



Full Length Research Paper

Emergence and Seedling Growth of Corn (*Zea mays* L.) as Influenced by Irrigation Schedules on Vertisol

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ABSTRACT

To investigate the effect of irrigation frequency on emergence and seedling growth of maize, a pot experiment was conducted under glass house condition in Ambo University. The experiment was arranged in Randomized Complete Block Design with three replications consisting of 3, 6, 9, 12, and 15 days interval of watering with 40mm, 80mm, 121.2mm, 160mm, and 200mm of irrigation water, respectively for a period of 30 days. A total of 400mm of water was applied during the 30days period as per treatments. The results revealed that emergence and seedling growth differed significantly under different watering frequencies, where in maximum number of leaves (8 leaves/plant), leaf area (63.75cm²), plant height (31.95cm), root length (23.94cm), shoot length (10.28g), root (8.23g) biomasses, seedling fresh weight (18.51g) and dry weight (2.91g) were observed with 6days interval of irrigation frequency, while they declined with increased watering interval.

Keywords: Maize, watering frequency, emergence, seedling growth.

INTRODUCTION

Maize is cultivated under smallholder subsistence farming system in both rainfed and irrigated conditions during major and minor seasons in Ethiopia. However, the crop growth and seed yield are generally lower in dry seasons due to moisture stress and high temperature (Edmeades et al., 1992). Farmers attempt to irrigate their crops to enhance yields, although irrigation water is becoming a scarce resource (Messmer et al., 2009) and an important limiting factor for tropical crop production due to erratic rainfall, haphazard irrigation schedules coupled with raising temperature which have significant impact on maize production (Zaidi et al., 2008).

In Ethiopia, the best maize regions are those which receive an annual precipitation of 600-1000mm except where the crop is irrigated (Kebele et al., 1993). The early vegetative stage (20 - 40days after sowing) and tasseling and silking stage (45-60days after showing) have been found to be the critical stages for soil moisture (Purseglove, 1985). Maize is sensitive to water logging and moisture deficit. Submergence of soil for 3 to 5days

during seedling and flowering period reduced the yield considerably (Kebede et al., 1993).

In recent years, scarcity of rainfall led to dwindled corn productivity. When rainfall is low and irrigation water supply is restricted, efficient use of irrigation water seems to be of vital importance. Irrigation scheduling is done based on avoiding water scarcity during seedling and flowering period followed by yield formation period. Lack of sufficient moisture affects growth and development of roots that are responsible for water uptake from the rhizosphere and for establishing soil-plant continuum (Kuchenbuch et al., 2006). Shallow root systems result in plants being stressed even for short periods of water deficit (Sanders, 1997). Reduced root growth due to water stress leads to a decrease in shoot dry weight, because there is a close correlation between root and shoot development (Ismail et al., 2007).

Irrigation scheduling involves making decision on how much, how to and when to apply it. Proper irrigation interval can play a major role in increasing water use

efficiency and the productivity by applying the required amount of water when it is needed (Ismail and Ozawa, 2009). Meshkat et al., (2000) concluded that an excessively high irrigation frequency could cause the soil surface to remain wet and the first stage of evaporation to persist most of the time, and resulted in more water loss. On the other hand, poor irrigation interval can lead to the development of water deficit and results in reduced yield due to water and nutrient deficiency. Many factors influence the watering frequency decision; however, the major ones are: water needs by the crop, water availability, and water holding capacity of the soil (Mohamed and Makki, 2005). However, there is varying agreement over the effect of irrigation frequency on crop water use (Snyman, 2004). Smasjtrla et al., (1985) pointed out that to minimize deep percolation and to maintain nearly constant high soil water potential, high frequency irrigations should be recommended. Whereas some others figured out that practicing irrigation water management with minimal plant water stress by maintaining high soil moisture content between irrigations can lead to significant deep percolation losses (Kang et al., 2001; Levin et al., 1979). This implies that there is inconsistent information on watering frequency based on crop and soil types. Therefore, this study was made to determine the effect of irrigation frequency on emergence and seedling growth of maize on vertisol.

