International Journal of Scientific Engineering and Science

Volume 1, Issue 1, pp. 22-25, 2017.

Effects of Drip and Furrow Irrigation Systems Application on Growth Characteristics and Yield of Sweet Maize under Sandy Loam Soil

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Abstract**—** *The study is the application of drip and furrow irrigation systems for several weeks in the cultivation of sweet maize under sandy loam soil. The effects of the systems on growth characteristics and yields were evaluated. To achieve these, the experiment was laid out in a 2 x 5 factorial design in two systems and five duration of weeks after planting (WAP) in three replicates. Amounts of irrigation water were calculated and pre-irrigation was done one week prior to planting. Subsequent irrigation was applied at two days interval on drip and three days interval on furrow. The growth characteristics (plant height, number of leaves, stem girth and leaf surface area) were measured at 2 WAP, 4 WAP, 6 WAP, 8 WAP and 10 WAP. The ANOVA results showed that the two irrigation systems had significant effect on the growth characteristics except stem girth. The weeks after planting had significant effect on all the growth characteristics. Turkeys test showed no significant comparative difference between drip and furrow at 2 – 6 WAP except in leaf surface area but showed significant difference between the systems at 8 – 10 WAP. The yields were harvested at maturity after fourteen weeks. Drip system gave 5941.2 kg/ha of maize while 3782 kg/ha for furrow. ANOVA result showed significant difference in yield between the systems. Turkeys test showed that furrow is significantly lower in comparison to drip. Therefore, drip irrigation system is recommended as more effective irrigation system.*

Keywords**—** *Irrigation, drip, furrow, maize, growth.*

I. INTRODUCTION

Development of irrigation has been to expand and intensify agriculture in order to improve food security at household and community levels. Irrigation farming is not just application of water on crops to supplement deficit rainfall but the type of system of irrigation used is a key factor in determining successful irrigation farming. The different systems of irrigation include: terraced irrigation, sprinkler irrigation, drip irrigation, furrow irrigation, basin irrigation etc. Maize (*Zea mays*) was originated in the Andean region of Central America and is one of the most important cereals grown for both human and animal consumption (FAOSTAT, 2000).

A number of studies have claimed that early irrigation schemes established by missionaries in the 1930 performed well in terms of agricultural yield, financial and economic viability (Webb, 1991; Mupawose, 1984 and Mulliet, 1997). Drip irrigation system is comparatively expensive only in the short run but could be very economical in the long run while furrow irrigation system requires almost similar procedures both at short and long run of the practice (Unger and Wiese, 1999). According to Camp (1998), crop yields in drip system exceeded furrow system and water use is significantly less when compared with furrow system. William *et al.* (2013) reported that in the cultivation of cotton, drip system always supersedes furrow system in the yields. For soybean and sunflower production when compared between drip and furrow, relative yields between drip and furrow varied, with drip resulting in greater production (Lamm *et al.* 2002; Collaizzi, Schneider, Evett and Howell, 2004). Also, according to FAOSTAT (2000), an experiment conducted on the comparative study between drip and furrow irrigation systems revealed that drip irrigation system saved 56.4 % water and gave 22 % more yield than furrow irrigation system. The objective of this work is to evaluate the effects of the application of drip and furrow irrigation systems in weeks on the growth and yield characteristics of sweet maize under sandy loam soil. This is relevant in identifying the system that is more suitable in a particular area. Through this, maximum benefit can be derived from irrigation farming as well as reduction in food importation and ensuring food security.

II. MATERIALS AND METHOD

A. Experimental Design

The study was laid out in a 2 x 5 factorial design in three replicates. The main treatments for the study include drip irrigation system, furrow irrigation system and five duration of weeks after planting (WAP). For drip system, irrigation applied were 217.98 mm, 565.83 mm, 892.84 mm and 59.64 mm of water respectively at two-day intervals. For furrow system, irrigation applied were 326.97 mm, 848.75 mm, 1339.27 mm and 89.47 mm of water respectively at three-day intervals. The growth characteristics measured were plant height, number of leaves, stem girth and leaf surface area.

B. Procedure

The land preparation was done using tractor with disc plough, harrow and ridger. The field layout comprised of three replicates with three plots in each replicate. Each plot was measured 3 m x 3 m with 4 m buffer. Two maize seeds of sweet maize variety were planted per stand at a space of 90 cm x 30 cm. Thinning was carried out a week after planting to

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allow one maize plant per stand. The source of water was borehole water collected through horse to a Geepee tank at the experimental site.

For drip system, the water moves from Geepee tank to the mainline to sub mainline and to drippers before discharging to different drip plots as the control valves were switched on. For furrow system, the mainline was connected to the Geepee tank such that the water moves from the Geepee tank to the mainline then to the sub mainlines before discharging to different furrow plots as the control valves were switched on. As water enters different plots through the water metre connected to the sub mainlines with the control valve, readings of the amount of water entering the plots were recorded in the water metre and at the required quantity of water, the control valve was switched off.

