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ASSESSMENT OF TOMATO FARMERS' IRRIGATION PRACTICE IN PAMPAIDA MILLENNIUM VILLAGE, IKARA LOCAL GOVERNMENT AREA, KADUNA STATE, NIGERIA

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ABSTRACT

This study was conducted in Pampaida Millennium Village (PMV), Ikara Local Government Area of Kaduna State, Nigeria; during the 2009/2010 dry season to assess Tomato farmer's irrigation water management practice using furrow irrigation. A total of 7 tomato farmers were selected out of 45 farmers for the assessment exercise. Soil moisture content was monitored throughout the growing season using gypsum blocks. The hydraulic performance of the farmer's plots were assessed. Similarly, the seasonal water requirement and irrigation schedule for the irrigated tomato were also determined. The results showed that the highest Application Efficiency, Distribution Uniformity and Adequacy of irrigation were obtained in plots T6 (92%), T3 (89%) and T7 (92 %) respectively. The least AE, DU and AI were obtained in plot T1 as 74%, 72% and 63% respectively. The yield obtained ranged from 11.6t/ha to 22.3t/ha. The least yield was obtained in plot T2; while the highest yield was obtained in plot T1. All the assessed farmers maintained a 4day irrigation interval throughout the growing season. The highest crop water use efficiency (CWUE) of 62.80 kg/ha-mm was obtained in plot T1, with a corresponding crop water use (CWU) of 355 mm/season. The least CWUE was obtained in plot T2 (41.6kg/ha-mm) with a corresponding CWU of 399 mm/season. Based on the results obtained it can be deduced that plot T1 gives best results among the assessed farmers' plots in terms of crop water use efficiency and effectiveness of irrigation, which maximizes net farm profit.

Keywords: Surface irrigation, water use efficiency, performance evaluation, Application Efficiency

INTRODUCTION

Agriculture is the major source of employment and livelihood for majority of Nigeria's population. The sector employs over two-thirds of the Nigerian labour force, accounting for about 35% of the Gross Domestic Product (GDP) (Fagade, 1997). The optimum use of irrigation water is a fundamental stride in attaining sustainable Agriculture. Optimal level use of irrigation water for a particular situation is that which produces the maximum profit per unit of water applied. One of the major setbacks to agricultural production in Nigeria has been the non availability and inefficient distribution of water (Phillip, 1990). Water as an agricultural source was found to be limiting. The declining water resources and growing competition for fresh water has continued to reduce its availability for irrigation in arid and semi arid regions. Feeding a planet of 8 billion by 2030 will require producing more food with less water and through improved water efficiency in agriculture (Qamar and Tyem, 1994;World Bank, 2011).

FAO (1989) outlined the problems irrigated agriculture may face in the future. One of the major concerns is the generally poor efficiency with which water resources have been used for irrigation. A relatively safe estimate is that 40 percent or more of the water diverted for irrigation is wasted at the farm level through either deep percolation or surface runoff. The need to meet the World's growing demand for food requires increased crop production from less water (FAO, 2002; Kirda 2002). But under the semi arid conditions of Nigeria, water is by far the major constraint to crop production (Graham et al., 1995). Therefore, techniques are needed to increase water use efficiency, which includes water management principles (Tariq and Usman, 2009).

The Pampaida Millennium Village (PMV) comprises of 28 settlements with a population of about 5,666 people (NPC, 2006). The community is a cluster of agrarian settlements that depend on rain fed agriculture as well as on smallholder traditional irrigation farming for their livelihood. Their livelihoods are mainly based on small-scale agriculture giving the region a characteristic presence of agricultural crops, trees and livestock.

Tomato, being one of the high value economic crops grown by farmers within the cluster, is actually grown two times under dry season irrigation farming. The farmers depend directly or indirectly on tomato production and sales as their means of livelihood during dry season period. However, in recent times, dry season farming in Pampaida is becoming increasingly difficult due to fluctuating weather conditions. The underground recharge has become unreliable,which also makes it difficult for the farmers to plan their irrigation schedules effectively and successfully (Sanchez *et al.*, 2009), it has become necessary for the farmers in Pampaida MVP to find ways of conserving the scarce natural resource so as to benefit from the efficient and effective utilization of the irrigation water. It is widely recognized that the traditional method of production techniques presently practice, do not put into consideration the amount of water applied to the crop, how frequent and how much water could be used by the crop in Pampaida, hence, the need for this research.