MATERIALS AND METHODS

A pot experiment was conducted to identify the effect of watering frequency on emergence and seedling growth of maize, under glass house condition in Ambo University. The experiment was arranged in Randomized Complete Block Design with three replications consisting of 3, 6, 9, 12, and 15 days interval of watering with 40mm, 80mm, 121.2mm, 160mm, and 200mm of irrigation water, respectively for a period of 30 days. In each treatment, 400mm of irrigation water was applied as per the treatments for 30 days crop period.

The soil was sieved to remove crop residues and roots, and sundried to reduce weed seed germination and disease causing organisms. The size of the pots was 20 x 23 x 60cm, and each pot was filled 3kg of black clay soil (vertisol). Two maize seeds of Melkassa-14 variety were sown in each pot at 3cm depth after moistening the soil up to field capacity. Uniform dose of fertilizer (8g of DAP and 8g of Urea) were applied to each pot at the time of sowing.

Emergence of seedling was recorded when the plumule came up above the soil surface. However, seedling growth parameters were recorded at 30th days of sowing. After measuring the height, plants were cut at soil level and root and above ground parts were

separated on 30th day. Plant height and root length were measured using a scale; and leaf area was measured as described by Lopez-Castaneda et al., (1996). Number of leaves was counted and recorded by averaging the two plants in each pot. The root biomass was gently washed to remove the soil, and dried for 8h under shade. The fresh weight of root and shoot were measured using a precision balance, and oven dried for 72h at a temperature of 65°C. The data were subjected to statistical analysis using MSTAT-C statistical software, and mean separations were performed using Least Significant Difference (LSD) at 1% and 5% levels.

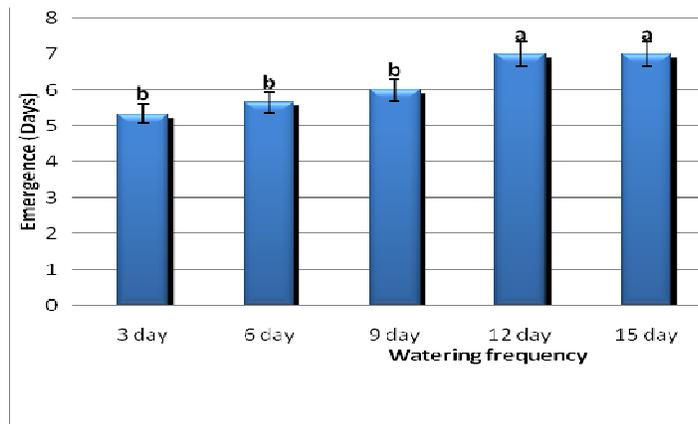
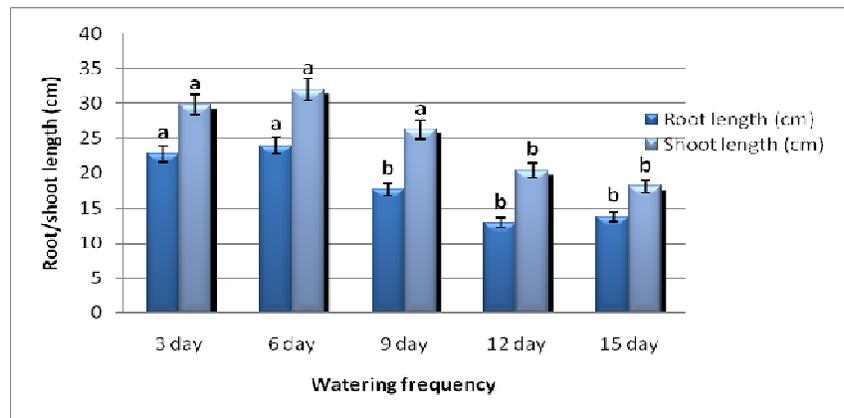
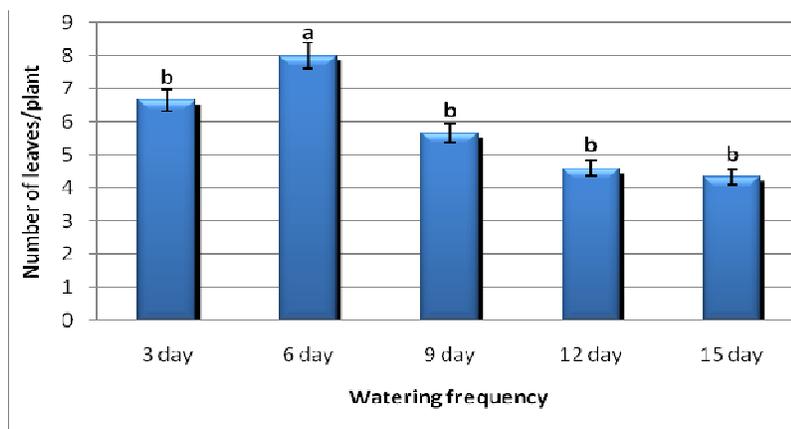
RESULTS AND DISCUSSION

