



ECONOMIC ANALYSIS OF IRRIGATION METHODS AND SCHEDULING FOR MAIZE PRODUCTION IN MAIDUGURI, SEMI-ARID NIGERIA

¹Ali Umar Bashir and ²Adam Lawan Ngala

¹ Department of Agricultural and Environmental Engineering, Faculty of Engineering, University of Maiduguri, P. M. B. 1069, Maiduguri, Borno State, Nigeria

² Department of Soil Science, Faculty of Agriculture, University of Maiduguri, P. M. B. 1069, Maiduguri, Borno state, Nigeria.

Corresponding author: alfakiumarbashir@gmail.com, +234-8035064841

ABSTRACT

Maize production in the semi-arid region of Nigeria relies widely on irrigation. The common irrigation method and schedule used by the farmers in the region has become unsustainable due to low yield and hence low net farm income. Field experiments were conducted for two dry seasons to study the economic viability of maize production under different irrigation and scheduling methods. The experiments consisted of a factorial combination of irrigation methods (drip, sprinkler and furrow) and scheduling (fixed irrigation interval of 7 days, soil moisture-based and climate-based). Significant effects of irrigation methods and schedules on growth, yield and yield parameters were observed during the crop growth and development. Results obtained from drip irrigated plots scheduled with tensiometer performed better compared to other combinations. The economic analysis result showed drip with various combinations of schedules had the best net income. The combination of drip irrigation and tensiometer schedule had the highest net farm income and benefit cost ratio of \$695.2 and 3.20, respectively compared to \$460.8 and 1.99 for sprinkler and \$545.8 and 2.84 for furrow irrigation methods. This study revealed that the combination of gravity drip irrigation method and soil moisture and climate-based schedules that resulted in 4 days irrigation interval is the most economically viable alternative in maize production for the semi-arid region environment of Nigeria because of improved yield, higher water savings and water use efficiency.

Keywords: Cost-benefit, Irrigation methods and schedule, maize, semi-arid.

INTRODUCTION

Yield of maize in the semi-arid region of Nigeria is low due to low and erratic rainfall as a result of impact of climate change. The distribution of rainfall is extremely irregular to the extent that the amount and distribution in space and time had not been ideal to optimally support the crop production adequately. This necessitate applying water through irrigation. Farmers in the region use furrow irrigation method and fixed irrigation interval schedule for maize

production. The irrigation method and schedule used by the farmers have become unsustainable due to low yield, low water use efficiency and low net farm income. Thus, there is a growing gap between the demand for maize and its production to meet the food requirement for the growing population in the region.

Irrigation is an agricultural practice designed to supplement the water available from precipitation and the contribution to soil moisture from ground water by providing the required quantity of water and at the time

needed to replenish soil moisture to the required level for optimum crop production (Zwart and Bastianssen, 2004; Hoffman *et al.*, 2007 and Nagy, 2008). Irrigation is therefore a risk management tool for agricultural production. The impact of irrigation is greatest in arid and semi-arid regions as well as in humid and sub-humid climates during drought periods. Yields from irrigated land are higher and more consistent than the yields from rain fed areas. Irrigation guarantees crop production and provides economic stability to farmers and communities. Drastig *et al.* (2016) described irrigation as one of the most effective means which guarantees income to farmers.

Maize is commonly irrigated using furrow irrigation method in the semi-arid region of Nigeria (Ahmad *et al.*, 2000). But due to its low application efficiency of 54% (Aljamal *et al.*, 2001), only 1.8 t/ha of maize is obtained compared to the world average of 5.3 and to 7.8 and 9.1 t/ha Egypt and Mauritius, respectively (FAOSTAT, 2014). Bashir and Akande (2017) reported a wide gap in maize yield from the use of furrow irrigation compared to drip irrigation method, with 2630 kg/ha from furrow irrigation compared to the yield of 5684 kg/ha obtained from the drip irrigation method in the semi-arid region of Nigeria. Similarly, Usuh *et al.* (2017) reported a 36% drop in furrow irrigated maize yield relative to those obtained using drip irrigation method in Nigeria. In similar research, Kharrou *et al.* (2011) reported that furrow irrigated wheat yield was 28% less relative to drip irrigated wheat in the semi-arid region of Morocco. Erdem *et al.* (2006) also found a 40% drop in furrow irrigated tuber yield relative to those obtained under drip irrigation.