MATERIALS AND METHOD

The study was carried out in Pampaida Millennium Village (PMV) site located at Saulawa District in Ikara Local Government Area of Kaduna State, during 2009/2010 dry season farming.The PMV site is about 60 km from Zaria city of Kaduna State. The topography of the area is of gentle slopes gradually sloping downwards into a river.Pampaida is located on latitude $11^0 29''$N and longitude $8^0 15''$ E .The irrigation method practiced is mainly furrow irrigation with furrow lengths of between 3 to 10m (Sanchez *et. al* .,2009).

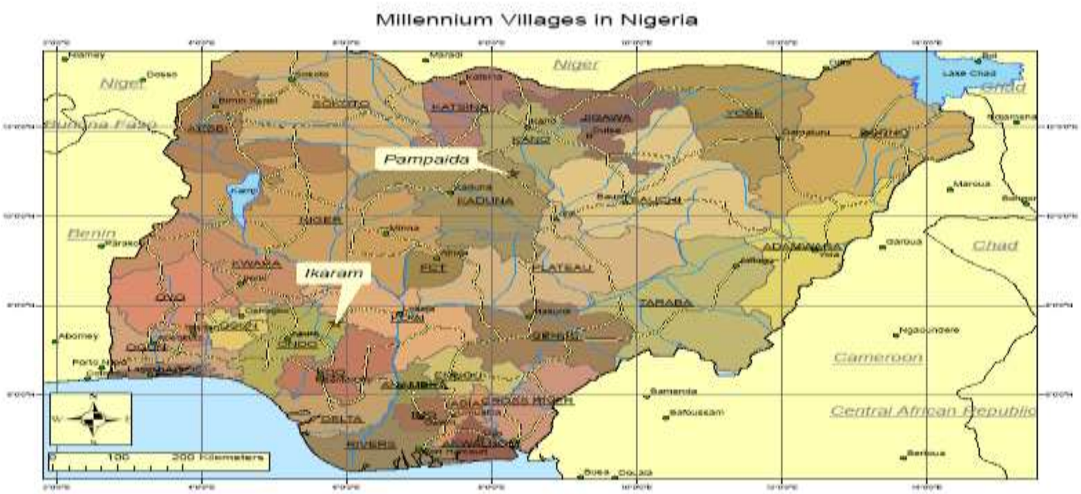

Figure 1. Map of Nigeria showing location of Pampaida (PMV)

The climate of Pampaida is marked by both wet and dry season which can be sub-divided into three, namely; a cool dry season from October to February; a hot dry season from March to May, and a warm wet season from June to September. The raining season usually starts from late May and ends in early October. Mean monthly temperatures range from 30^{o}C to 39^{o}C, and a mean relative humidity ranging from 30-70% annually. Irrigation is normally practiced in the months of November to May, which are the driest months in the year.The PMV1 area has an annual rainfall ranging from 800-1,050 mm per annum. (Sanchez *et.al.,* 2009)

Soil samples were taken from all the selected farmers field at an incremental depth of 150mm from the soil surface to a depth of 600mm (0-15cm, 15-30cm,30-45cm, and 45-60cm). The samples were taken to the laboratory for the determination of field capacity and wilting point using pressure membrane apparatus at 0.3atm and 15atm respectively as reported by Michael, (1978). The textural analysis used was sieve hydrometer methods using standard procedures as described by Love day, (1974). The general characteristics of each of the farmers field are presented in Table 1.