Seedling emergence

Significant difference was observed among irrigation frequencies on emergence of maize seedlings (Figure 1). Earlier emergence (5.33 days) was recorded with 3 days watering frequency, while delayed emergence was recorded with 12 and 15 days watering frequencies. However, there was no significant difference ($p < 0.01$) between 3, 6, and 9-days watering frequencies; and between 12 and 15 days frequencies. As watering frequency decreased from 3 to 15 days interval, seedling emergence was delayed significantly ($P < 0.01$). This indicated that 6 - 9 days watering frequency provides sufficient moisture that promotes the plumule to emerge as quickly as in 3 days, while 12 and 15 days intervals exposed the germinated seed to soil moisture stress that caused delayed emergence of seedling. These findings are in agreement with the results of Kang et al., (2001) and Ismail et al., (2007).

Effect on Seedling Growth

The maximum plant height (31.95cm) was observed with 6 days watering frequency, and the minimum (18.06cm) height was recorded with 15 days interval of watering frequency. As watering frequency increased from 3 to 6 days, plant height increased, while after 6 days it showed a gradual decrease. The gradual decrease in plant height after 6 days interval was due to decrease in soil moisture that exposed the plant to moisture stress conditions, which resulted in restriction of cell elongation, and short statured plants. The contribution of high watering frequency on plant height could be due to the high level of capillarity water and water use efficiency of the crop. Water use efficiency began to decrease as irrigation frequency increased (Yuan, 2001). The result of the study was in line with the findings of other reports (Abdullahi et al., 2013; Hassan et al., 2011; Elzubeir and Mohamed,

Figure 1. Effect of watering frequency on emergence of maize seedlings**Figure 2.** Effect of watering frequency on shoot and root lengths of maize seedlings**Figure 3.** Effect of watering frequency on number of leaves /plant

2011) who reported that high watering frequency gave the tallest plants, and the short plants at low frequencies of irrigation. Increase in watering frequency from 3 to 6

days increased root length significantly ($p < 0.01$). However, watering frequency at 9 - 15 days interval reduced root length significantly (Figure 2). Water

Figure 4. The effect watering frequency on Leaf area (cm²)