Several studies investigated the economic analysis of maize production under different irrigation Methods. Hall *et al.* (1988) used the annual budgeting approach to compare the benefit of corn production using low energy precision application (LEPA) center pivot, subsurface drip irrigation system, high pressure center pivot and furrow irrigation system in the Texas High Plains. The result indicated that the low energy application (LEPA) center pivot

system was found to be the most profitable. Dhuyvetter *et al.* (1995) analyzed the profitability of subsurface drip irrigation system and center pivot irrigation system using the partial budgeting technique in the Kansas High Plains for a full 65 ha field and reported that center pivot sprinkler system was more profitable compared to the subsurface drip irrigation system basically due to lower investment costs. Henggler (1997) reported that subsurface drip irrigation was more profitable compared to other irrigation methods due to an increase in the countries average cotton yield from 150% to 190%. Bostch *et al.* (1992) examined the economic viability of Virginia crops under subsurface drip irrigation, fixed location center pivot and movable center pivot systems using the net present value technique and reported that, subsurface drip irrigation system is the most profitable due to lower investment costs and lower pumping costs. O'Brien *et al.* (1998) carried out a field experiment in Western Kansas to analyse the profitability of changing from surface irrigation to center pivot or subsurface drip irrigation for corn production. The result of their study revealed that, the subsurface drip irrigation system is not profitable compared to center pivot sprinklers for subsurface irrigation system life of less than 10 years. They recommended the use of center pivot sprinkler system based on its profitability for corn production. Namara *et al.* (2007) compared the economic viability of crop production under different irrigation systems in India and their findings revealed that, for all the crops studied drip irrigation system was found to be the most profitable compared to other traditional methods. In another study, El-Wahed and Ali (2013) compared the profitability of corn using drip and sprinkler irrigation systems in Egypt. They reported the highest net profit values of 4944 and 3687 \$/ha under drip and sprinkler irrigation systems respectively. Narayanamoorthy (2008) studied the effect of drip irrigation systems on the performance of cotton and the profitability or otherwise of its production to the farming communities in three case studies. The study reported a 50% reduction

in irrigation cost by using drip irrigation. The result of the study also shows that drip irrigation system saved 45% of water compared to the conventional irrigation practice. The study also estimated 114% higher productivity than that under conventional irrigated.

Researches pointed out that furrow irrigation is not economically viable compared to drip irrigation method. Baranchuluun *et al.* (2016) reported a lower benefit cost ratio of 2.12 from furrow irrigation method compared to the benefit cost ratio of 3.60 obtained using drip irrigation method. Sprinkler and drip irrigation methods remain more efficient relative to any of the surface irrigation methods (Ayars *et al.*, 1999; Dogan and Kirnak, 2010). But these pressurized irrigation methods are rarely practiced by Nigerian farmers probably due to lack of their technical know-how, unawareness on their benefits or due to high initial expenditure required for installation, thus, there is still a growing gap between the demand of maize and its production. It is obvious from above that developing an operational irrigation method and schedule for efficient use of the limited water resources and for the growth and production of maize is crucial in the northern semi-arid region of Nigeria. Furthermore, despite the preference of pressurize irrigation methods over the surface irrigation methods; their productivity and profitability or otherwise for Maize have not been evaluated in dry semi-arid region of Nigeria. Therefore, there is need to determine the proper and the most economically viable irrigation method and schedule for optimum maize production in the study area.

Materials and Methods

Two years field experiment was carried out at the Teaching and Research Farm of Ramat Polytechnic, Maiduguri, Borno State (latitudes 11° 46'18"N to 11° 53' 21"N and longitudes 13° 03' 23"E to 13° 14' 19"E) in the semi-arid region of Northern Nigeria to determine the economic viability of maize production under varied irrigation methods and schedules in the region. The experiment consisted of a factorial

combination of irrigation methods and irrigation schedules laid out in a randomized complete block design that resulted in nine (9) treatments, replicated three times. Irrigation methods were at 3 levels namely; furrow, sprinkler and drip irrigation methods. Irrigation scheduling methods were also at three levels namely fixed irrigation interval, scheduling using tensiometer and the ratio of irrigation amount to pan evaporation method. The treatments were randomly assigned to plots. A total of 27 experimental plots were used for the study.

Maize seeds (TZEY cultivar) were planted at three seeds per hole and later thinned to two per stand. All the good agronomic practices for maize production were followed. Collection of data started two weeks after planting and were continued at two weeks interval. Growth and yield parameters recorded during the crop growth and development were number of leaves per plant, leaf area index, girth, plant height, cob length, cob diameter, number of rows per cob, cob weight, number of seeds per row, weight of seeds per cob, 1000 seeds weight and total yield per hectare according to standard procedures. Maize was harvested after reaching physiological maturity.