Fertilizer application was done using side dressing method at the rate of 100 kg/ha (Anon, 1995). In the application of fertilizer, holes 8-10 cm away from the plant and 5-8 cm deep were made according to Ibia and Udo (2009), Enwezor *et al.* (1990) and Ekpe (1998). Five random plant samples were selected and tagged with ribbons of different colours in each plot for the purpose of measuring the growth characteristics. The growth characteristics were measured at 2 WAP, 4 WAP, 6 WAP, 8 WAP and 10 WAP using measuring tape. The maize plants were harvested at maturity after fourteen weeks of planting.

C. *Statistical Analysis*

The growth and yield data collected were analyzed using descriptive statistics (range, mean, standard deviation) and analysis of variance (ANOVA). Turkey's test was employed to compare the significant difference of the irrigation systems over the growth period.

III. Results of Findings

A. *Effects of Irrigation Systems and Treatment in Weeks on the Plant Height*

The ANOVA table (Table 1) for plant height shows that the two systems of irrigation had significant effect ($p < 0.05$) on the plant height. The treatment in weeks after planting also had a higher significant effect on the plant height. There is no significant interaction effect between the systems of irrigation and the treatment in weeks after planting, as such, the effects are additive. The Turkey's pair-wise comparison test (Table 2) shows that there is no significant comparative difference in the mean plant height from 2 - 8 weeks after planting (WAP) between the systems of irrigation. Furrow irrigation system is significantly lower in comparison to drip irrigation system only after 10 WAP.

Table 1. ANOVA table for plant height.

Source of Variation	Sum of Squares	df	Mean Square	F-cal	F-tab (0.05)
Systems	2,133.64	1	2,133.64	11.03*	7.71
Treatments	67,090.72	4	16772.68	86.73*	6.39
Interaction	773.514	193.38	1.10	2.87	
Error	3,507.50	20	175.38		
Total	73,505.37	29			

Table 2. Turkey's pair-wise comparison test for plant height.

Irrigation Systems	Plant Height (cm)					Turkey's Test Value
	2WAP	4WAP	6WAP	8WAP	10WAP	22.5
Drip – Furrow	2.54	7.66	19.33	21.34	26.54	

B. *Effects of Irrigation Systems and Treatment in Weeks on the Number of Leaves per Plant*

The ANOVA table (Table 3) for number of leaves shows that the two systems of irrigation had significant effect ($p < 0.05$) on the number of leaves. The treatment in weeks after planting had a highly significant effect ($p < 0.05$) on the number of leaves. There is no significant interaction effect between the systems of irrigation and the treatment in weeks after planting, as such, the effects are additive. The Turkey's pair-wise comparison test (Table 4) shows that there is no significant comparative difference in the number of leaves per plant from 2 - 6 WAP between the systems of irrigation. Furrow irrigation system is significantly lower in comparison to drip irrigation system after 8 and 10 WAP.

Table 3. ANOVA table for number of leaves.

Source of Variation	Sum of Squares	df	Mean Square	F-cal	F-tab (0.05)
Systems	10.81	1	10.81	63.59**	7.71
Treatments	366.48	4	91.62	538.94*	6.39
Interaction	0.68	4	0.17	0.23	2.87
Error	15.5	20	0.78		
Total	393.47	29			

Table 4. Turkey's pair-wise comparison test for number of leaves.

Irrigation Systems	Number of Leaves (cm)					Turkey's Test Value
	2WAP	4WAP	6WAP	8WAP	10WAP	1.77
Drip – Furrow	0.46	0.33	1.67	1.8	2.60	

C. *Effects of Irrigation Systems and Treatment in Weeks on the Stem Girth*

The ANOVA Table (Table 5) for stem girth shows that the treatment in weeks after planting had a highly significant effect ($p < 0.05$) on the stem girth but there is no significant effect due to the systems of irrigation. There is no significant interaction effect between the systems of irrigation and the treatment in weeks after planting, as such, the effects are additive. The Turkey's pair-wise comparison test (Table 6) shows that there is no significant comparative difference in the mean stem girth from 2 - 10 WAP between the systems of irrigation.

Table 5. ANOVA table for stem girth.

Source of Variation	Sum of Squares	df	Mean Square	F-cal	F-tab (0.05)
Systems	3.34	1	3.34	3.67	7.71
Treatments	153.81	4	38.45	42.25*	6.39
Interaction	3.634	0.91	1.82	2.87	
Error	10.0220	0.50			
Total	170.80	29			

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Table 6. Turkey's pair-wise comparison test for stem girth.

Irrigation Systems	Stem Girth (cm)					Turkey's Test Value
	2WAP	4WAP	6WAP	8WAP	10WAP	2.37
Drip – Furrow	0.24	0.77	0.85	0.53	0.76	

D. Effects of Irrigation Systems and Treatment in Weeks on the Leaf Surface Area

The ANOVA table (Table 7) for leaf surface area shows that the two systems of irrigation had significant effect ($p < 0.05$) on the leaf surface area. The treatment in weeks after planting also had significant effect ($p < 0.05$) on the leaf surface area. There is no significant interaction effect between the systems of irrigation and the treatment in weeks after planting, as such, the effects are additive. The Turkey's pair-wise comparison test (Table 8) shows that there is no significant comparative difference in the mean leaf surface area between drip and furrow from 2 – 4 WAP but from 6 – 10 WAP, the mean leaf surface area of furrow is significantly lower in comparison to drip.

