhibitory. The optimum soil temperatures for germination and early seedling growth are 12 °C or greater, and at tasselling 21 to 30 °C is ideal (Stephanie and Brown, 2008).

It is a cereal crop adapted to a wide range of environmental conditions and is cultivated in all agro-ecologies of West and Central Africa. The crop is grown throughout the region, even under suboptimal conditions. Suitability for maize production is determined mainly by the length of the growing season that in turn is determined by the amount of rainfall and its distribution and temperature (Aprakue*t al*., 2012).Approximately 10 to 16 kg of grain are produced for every millimeter of water used. Yield of3 152 kg/ha requires between 350 and 450 mm of rain per annum. At maturity, each plant will have used 250 liter of water in the absence of moisture stress (Plessis, 2003).

According to the Stephanie and Brown (2008) maize can grow and yield with as little as 300 mm but prefers 500 to 1200 mm as the optimal range. Depending on soil type and stored soil moisture, crop failure would be expected if less than 300 mm of rain were received in crop. The crop grows well under any soil type with pH ranging from slightly acidic to slightly alkaline (pH range of 5.8 to 7.5). Adequate drainage is needed to allow for the maintenance of sufficient oxygen in the soil for good root growth and microbial activity, as well as water holding capacity to provide adequate moisture throughout the growing season (ATA, 2013).

2.3. Effect of Watering Frequency on Maize Crop Production

Irrigation frequency is the number of days between irrigation periods without rainfall. Crop irrigation requirement is the portion of the water consumptive use of crop, which must be supplied by irrigation to ensure optimal crop growth and development. With the rising human population and resultant increase in daily demand for maize for various uses, it becomes imperative to intensify effort at all year-round Maize Production in the country. Traditional crop of maize is greatly affected by various weather conditions. The rain in the country is very uncertain and may either cause prolonged drought or water-logged conditions. It is, therefore, essential to consider both aspects of water requirement to produce 1 kg of dry matter is the lowest in case of maize. Thus, very high water use efficiency can be achieved by maize as

compared to other cereal crops. Although maize needs less water requirement for germination, it needs 10 to 30 times greater than that of wheat and mustard. According to (Rathore, 2005), it is very critical to have enough moisture for the maize seed, during germination so that successful seed germination may occur. In Ethiopia, there is no adequate information on early time water requirement of maize.

3. Material and methods

3.1. Experimental location

The experiment was conducted in Wolkite University, one of the Ethiopian Federal Educational Institutions. The educational center is located in Gurage Zone of southern Regional state. The site is located at 116 km west of Addis Ababa (The capital city of the Ethiopia) having an altitude of 2185 m.a.s.l., latitude of 8.25 N and longitude of 37.75 E with mean annual minimum and maximum temperatures of about 13C and 30C, respectively. According to metrological data obtained from Gurage zone metrology station the area receives mean annual rainfall of 600-1600 mm with Uni-modal rainfall pattern.

3.2. Experimental material

The soil was filled in 8 cm diameter plastic pots and sown with maize seed in Wolkite university green house. Four seeds were sown per each pot evenly and with equal sowing depth. Maize hybrid variety – BH661 was used as planting material. The pots were arranged in CRD with four replication in a greenhouse such a way that 4 pots were watered at day interval, four pots with the three days interval and four pots with the five days interval were watered using an equal volume of water for consecutive 15 days. The twelve pots (8 cm diameter) height of the pots are 20 cm were used to triplicate twelve treatment combinations (6×2) with a two factor factorial completely randomized design. The pots were lined with plastic bags from inside to restrict leaching. Each pot was filled with 1 kg soil after mixing combining. The pots possess holes at the bottom to suck water during watering.

3.3 Soil type

According to Wolkite university classification, the soil type of the study area is Vertisols. The soil of study area is clay dominated and the soil textural class is clay. Vertisols are clay rich soils contain a type of expansive clay that shrinks and swells dramatically. Vertisols is categorized in

problematic soil due to its water logging problem. However, Vertisols are highly fertile soil type than red soils due to their high clay content with high cat-ion exchangeable capacity.