Determination of Performance of Farm Enterprise

The rationale behind the estimations of the different costs and returns components associated with a production process is in order to evaluate the performance of the production activities of an enterprise or the entire farm business. Performance indices such as profitability, gross margin, net farm income, the rate of returns to investments etc. are some performance indicators that were used to determine the optimal production process, enterprise selection, enterprise combination, make pricing decisions, marketing decisions as well as ascertaining the sustainability of investments.

The methods used in determining the performance of the farm business include farm

profitability analysis, net farm income analysis, gross margin analysis and benefit cost ratio (Srivastava, 2012). Farm profitability involves subtracting from the total returns the total costs of production to arrive at the profitability index. A positive value indicates that some profits are realized from the investments. The net farm income analysis is very similar to the profitability procedure with the major difference

that it is used in cases of having a number of enterprises on the same farm with a common cost which cannot be easily allocated to a single enterprise. What is done in such a case is to calculate the gross returns from each enterprise and then get the net farm income by subtracting from the pooled gross returns. The net farm income was calculated using equation 1 used by Haruna *et.al.* (2010).

$$\text{NFI} = \text{TR} - \text{TC} \dots\dots\dots (1)$$

Where:

NFI = net farm income from production per hectare.

TR = total revenue/returns from production per hectare.

TC = total costs of production per hectare.

Benefit cost ratio (BCR)

The benefit cost ratio (BCR) which is the ratio of the present value of benefit and the present value of cost was determined using equation 2.

$$\text{BCR} = \frac{\text{Benefit}}{\text{Cost}} \dots\dots\dots (2)$$

These were performed by identifying all costs incurred and the total revenue obtained from the production based on the irrigation methods and schedules used in the study. All costs were classified as either fixed or variable cost. Costs that were incurred due to land hiring, land preparation, seed, fertilizer, water used, fuel, rented pump, rented water reservoir, water application, planting, fertilizer application, weeding, harvesting and threshing were classified as a variable cost. While costs incurred from sprinkler and drip irrigation components were classified as a fixed cost. The variable cost and fixed cost were summed up to arrive at the total production cost for the research. The total revenue was obtained by quantifying the yield in monetary terms. The two costs-production cost and selling price (total revenue) were compared to evaluate the economic viability of different irrigation methods and techniques for maize production. The net farm income and benefit cost ratio were determined using the procedures outlined by Rao (1994), Brennan (2008) and Srivastava *et al.* (2012) as shown in equations 1 and 2, respectively.

Costs of Production

Costs of production are generally classified into fixed costs and variable costs. To facilitate the calculation of net farm income and benefit cost ratio which were used to determine the profitability and economic viability of the different irrigation methods and schedules, the different cost items were identified, quantified and the amount involved in their use in the maize production were summed up and subtracted from the total returns. The following are the different costs and the various procedures used in getting the value of their worth in the maize cultivation under the different irrigation methods and schedules.

Land Hiring

As most of the land used for irrigation by the farmers were rented, the average rent value per hectare was used. In some areas the farms are not clearly divided into hectare and so the value is not accordingly charged on per hectare basis rather, for the whole farm land. In such cases, the total amount paid for the farm land is divided by the number of hectares to arrive at its rent per hectare basis. The land rent per hectare therefore, was determined using equation 3.

$$LR = \frac{LP}{FLS} \dots\dots\dots (3)$$

Where:

LR = land rent per hectare.

LP = land payments.

FLS = farm land size (Hectares)

Land Preparation

This involves clearing the land and then using farm tools or machines to harrow, till as well as making the land suitable for irrigation purpose. For each particular farm operation, a specific amount is paid for carrying out such activities. The total amount paid for all of these activities divided by the total hectareage of the farm is the per hectare cost for land preparation. This was arrived at using equation 4.

$$LPC = \frac{TALP}{FLS} \dots\dots\dots (4)$$

Where:

LPC = land preparation cost per hectare.

TALP = total amount paid for the various land preparation activities.

FLS = farm land size (Ha)

Seed Cost

In order to arrive at the seed cost per hectare, the total quantity of seed used was multiplied by the seed rate. This total was then divided by the total hectares of land cultivated with maize to get the seed cost per hectare as shown in equation 5.

$$SC = \frac{TSC}{FLS} \dots\dots\dots (5)$$

Where:

SC = seed cost (Ha)

TSC = total cost of seed used.

FLS = farm land size (Ha)

Cost of Fertilizer

Different types of fertilizer command different prices in the market and the total quantity used by a particular farmer influences his/her total cost of production. The total amount expended on fertilizer was divided by the total land size to arrive at the cost of fertilizer per hectare as shown in equation 6.

$$FC = \frac{TCF}{FLS} \dots\dots\dots (6)$$

Where:

FC = fertilizer cost per hectare.