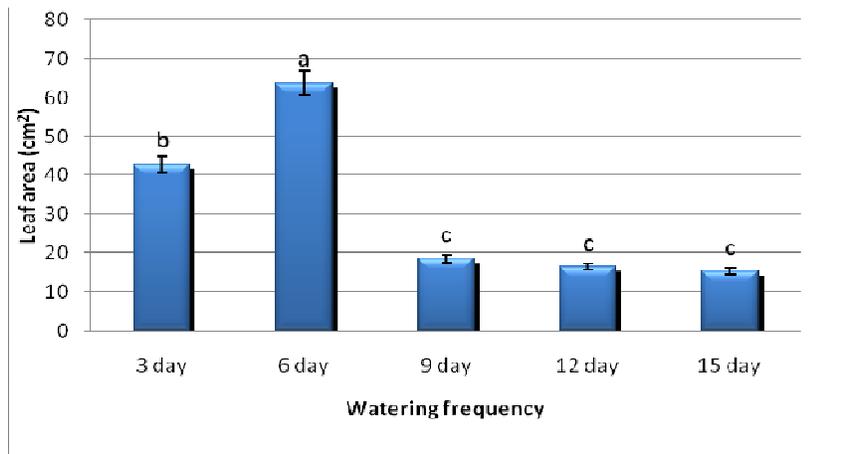


Figure 5. The effect watering frequency on shoot and root biomass of maize seedling

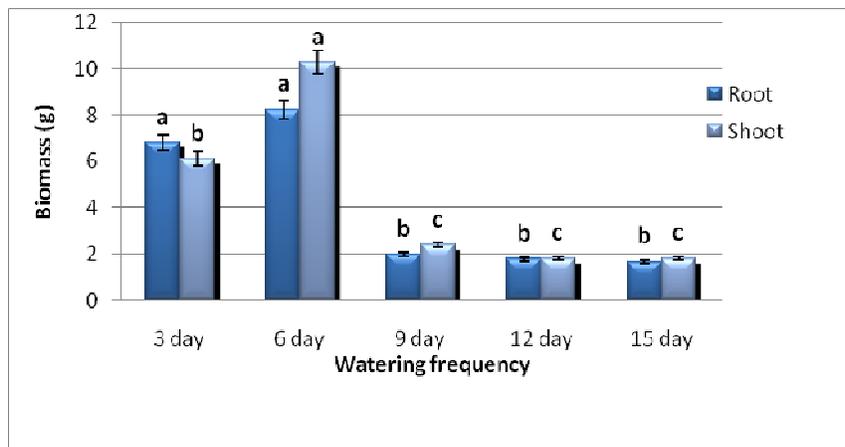
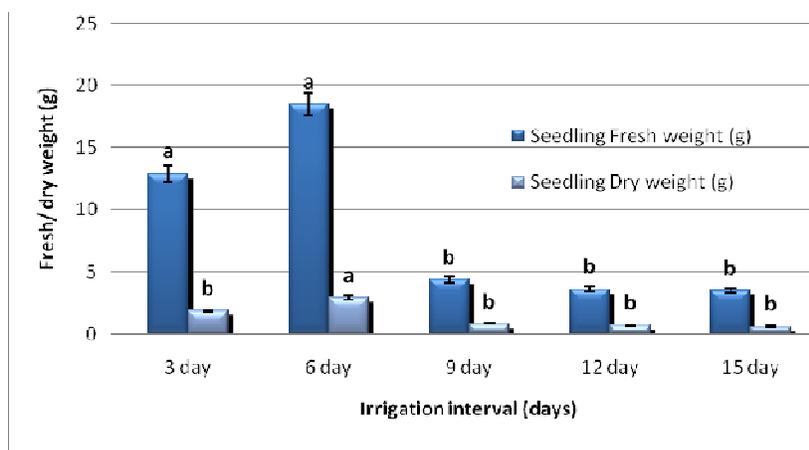


Figure 6. Effect of watering frequency on seedling fresh and dry weights (g)



stressed plants generally exhibit a small root system, and the reduction in root system is directly proportional to the magnitude of water shortage (Ismail and Ozawa, 2009). Increasing the watering interval causes a decrease in the root length because the pattern of root growth was similar to that of the moisture distribution (Levin et al., 1979; Kramer, 1995). Snyman (2004) also reported that root length decreased significantly with water stress. As the plant gets sufficient moisture from the soil its root length increased, but inadequate moisture in the soil resulted in reduced root extension.