Table 1 physical characteristics of the soil in the study area.(source from WKU Research wabe district publication 2018 by Teshome Tesfay *e.t.l*) .

Soil characteristics	**Value**
Clay (%)	58
Silt (%)	22
Sandy (%)	20
PH-H2O (1:2.5) (%)	5.6
O c(%)	3.75
Total N(%)	0.38
Cec (cmol(+) kg soil)	46.73
P(ppm)	Haplic vertsol

3.4. Experimental design and data analysis

The treatment was arranged in Completely Randomized Design (CRD) with four replications. Data collected were number seeds emerged, shoot length and biomass weight. The collected data were analyzed using gomez and gomez (LSD) at 5% level of significance. Procedure was take after 5 days the seeds planted emerged Seeds was count. It was calculated by counting normal seedlings after 15 days from planting. Seedlings from bigger seeds tend to emerge more successfully and are more vigorous both at the start of their life and throughout their whole life. Shoot length (cm) after 15 days from planting the seedling biomass was gently washed to remove the soil and shoot length was measured of each pot and each treatment seedlings (cm). Biomass weight after evaluating shoot and root lengths, from each pot 4 seedlings were dried in a forced air at green house at room temperature 28°C for 5 days to obtain seedlings dry weight and expressed as grams. The number of seedlings were limited to only four, because of the experiment was designed for the green house and to use the advantage of the pot size.

4. Results and discussion

The effect of watering frequencies on germination and early growth of maize seeds were observed under different watering frequencies. As shown in Table 2, watering frequencies had no significance effect on number of maize seedlings emergence, but considerable variation was observed on their emergence date, that the early emergence of maize seeds were enhanced during watering made daily than the rest of the treatments. As watering frequency decreased from 1 to 5 days interval, seedling emergence was delayed significantly ($P<.0.05$). This indicates that a continuous application of enough water to the soil and maintaining soil moisture enhance the emergence of maize seeds to be takes placed earlier. These findings are in agreement with the results of Kang, *et al*. and Ismail, *et al.*, they stated that watering frequencies had a significant and negative effect on maize shoot length, as the date of watering elongated, the shoot length consistently and significantly reduced (Table 3). Thus, unlike maize seedlings emergence its growth very much dependent up on the amount and rate of watering. Similarly, watering frequencies had significance effect on maize biomass production. In that daily watered plots considerably outperformed the others in biomass weight gained.