TCF = total cost of fertilizer used.

FLS = farm land size (Ha).

Cost of Fuel

This is the amount expended on the fuel used to run the water pump. It was calculated by summing all the amount of money spent on fuel which was then divided by the total hectareage with planted with maize to arrive at the fuel cost per hectare using equation 7.

$$FUC = \frac{TAF}{FLS} \dots\dots\dots (7)$$

Where:

FUC = fuel cost per hectare.

FLS = farm land size (Ha).

TAF = total amount spent on fuel.

Rented pump

This is the amount paid for the use of water pump to irrigate the farm under maize cultivation. The total amount paid as rent for the use of pump was summed and divided by the total hectares farmed using equation 8.

$$RP = \frac{TRC}{FLS} \dots\dots\dots (8)$$

Where:

RP = pump rent per hectare.

TRC = total rental cost.

FLS = farm land size (Ha)

Water used Cost

The area of study being in the semi-arid region of the country is an area with a scarcity of water. For this reason, the total quantity of water used was quantified and cost based on the average prevailing water rate using equation 9.

$$WCH = \frac{WUA}{FLS} \dots\dots\dots (9)$$

Where:

WCH = cost of water hectare.

WUA = total quantity of water used × average water rate.

WUC = total cost of water used by the farmer.

Rented Water Reservoir Cost

Water pumped had to be reserved in some type of container before ultimately being used for irrigating the maize crops. While some farmers purchase large plastic containers others use concrete water reservoirs. The reservoir is normally rented for the period of cultivation. The cost of renting the reservoir was arrived at by dividing the total cost of rented reservoir by the number of hectares cultivated to convert to per hectare basis using equation 10.

$$RWR = \frac{TRC}{FLS} \dots\dots\dots (10)$$

Where:

RWR = water reservoir rent per hectare

TRC = total rental cost

FLS = farm land size

Labour Cost

Labour costs were incurred for carrying out the different cultural practices such as planting; fertilizer application, weeding, harvesting, threshing etc. involved in the maize production activities. The total amount of money expended on each of these operations were calculated and divided by the size of the farm in hectares to get their per hectare basis. For instance, water application cost per hectare is the total amount per water application divided by farm size in hectares. For planting operation cost per hectare, it is the total cost of planting divided by farm size in hectares. For fertilizer application cost per hectare, it is the total cost for applying fertilizer divided by farm size in hectares. For weeding cost per hectare, it is total amount spent on weeding divided by farm size in hectares. For harvesting cost per hectare, it is total amount spent on harvesting divided by farm size in hectares. For threshing cost per hectare, it is total amount spent on threshing divided by farm size in hectares. The total for each of these activities on per hectare basis were the cost expended on labour for maize production per hectare.

Results and Discussion Economic Analysis of Maize Production under Different Irrigation Methods and Schedules

The process of choosing the most economically viable combination of irrigation method and schedule is one of the most important considerations in the development of irrigated agriculture especially in arid and semi-arid areas. The results of the total cost involved in maize production under the different irrigation methods and schedules are presented in Table 1. The result shows that the total cost of production for drip, sprinkler and furrow irrigation methods varied from 296.45 to 316.04, 403.39 to 467.33 and 259.51 to 297.31 \$/ha, respectively. The total cost of production in sprinkler irrigation is comparatively higher than drip and furrow irrigation methods as shown in Figure 1. The higher cost of production could be attributed to the higher cost of the sprinkler components including the costs involved in the maintenance of the sprinkler system.

The drip and the sprinkler irrigation systems fixed costs accounted for 19.07 to 20.33% and 23.73 to 27.49% of the total cost of production, respectively. The variable costs per hectare for the irrigation methods and schedules were 236.18 to 255.77, 293.20 to 367.8 and 259.51 to 297.31 \$/ha for drip, sprinkler and furrow irrigation methods, respectively.

The variable costs of production are higher in sprinkler compared to drip and furrow irrigation methods. This is due to the capacity of the pump used by the sprinkler as well as the fuel consumption. The variable costs were higher in pan and tensiometer irrigation techniques with shorter irrigation interval (4 days) which resulted in higher cost of fuel and water application compared to the fixed irrigation interval of 7 days. The total variable cost contributed 79.67% to 80.91% and 72.68% to 76.42% to the total cost based on the usage of drip and sprinkler irrigation methods, respectively. Fertilizer and water application costs accounted for 40.3 to 61.00% and 7.3% to 16.0% of the total variable cost, respectively.