Soil Physical Properties

Table 1: General characteristics of the selected farmer's plots

Plot	Area of farms (m^2)	Area (ha)	Transplanting date
T1	48x47	0.226	06-03-10
T2	145x46	0.207	10-03-10
T3	50x50	0.252	18-03-10
T4	47x46	0.216	09-03-10
T5	49x49	0.240	23-02-10
T6	55x55	0.303	17-02-10
T7	50x50	0.250	21-02-10

Sample Size and Sampling Techniques of The Farmers Plots

Seven (7) farms were randomly selected for the study out of about fouty five (45) farms. The farms were identified as plots T1, T2...T7. Twelve (12) measurement points per farmer plot were used for soil moisture measurements. The measurement points were randomly selected across each farmers plot. For each of the measurement points, moisture content were determined at varying incremental depths. As reported, tomato was observed to have a deep rooting habit (Doorenbos and Kassam, 1979), with an effective root zone depth of 600mm (Mudiare and Kwayas, 1995). Therefore, the soil samples were taken at 150mm incremental depths to a depth of 600mm.

Description of Farmers' Field and Activities

The experimental set-up essentially consisted of the selected farmers' irrigation plots. The farmers prepared their land by clearing and burning the farm debris. They followed it with wild flooding of the entire farm, followed by making of furrows using animal plough traction. Thereafter, the furrows were then shortened into 2- 3m length to form blocks of furrows. Each block averagely consists of ten furrows. Transplanting was preceded with the irrigation of the blocks of furrows. Usually as they irrigate, they transplant the seedlings (Table 2.1). The transplanting was done both in the early morning hours and at late evening hours. After transplanting, irrigation was carried out 3 days later which is immediately followed by mild fertilizer application. Compound fertilizers (NPK and Urea) in equal proportions are mixed in the ratio 25kg NPK (15:15:15) with 25kg Urea and applied for a quarter of a hectare. This is usually the first dose. During the fertilizer application, the farmers usually apply a handful at the base of the tomato plant and covered it with soils in some cases and at times left uncovered.

Source of water for the irrigation was through tube wells/wash bore that was dug in the river beds and water was lifted from the tube wells using a 6.5hp (4.8kW) petrol engine pumps (commonly use pump in the area) and conveyed through 2" PVC pipes to the farm inlet. Irrigation water conveyed through PVC pipes to the desired inlet point within the farm was then distributed by gravity flow through small earthen channels to irrigate all the furrows in all the plots during the study. This process was maintained throughout the growing season in all the selected farmers' plots.The farmers used varying indices to judge the timing of irrigation. Some relied on cracking of the soil surface; others depend on folding of the leaves of their crops, while others simply determined the need for irrigation shortly after water dried off from the soil surface.

In Pampaida MV, the farmers irrigate their crops mostly every four days (averagely twice every ten days). According to Mofoke et al., (2002), for most small holder farmer's water application is done at intervals based on the farmers' judgments, not necessarily backed by any scientific principle.

Measurement of Irrigation Water

The pump discharges for each farmer was estimated with the use of a 55litre barrel plastic container and stopwatch. Irrigation water was discharged into the known volume container and timed with a stopwatch to know the time it takes to fill the container. This was repeated 5 times to come up with approximate average pump discharge for each farmer.

The irrigation water applied (IRR) at each irrigation was computed from average pump discharge (Q) and application time (t) using Enq. 2. & 3 respectively. By measuring the pump discharge (Q) and application time (t), the total quantity of water applied during irrigation was estimated (James, 1988). The farmers measured their application time themselves with wristwatches after being educated on the procedure and necessary precautions to reckon with.

Now, to express IRR on depth basis rather than volume basis, equation 3 was used to obtained the irrigation water on depth basis. That is, since

$$Q = V/t \quad \ldots (1)$$

Where:

Q = Discharge, m^3/s
t = Time, sec
V = Volume of container, litres

$$\text{Irrigation (IRR)} = Q \times t \quad \ldots (2)$$

Where 'Q' is in m^3/s,and 't' in secs,Irrigation (IRR) would be in m^3

$$\text{Irrigation (IRR)}_{\text{depth basis}} = \frac{Q\,x\,t}{A}\,x\,1000 \quad \ldots (3)$$

Irrigation $(IRR)_{\text{depth basis}}$ = irrigation water applied in equivelent average depth,mm

A= average farm area m^2

Reference Crop Evapotranspiration

An average of 10 year weather data was used, to determine the reference crop evapotranspiration (ETo) using the Hargreaves equation (Eqn. 4). The weather data was obtained at the Institute for Agricultural Research (IAR), Ahmadu Bello University, Samaru Zaria. The data were temperature, sunshine, relative humidity and wind speed.