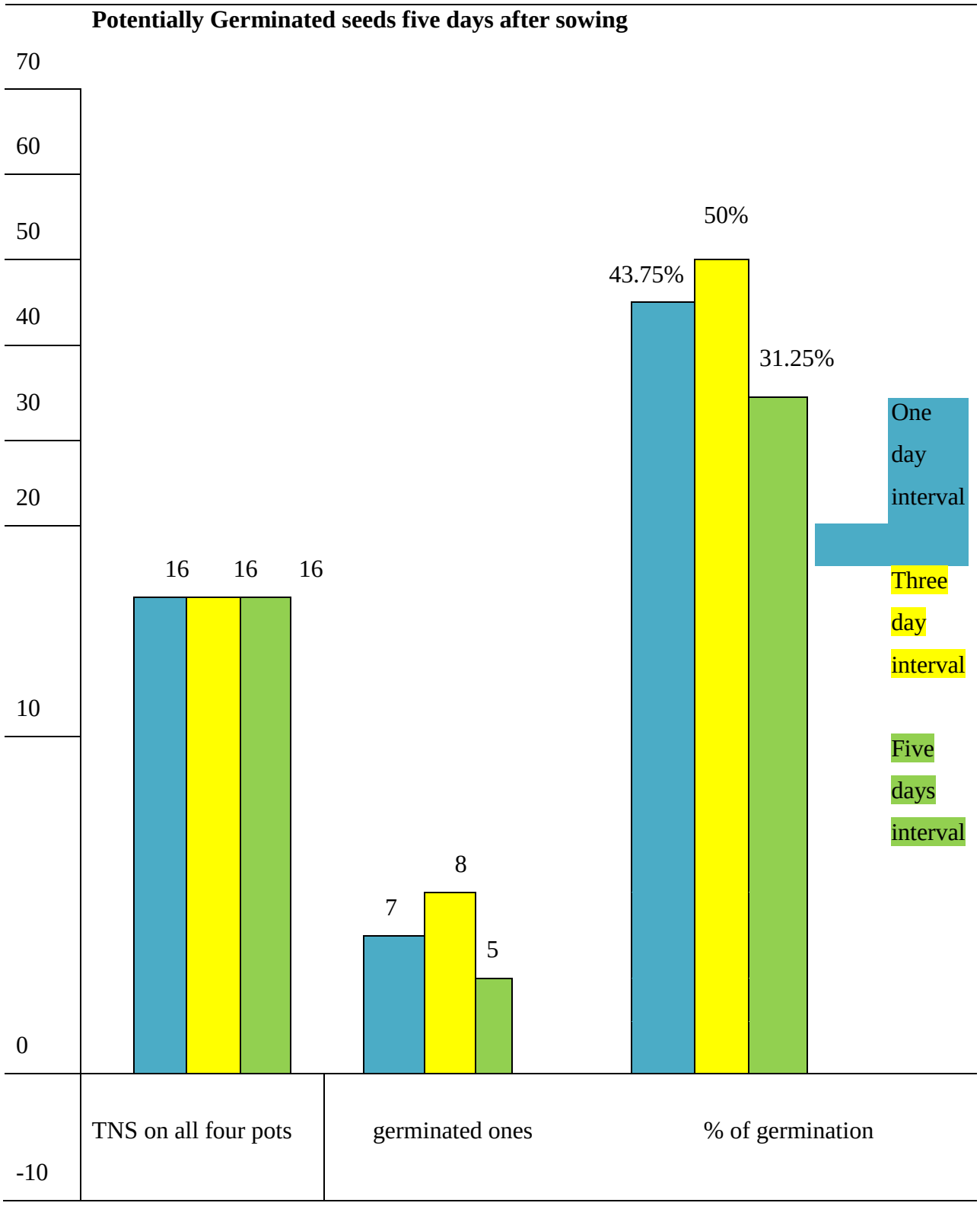
A total of 16 seeds were used for each interval (One day interval, three-day interval and Five-day interval) and two counts were done during the present studies. The first count was done five days after sowing. In these rounds a total of 16 seed were used for each of the three intervals. The present studies result elucidates that continuous application of enough moisture via watering in three-day interval enhance relatively higher (50%) percentage of germination followed by one day interval (43.75%) (Figure1). This implied that moisture stress negatively affects root initiation earlier even in pot growing conditions as in field conditions. This is related with a work done by Konopka, *et al.* irrigation intervals of 14 or 21 days initiated an earlier growth of seminal roots in the seedlings than when irrigated more frequently. The delay in root emergence with frequent irrigations could be due to the diffusion of water into the seed for its physiological processes of early growth. But maintaining adequate amount of moisture in the soil fasten early emergence. The second count was done seven days after sowing. In these rounds a total of 16 seed were used for each of the three intervals. The result showed that the application of water or providing enough moisture at five-day interval enhance or promote relatively better germination performance (68.75%) followed one day interval (56.25%) (Figure 2).

Table 2: Effect of watering frequency on number of maize seeds Germination at Wolkite university 2022.