The next limiting factor is the cost of fuel for the sprinkler irrigation system. The cost of fuel incurred for the sprinkler irrigation system was 19.09% of the average variable costs of production under this system of production. The implication of this finding is that for optimum output of maize to be obtained under these systems of farming adequate provision should be made to cater for these factors.

Land hiring, preparation, seeds, water used, weeding, harvesting and threshing contributed 5 to 7.56%, 3 to 4.53%, 1.33 to 2.02%, 1.54 to 3.40%, 1.25 to 1.90%, 1.33 to 2.02% and 1 to 1.51% of the total variable cost, respectively. Fuel and rented pump accounted for 4.13 to 21.33% and 2.05 to 6.67% of the total variable cost, respectively. A substantial proportion of the total variable cost was expended on fertilizer and water application. The total revenue under the different irrigation schedules for drip, sprinkler and furrow irrigation methods ranged

from 468.3 to 1011.2, 456 to 928.1 and 435.3 to 843.1 \$/ha, respectively as shown in Table 2 and Figure 2.

Drip irrigation led the highest total revenue of \$1011.2 compared to \$982.1 from sprinkler and \$982.1 obtained using furrow irrigation methods as shown in Table 4.24 and Figure 4.23.

This could be due to the higher drip water application efficiency of 80% which resulted in improved yield production. The tensiometer and the ratio of irrigation amount to cumulative pan evaporation techniques also gave higher total revenue when compared with the fixed irrigation interval (7 days).

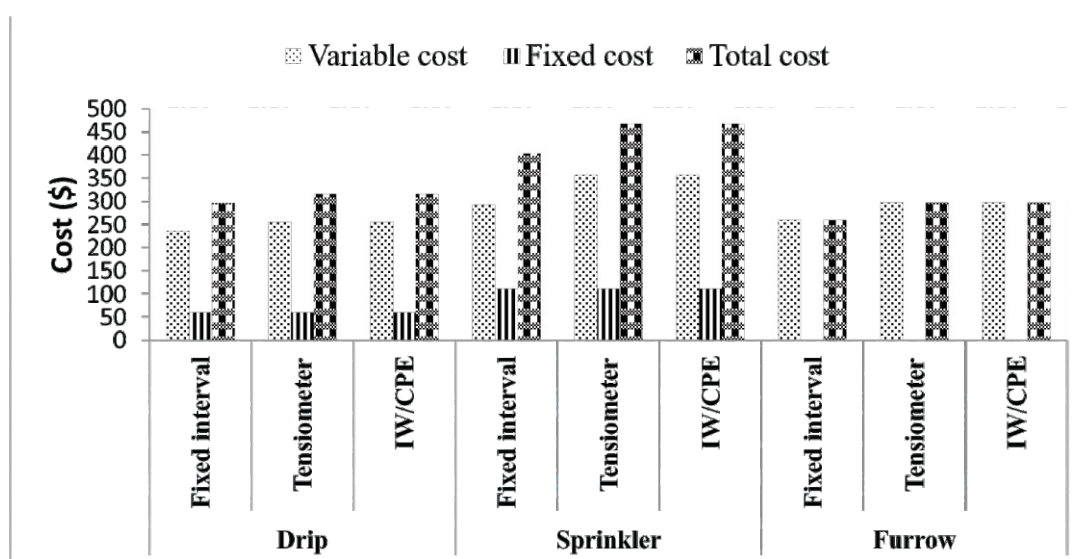


Figure 1: Costs incurred in maize production using drip, sprinkler and furrow irrigation methods under fixed, tensiometer and the ratio of IW/CPE irrigation scheduling methods.

The result further revealed that the highest net farm income and benefit cost ratio of \$695.2 and 3.2, respectively were obtained from the drip irrigation system compared to \$460.8 and 1.99 for sprinkler and \$545.8 and 2.84 for furrow (Table 2 and Figure 3). A relatively higher net returns but a lower benefit-cost ratio can be observed for the sprinkler system compared to furrow method of irrigation. This cannot be

unconnected with the additional costs of installing and maintaining the sprinkler system which are not borne in the furrow method thereby resulting in a lower benefit-cost ratio compared to the sprinkler system. The result of this study is similar to the findings of Bostch *et al.* (1992), Henggler (1997), O'Brein *et al.* (1998) and Namara *et al.* (2007).