The Hargreaves ET_O Equation expressed as :

$$ET_O = 0.0023(T_{mean}+17.8)(T_{max}-T_{Min})^{0.5}R_a \quad \ldots (4)$$

Where:

T_{max} = daily maximum air temperature (°c)
T_{min} = daily minimum air temperature (°c)
T_{mean} = mean of the daily maximum and minimum air temperatures.
Ra = extra terrestrial radiation for daily periods ($MJm^{-2}day^{-1}$) as detailed by Allen et al (1998).

Calibration of Gypsum Blocks

Soil samples were collected from various depths for gravimetric moisture content determination (Brady and Weil, 1999). Installation of gypsum blocks were done by soaking the blocks in water for about five minutes to saturate the blocks. Four small diameter holes were made in each measurement point representing depths of 15, 25,40 and 55 cm with the use of auger. Resistance readings were taken with the aid of an electrical resistance meter connected to the electrode of the gypsum blocks. Measurement made at depth 15, 25,40 and 55cm below the soil surface represent soil profile depth of 0-15, 15-30 and 30-45cm and 45-60cm respectively.

Regression analysis was done on volumetric moisture content from gravimetric method on the ordinate axis and their corresponding resistance values indicated by the resistance meter reading on the abscissa axis at various depths. The calibration curve and the regression model equation was thus obtained.

Measurement of Soil Moisture

The farmers generally observed four days irrigation intervals. Soil moisture content measurement were carried mostly twice in ten days, according to the farmer's irrigation practice, throughout the growing season.

Determination of Actual Crop Evapotranspiration.

Crop evapotranspiration (ET_a) is an empirical estimate of the total amount of water required for a crop growing in an area under known climate conditions so that crop production is not limited by lack of water. The actual crop evapotranspiration was calculated from measured soil moisture content data obtained using gypsum blocks as outlined by Michael (1979). The average daily actual evapotranspiration expressed was calculated using Eqn. 5.

$$ET_a = \sum_{i=1}^{n} \frac{M_{1i} - M_{2i}}{100} \times Bd_i D_i \quad \ldots (5)$$

Where:

ET_a is actual crop evapotranspiration mm/day

M_1 is the gravimetric moisture content (g/g) at the first sampling in the ith layer

M_2 is the gravimetric moisture content (g/g) at the second sampling in the ith layer

Di is the depth of ith layer (mm); n is the number of depth within the soil profile

Bdi is the specific gravity of the soil layer

Water Application Efficiency

The water application efficiency as reported by Michael, (1972) was calculated as the ratio of the average depth of irrigation water infiltrated and stored in the root zone to the average depth of irrigation water applied, expressed as a percentage.

Distribution Uniformity

The distribution uniformity was computed as ratio expressed in percent, of average low-quarter amount infiltrated (average of lowest 3 catches) to the average amount infiltrated (average of the catches of the 12 sampling points) for each irrigation event.

Determination of Crop Water Use

Crop water use efficiency (CWUE) is commonly expressed as the economic yield divided by the seasonal crop water use (seasonal evapotranspiration) (Flenet et al. 1996; Karam et al. 2007). The water use efficiency was calculated on the basis of marketable product since this is of fundamental concern to the farmers. The crops were observed to be grown entirely under irrigation as there was no contribution of water from precipitation.

Adequacy of Irrigation

Adequacy of irrigation was determined through a frequency distribution plot of infiltrated depths against cumulative percent area. The infiltrated depths were plotted on the vertical axis against the cumulative percent area on the horizontal axis, to generate a curve of infiltrated depth against cumulative percent area. Adequacy of irrigation was then read off from the curve as the cumulative percent area at the infiltrated depth equal to the moisture depleted for the specific irrigation.