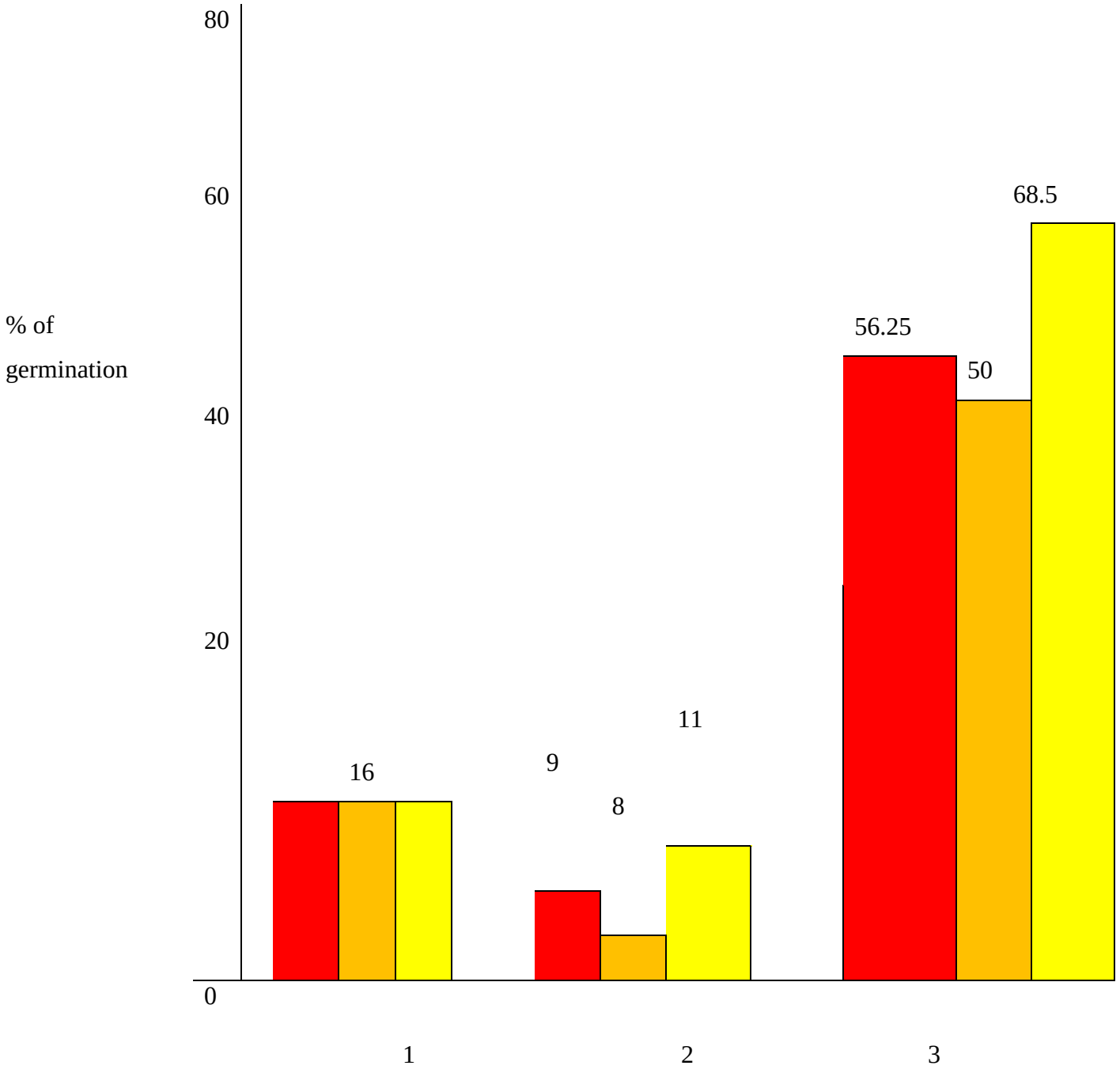
Treatment	First count /5 days after sowing							Second count/7 days after sown						
	Pot 1	Pot 2	Pot 3	Pot 4	Total seed sown	Total germi nated	%of germi Nation	Pot1	Pot2	Pot3	Pot4	Total seed sown	Total germi nated	%of germi nation
One day interval	2	2	1	2	16	7	43	2	2	3	2	16	9	56.25
Three day intervals	2	1	3	3	16	8	50	2	3	2	1	16	8	50
Five day intervals	2	1	1	1	16	5	31.25	2	3	3	3	16	11	68.75

As shown in Table 3, watering frequencies on all the treatments had no significance effect on number of maize seedlings emergence. Watering frequencies had significance effect on maize shoot length therefore as date of watering elongating shoot length consistently and significantly reduced.