Table 1: Total cost (\$/ha) incurred and cost-benefit ratio (in parenthesis) of maize production under the different irrigation methods and schedules

Items Output	Drip			Sprinkler			Furrow		
	Fixed	Tensiometer	IW/CPE	Fixed	Tensiometer	IW/CPE	Fixed	Tensiometer	IW/CPE
Variable inputs cost (VC):									
Land hiring	10.71(4.53)	10.71(4.19)	10.71(4.19)	10.71(3.65)	10.71(3.00)	10.71(3.00)	10.71(4.13)	10.71(3.60)	10.71(3.60)
Land preparation	17.86(7.56)	17.86(6.98)	17.86(6.98)	17.86(6.09)	17.86(5.00)	17.86(5.00)	17.86(6.88)	17.86(6.01)	17.86(6.01)
Seed	4.76(2.02)	4.76(1.86)	4.76(1.86)	4.76(1.62)	4.76(1.33)	4.76(1.33)	4.76(1.83)	4.76(1.60)	4.76(1.60)
Fertilizer	144.05(60.1)	144.05(56.3)	144.05(56.3)	144.05(49.1)	144.05(40.3)	144.05(40.3)	144.05(55.5)	144.05(48.5)	144.05(48.5)
Water used	3.75(1.59)	6.67(2.61)	6.67(2.61)	4.52(1.54)	8.04(2.25)	8.04(2.25)	5.69(2.19)	10.12(3.40)	10.12(3.40)
Fuel	-	-	-	42.86(14.62)	76.19(21.33)	76.19(21.33)	10.71(4.13)	19.05(6.41)	19.05(6.41)
Rented pump (1.5 hp)	-	-	-	-	-	-	5.32(2.05)	9.52(3.20)	9.52(3.20)
Rented pump (6.5 hp)	-	-	-	13.39(4.57)	23.81(6.67)	23.81(6.67)	-	-	-
Rented water reservoir	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9
Water application	21.43(9.07)	38.1(14.90)	38.1(14.90)	21.43(7.31)	38.1(10.7)	38.1(10.7)	26.79(10.3)	47.62(16.00)	47.62(16.00)
Fertilizer application	8.93(3.78)	8.93(3.49)	8.93(3.49)	8.93(3.05)	8.93(2.50)	8.93(2.50)	8.93(3.44)	8.93(3.44)	8.93(3.44)
Weeding	4.46(1.89)	4.46(1.90)	4.46(1.74)	4.46(1.52)	4.46(1.25)	4.46(1.25)	4.46(1.72)	4.46(1.50)	4.46(1.50)
Harvesting	4.76(2.02)	4.76(1.86)	4.76(1.86)	4.76(1.62)	4.76(1.33)	4.76(1.33)	4.76(1.83)	4.76(1.60)	4.76(1.60)
Threshing	3.57(1.51)	3.57(1.40)	3.57(1.40)	3.57(1.22)	3.57(1.00)	3.57(1.00)	3.57(1.38)	3.57(1.20)	3.57(1.20)
Sub Total	236.18	255.77	255.77	293.20	357.14	357.14	259.51	297.31	297.31
Fixed inputs cost (FC):									
Sprinkler components	-	-	-	110.91	110.91	110.91	-	-	-
Drip components	60.27	60.27	60.27	-	-	-	-	-	-
Sub Total	60.27	60.27	60.27	110.91	110.91	110.91	-	-	-
Total Cost	296.45	316.04	316.04	403.39	467.33	467.33	259.51	297.31	297.31

Source: Field experiment 2014/2015

Table 2: Net farm income (\$/ha) for maize production under the different irrigation methods and schedules

Items Output	Drip			Sprinkler			Furrow		
	Fixed	Tensiometer	IW/CPE	Fixed	Tensiometer	IW/CPE	Fixed	Tensiometer	IW/CPE
Yield (kg)	2431.3	5056.0	5049.3	2281.3	4640.7	4635.7	2176.7	4215.3	4125.7
Unit price/100 kg	20	20	20	20	20	20	20	20	20
Total revenue	468.3	1011.2	1009.8	456	982.1	927.1	435.3	843.1	825.1
Total Cost	296.45	316.04	316.04	403.39	467.33	467.33	259.51	297.31	297.31
Net farm income	171.8	695.2	693.8	52.6	460.8	459.8	176.1	545.8	527.3
Benefit cost ratio	1.64	3.2	3.2	1.13	1.99	1.98	1.68	2.84	2.78