Table 7. ANOVA table for leaf surface area.

Source of Variation	Sum of Squares	df	Mean Square	F-cal	F-tab (0.05)
Systems	102433.64	1	102433.64	12.71*	7.71
Treatments	1008125.22	4	252031.31	31.27*	6.39
Interaction	32240.82	4	8060.212.55	2.87	
Error	63205.69	20	3160.28		
Total	1,206005.37	29			

Table 8. Turkey's pair-wise comparison test for leaf surface area.

Irrigation Systems	Leaf Surface Area (cm^2)					Turkey's Test Value
	2WAP	4WAP	6WAP	8WAP	10WAP	104.65
Drip – Furrow	3.33	98.13	153.67	161.00	259.00	

E. Effects of Irrigation Systems on the yield

The ANOVA table (Table 9) shows that there is significant difference in the yield between the systems ($p < 0.05$). Comparatively, Turkey's pair-wise test (Table 10) shows that there is significant comparative difference in the yield between the systems. Furrow is significantly lower in comparison to drip.

Table 9. ANOVA table for yield.

Source of Variation	Sum of Squares	df	Mean Square	F-cal	F-tab (0.05)
Systems	12,330.66	1	12,330.66	20.09*	7.71
Error	2454.67	4	613.67		
Total	14,785.33	5			

Table 10. Turkey's pair-wise comparison test for yield.

Irrigation Systems	Yield (kg)	Turkey's Test Value
		68.9
Drip – Furrow	90.67	

IV. Discussion on Findings

Findings revealed that irrigation is essential on growth and yield characteristics of maize cultivated especially in the dry season. However, method of irrigation has a great influence on the performance of the irrigated crops. From the study, maize responded differently to drip and furrow irrigation judging from its growth and yield characteristics. Generally, maize plants irrigated by drip method had a higher plant height, number of leaves, stem girth and leaf surface area from 2 -10 WAP compared to maize plants irrigated by furrow method. It also had yield higher than furrow method and the mean difference was statistically significant. Also, ANOVA tables (Tables 1, 3, 5, 7 and 9) revealed that there was significant difference in growth and yield characteristics of maize under these two irrigation systems. The treatment in weeks after planting also showed a higher significant effect on both the growth and yield characteristics.

The Turkey's pair-wise comparison test (Tables 2, 4, 6, 8 and 10) showed significant comparative difference in the mean of growth characteristics (plant height, number of leaves per plant and leaf surface area) as well as yield. This collaborates with findings of Schneider (2000) who reported that drip is most efficient in crop production than furrow and other surface irrigation. According to Schneider, surface irrigation is characterized by high water loss resulting in poor growth and yield formation compared to drip. Water loss pathways described for furrow and drip can potentially be eliminated through proper design, maintenance, and management, which is likely to also conserve expensive fertilizer and chemicals commonly injected into irrigation water (Lamm *et al.* 2002).

Also, according to Paul, Mishra, Pradhan and Panigrahi (2013), drip irrigation system is observed to be economical and cost effective as compared with conventional surface irrigation. They further said that, the use of drip irrigation system either alone or in combination with mulching, could increase the capsicum yield up to an extent of 57 % over surface irrigation method with the same quantity of water. The low utilization of drip has been reported by Camp (1998). The low patronage of drip irrigation by farmers could be attributed to high cost of drip over others like furrow and basin irrigation systems. Camp who reviewed published research on drip noted that though crop yields from drip exceeded those of other irrigation systems, and water use was significantly less, adoption of drip in the Great Plains remained low relative to spray and furrow primarily because of capital costs but also due to greater maintenance and management requirements, among other factors.

V. Conclusion

In conclusion, crop production depends mainly on the relationship between soil, water and climate. A high level of water availability and soil with nutrient together with conducive climate usually ensure an optimal yield. Any restriction in the supply of any of these factors is likely to induce a decrease in crop yield and food security. The type of irrigation system adopted in a particular area also contributes

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to either success or failure in irrigation farming. The drip and furrow irrigation systems evaluated in this work have proved to work differently.

Findings revealed that the types of irrigation system evaluated had a significant effect on the plant height, number of leaves and leaf surface area but there is no significant effect on the stem girth. The number of weeks after planting had a significant effect on the plant height, number of leaves, leaf surface area and stem girth. On the growth characteristics generally, Turkey's pair-wise comparison test revealed that furrow is significantly lower in comparison to drip.

In the drip irrigation system, 5941.2 kg/ha of maize was harvested while 3782 kg/ha for furrow irrigation system. Therefore, there is significant comparative difference in the yield between the systems of irrigation studied. The Turkey's pair-wise comparison test showed that furrow irrigation system is significantly lower in yield compared to drip irrigation system. Therefore, drip irrigation system is recommended as more effective system of irrigation.

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