Treatment	Emergence seedlings
One day interval	4 a
Three day intervals	4a
Five days intervals	4a
CV (%)	0
LSD(0.05)	0
F value	0
F P	0


Potentially Germinated seeds five days after sowing
70
60
50
40
30
20
10
0
-10
16
16
16
7
8
5
43.75%
50%
31.25%
One day interval
Three day interval
Five days interval
TNS on all four pots
germinated ones
% of germination

Potentially Germinated seeds seven days after sowing



- Mean Total number of seed
- **ONE DAY INTERVAL**
- **THREE DAY INTERVAL**
- **FIVE DAY INTERVAL**

Thus, Treatment One day interval is significantly different from three days interval and five days interval. However, there is no significant difference between both treatment (Three-day interval and Five-day interval). In the early stages of vegetative growth, plants are more susceptible to water stress than at the middle stages. Thus, water stress during the vegetative stages of crop growth can lead to reduced plant growth. With increased water application, plant height increases. Research by Dunford and Vazquez supports these findings where plants that received more water accumulated more plant material and, therefore, increased in height Table 5.

Watering frequencies had significance effect on maize green biomass production among the treatments, for instance, in one day interval watered plots had maximum weight of green biomass when compared with the remaining treatments. However, there is no considerable significant difference between the two treatments (Three-day interval and five-day interval) in terms of green biomass Table 6.

Watering frequencies had significance effect on maize dry biomass production among the treatments, for instance, in one day interval watered pots had maximum weight of dry biomass when compared with the remaining treatments. However, there is no considerable significant difference between the two treatments (Three-day interval and five-day interval) in terms of dry bio mass.

5. Conclusion

The research work determined the effect of watering frequency on emergence and early growth of maize seedlings.

Table 4. Effect of watering frequency on shoot length (cm) of maize

Treatment	Shoot length (cm)
One Day Interval	52.875 a
Three Day Interval	41.950 b
Five Day Interval	41.100 b
CV(%)	13.42
LSD(5%)	10.52
F Value	2.93
F P	0.1114

Table 5. Effect of watering frequency on green bio mass weight (gm) of maize

Treatment	Green bio mass (gm)
One Day Interval	83.000a
Three Day Interval	48.025b
Five Day Interval	36.650b
CV(%)	15.419
LSD(5%)	14.911
F Value	13.82
F P	0.0031

Table 6. Effect of watering frequency on dry bio mass weight (gm) of maize

Treatment	**Dry bio mass (cm)**
One Day Interval	9.125 a
Three Day Interval	4.9250 b
Five Day Interval	4.3000 b
CV(%)	13.30136
LSD(5%)	1.4077
F Value	18.13
F calculated	0.0015

The early growths of maize are greatly affected by the different watering frequency. So that, the different watering frequencies considerably affected plant shoot length, green biomass weight and dry biomass weight, however, these studies have revealed there is no significant difference among the treatments (One day interval, three-day interval and five-day interval) in terms of maize seed emergence. So that we concluded that moisture however is critical for seedling emergence in the treatments used in the study.

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APPENDIX

ANNOVA for analysis of shoot length

Source of variation	DF	SS	MS	F. calculated	F. tabulated	
Treatment	2	11.8744	5.881	4.499*	1%	5%
					6.16	3.10
Error	9	11.7621	1.3069			
Total SS	11	23.6365				

ANNOVA for analysis of Green weight

Source of variation	DF	SS	MS	F. calculated	F. tabulated	
Treatment	2	292.3649	146.1824	2129.2**	1%	5%
					6.16	3.10
Error	9	0.6179	0.0686			
Total SS	11	29.7469				

ANNOVA for analysis of Dry weight bio mass

Source of variation	DF	SS	MS	F. Calculated	F. tabulated	
Treatment	2	3.4426	1.7213	0.9566	1%	5%
					6.16	3.10
Error	9	16.1939	1.7993			
Total SS	11	19.6365				