Source: Field experiment 2014/2015

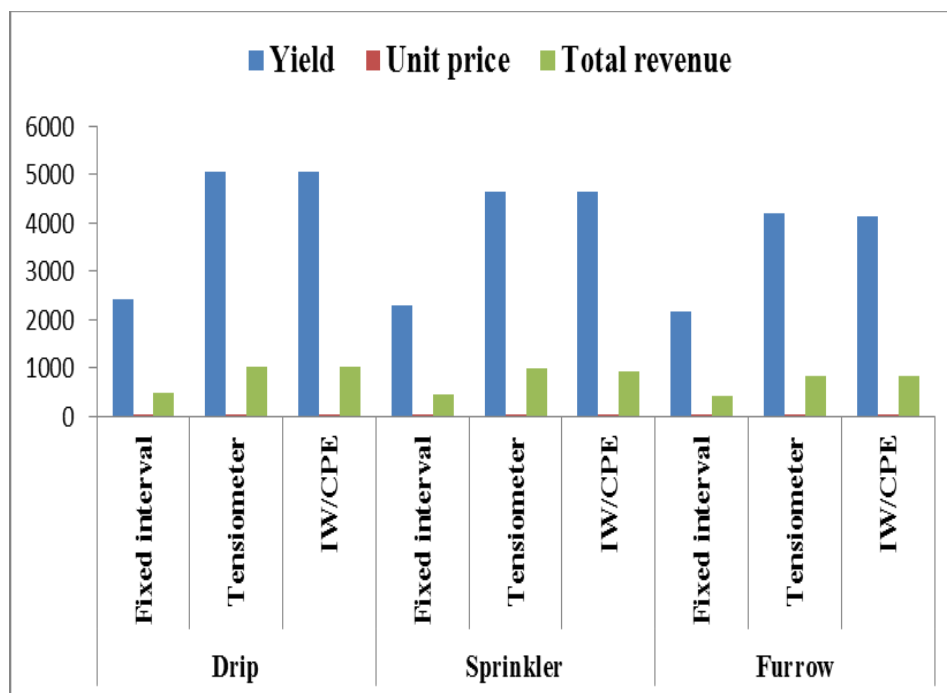


Figure 2: Relationship between maize yield, unit price and revenue for the three irrigation methods under fixed, tensiometer and the ratio of IW/CPE Irrigation scheduling methods

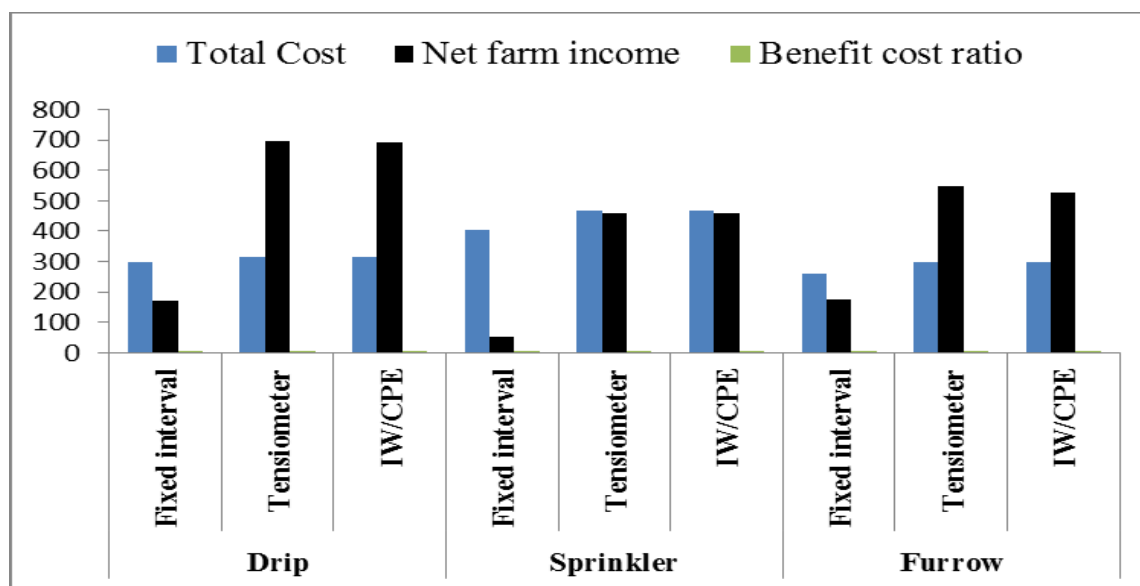


Figure 3: Profitability assessment of three irrigation methods under three irrigation scheduling methods

Conclusion

Drip irrigation was found to be the most profitable irrigation method for maize production with higher net farm income of \$695.2 and benefit cost ratio of 3.2 compared to the net farm incomes of \$460.8 and benefit cost ratios of 1.99 obtained using sprinkler and \$545.8 and 2.84 from the furrow irrigated plots.