The maximum number of leaves (8 leaves/plant) were observed at 6-days watering frequency, while the minimum number (4 leaves/plant) was with 15 days watering interval (Figure 3). Watering at 6 days interval did not expose the plant to moisture stress; hence contributing to better vegetative growth. However, 15 days watering interval caused the plant to experience moisture stress that restricted growth and reduced leaf number. The highest number of leaves per plant recorded in pots with 6 days watering intervals could be attributed to adequate moisture in the surface layer, resulting in better crop nourishment and consequently higher number of leaves. Yuan et al., (2001), Ahmed and El Hag (1999), and Mohamed and Makki (2005) reported similar results as prolonging watering intervals decreased the number of leaves per plant.

Effect on leaf area

A decrease in watering frequency increased leaf area significantly up to 6 days watering frequency, however further reduction in watering frequency negatively influenced leaf area (Figure 4). The maximum leaf area (63.75cm²) was recorded with a watering frequency of 6 days interval, while the least (15.37cm²) with 15 days watering interval.

Watering frequency at 3 days interval resulted in lower leaf area as compared to 6 days interval, which could be due to high water holding capacity of the soil, exposing the maize seedlings to excess moisture condition. Maize plants under water logged condition exhibits poor leaf growth and less photosynthesis. However, 9, 12, and 15 days interval watering frequency produced lower leaf area. The finding of this study is in agreement with the results of Elzubeir and Mohamed (2011), Ahmed and Mohmoud (2010), and Amarasekara and Sangakkara (2010) who reported frequent irrigation improved the vegetative growth based on soil type.

Effect on shoot and root biomass

The maximum shoot and root biomass was obtained with 6 days watering intervals followed by 3 days watering

frequency (Figure 5). The lowest shoot and root biomass was recorded with 9, 12 and 15 days watering frequencies. Significant differences were found between 9, 12 and 15 days of watering intervals. This implies that maize seedling grown with optimum moisture produce large shoot and root volume with the highest biomasses, while excess and deficit moisture restrict root production (Oktem et al., 2003; Amarasekara and Sangakkara, 2010). Singandhupe et al., (2003) also reported that inadequate available moisture in soil hampers various physiological processes in plant and finally reduced shoot and root biomass.

Fresh and dry weights of seedling

As watering frequency decreased from 3 to 6 days intervals, fresh weight increased from 12.91 to 18.51g, respectively. However, significant ($p < 0.01$) reduction of fresh weight was noticed as watering frequency decreased from 6 days to 15 days interval (Figure 6). The maximum fresh weight of seedling (18.51g) was recorded with 6 days interval, while the minimum (3.48g) was obtained with 15 days interval. As watering frequency extended to 15 days, shoot biomass decreased due to moisture stress that affected the normal physiological process of the maize plant.

As watering frequency decreased from 3 to 6 days interval, the seedling dry weight increased significantly (Fig. 6). The maximum seedling dry weight (2.91 g) was obtained with 6 days frequency, but the minimum (0.57 g) was recorded with 15 days interval. With 3 days watering frequency the seedlings were affected by excess moisture, resulting in low dry matter accumulation. Besides, a decrease in watering frequency after 6 days interval restricted growth due to moisture deficit. However, at 6 days watering frequency the plant obtained optimum moisture from the soil that enabled it to accumulate more dry matter as compared to other frequencies. Similar results were reported by Ismail and Ozawa (2009) and Ismail et al., (2007) who stated that increase in irrigation interval caused a decrease in seedling fresh and dry weights.

CONCLUSION

Application of irrigation water at different watering frequencies has an effect on the emergence and seedling growth of the maize crop. Watering frequency at 6 days interval showed the maximum growth in terms of plant height, number of leaves, root length, shoot and root biomass, seedling fresh and dry weights, and leaf area. Hence, maize crop can be irrigated at 6 days interval for better emergence and seedling growth under vertisol condition.

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