REFERENCES

- Al-Jamal, M. S., Ball, S., and Sammis, T. W. (2001). Comparison of sprinkler, trickle and furrow irrigation efficiencies for onion production. *Agricultural water management*, 46(3), 253-266.
- Ayars, J. E., Phene, C. J., Hutmacher, R. B., Davis, K. R., Schoneman, R. A., Vail, S. S., and Mead, R. M. (1999). Subsurface drip irrigation of row crops: a review of 15 years of research at the Water Management Research Laboratory. *Agricultural water management*, 42(1), 1-27.
- Baranchuluun, S. D., Bayanjargal, A., and diyabadam, G. (2016). A Cost Benefit Analysis of Crop production with various irrigation systems IFEAMA SPSC P, 5:146 - 156.
- Bashir, M. and Akande, O. (2017). Effect of irrigation methods on the growth and yield of maize. *Journal of Arid Agriculture*, 10(2), 50-57.
- Brennan, D. (2008). Factors affecting the economic benefits of sprinkler uniformity and their implications for irrigation water use. *Irrigation Science*, 26(2), 109-119.
- Dhuyvetter, K. C., Lamm, F. R., and Rogers, D. H. (1994). Subsurface drip irrigation for field corn: An economic analysis. Kansas State University. Cooperative Extension Service (USA).
- Dogan, E. and Kirnak, H. (2010). Water temperature and system pressure effect on drip lateral properties. *Irrig. Sci.* 407-419
- Drastig, K., Libra, J., Kraatz, S., and Koch, H. (2016). Relationship between irrigation water demand and yield of selected crops in Germany between 1902 and 2010: a modeling study. *Environmental Earth Sciences*, 75(22), 1427
- Erdem, T., Erdem, Y., Orta, H., and Okursoy, H. (2006). Water-yield relationships of potato under different irrigation methods and



- regimens. *Scientia Agricola*, 63(3), 226-231.
- FAOSTAT, (2014). FAO Statistical Yearbook, <http://faostat.fao.org>
- Haruna, U, Garba, M., Nasiru, M. and Sani, M. H. (2010). Economics of Sweet Potato Production in Toro Local Government Area of Bauchi State, Nigeria. Proceedings of 11th Annual National Conference of National Association of Agricultural Economists (NAAE), Federal University of Technology, Minna. 30th – 3rd December.
- Henggler, J. C. (1997). Irrigation economics of drip-irrigated cotton under deficit irrigation. In Proc. Irrigation Association Technical Association, 125-132.
- Hoffman, G. J., Evans, R. G., Jensen, M. E., Martin, D. L., and Elliott, R. L. (2007). Design and operation of farm irrigation systems. St. Joseph, MI: American Society of Agricultural and Biological Engineers.
- Kharrou, M. H., Er-Raki, S., Chehbouni, A., Duchemin, B., Simonneaux, V., LePage, M., and Jarlan, L. (2011). Water use efficiency and yield of winter wheat under different irrigation regimes in a semi-arid region. *Agricultural Sciences in China*, 2(03), 273-282.
- Nagy, J., (2008). Maize Production. Akadémiai Kiadó, Budapest, p. 391.
- Namara, R. E., Nagar, R. K., and Upadhyay, B. (2007). Economics, adoption determinants, and impacts of micro-irrigation technologies: empirical results from India. *Irrigation Science*, 25(3), 283-297
- Narayanamoorthy, A. (2008). Economics of drip irrigated cotton: a synthesis of four case studies. In International Water Management Institute, Conference Papers h042297, Colombo, Sri Lanka
- O'Brien, D. M., Rogers, D. H., Lamm, F. R., and Clark, G. A. (1998). An economic comparison of subsurface drip and center pivot sprinkler irrigation systems. *Applied Engineering in Agriculture*, 14(4), 391-398.
- Rao, A.S. (Ed.), 1994. Drip irrigation in India. Indian National Committee on Irrigation and Drainage. Ministry of Water Resources, Government of India, New Delhi, India, p. 176.
- Srivastava, S. K., Rai, B., and Kumar, S. (2012). Role of micro irrigation in improving food productivity. India water week: water, energy and food security.
- Usoh, G. A., Nwa, E. U., Okokon, F. B., Nta, S. A., and Etim, P. J. (2017). Effects of Drip and Furrow Irrigation Systems Application on Growth Characteristics and Yield of Sweet Maize under Sandy Loam Soil. *International Journal of scientific Engineering and Science*, 773(193), 1-10.
- Zwart, S. J. and Bastiaanssen, W. G. (2004). Review of measured crop water productivity values for irrigated wheat, rice, cotton and maize. *Agricultural water management*, 69(2), 115-133.