Agronomic Practices

All the selected farmers in this study planted tomato crop (*Lycopersicum esculentum,* Mill) seeds of variety UC82B in their nurseries.The bed was well tilled and rows of 20cm-25cm marked out along the bed. Then a groove of 1.5-2cm deep was made along the row and the seeds were sown , then covered lightly with soil and the bed watered. The bed was covered with straw until germination starts. After germination has taken place, the straw was removed. The tomato seedlings were transplanted after about 32-35days of nursery across the seven farmers plots. Due to the varying dates of the nurseries, the transplanting dates also vary among the seven selected farmers. Weeding was done manually using hoes at different dates. It was done approximately two times by each farmer from transplanting to harvesting stage. Two days after the first weeding they applied a full dose of fertilizer. Before the application, they mixed 1bag of 25kg NPK (15:15:15) with ½ bag of 25Kg Urea for a quarter of a hectare size farm.

The plants were sprayed with *cypermethrin* insecticides and *Mancozeb* fungicide against White flies (*Bemicia tabaci*), fruit wors and other pests which were noticed on the entire selected field, especially during fruiting and they use various dosage of the insecticides to spray the crops. The insecticide and fungal spray was done at the same time by mixing them together and spraying with a 16 liter size knapsack spray. The ratio of mixing was 1 liter/ha insecticide (*cypermethrin)*, mixed with about 100gm of fungal powder *(Mancozeb)* and sprayed with a 16 liter knapsack spray.

Ripening of fruits became evident when the fruit started turning yellow and eventually red 65-70days after transplanting across the selected plots. Fruits were harvested separately in baskets and weigh, each time harvesting was done. Harvesting was done manually using hand picking and the period of harvesting lasted between four to six weeks across the assessed farmer's plots.

Statistical Analysis.

Crop data obtained were AE, DU, AI, and CWUE, however, for the tomato crop, were weighed to find the total yield per plot for all the selected farmers were collected and subjected to statistical analysis of variance and the significance among treatment means was evaluated with Duncan's Multiple Range Test to check significant differences between the treatments (SPSS,2017).

RESULTS AND DISCUSSION

The performance of the various amount of water applied were based on quantitative analyses. The parameters considered include: Water applied, crop water use and tomato yield. Average tomato yield for various amount of water applied in terms of how much water was utilized were determined and compared.

Soil Physical Properties

The soil physical properties for plots of each farmers are presented in Table 2 (a-g), from the soil physical properties of plots T1…T7 showed that there was not much variation within the selected farms in the study area. The soil of the experimental site is predominantly sandy loam. All the soils were found to be of a homogenous profile within the 0-600mm depth.

Table 2a: Soil Physical Properties for Plot T1

Soil depth (mm)	Soil texture Class	FC (% by weight)	PWP (% by weight)	Bulk density g/cm3	TAWC (%Vol. basis)
0-150	Sandy Loam	36.6	26.0	1.50	15.98
150-300	Sandy Loam	30.3	22.8	1.75	13.18
300-450	Sandy Loam	32.7	22.6	1.53	15.45
450-600	Sandy Loam	36.6	23.6	1.53	19.91

Table 2b: Soil Physical Properties for Plot T2

Soil depth (mm)	Soil texture Class	FC (%by weight)	PWP (% by weight)	Bulk density g/cm3	TAWC (% Vol. basis)
0-150	Sandy Loam	24.7	12.2	1.83	22.88
150-300	Sandy Loam	21.6	15.1	1.77	11.51
300-450	Sandy Loam	25.3	17.9	2.21	16.35
450-600	Sandy Loam	27.2	20.2	1.76	12.32

Table 2c: Soil Physical Properties for Plot T3

Soil depth (mm)	Soil texture Class	FC (% by weight)	PWP (% by weight)	Bulk density g/cm3	TAWC (% Vol. basis)
0-150	Sandy Loam	36.1	19.2	1.57	26.53
150-300	Sandy Loam	24.0	11.2	1.22	15.62
300-450	Sandy Loam	36.7	21.7	1.30	19.62
450-600	Sandy Loam	45.0	28.3	1.33	22.21

Table 2d: Soil Physical Properties for Plot T4

Soil depth (mm)	Soil texture Class	FC (%by weight)	PWP (%by weight)	Bulk density g/cm3	TAWC (% Vol. basis)
0-150	Sandy Loam	31.4	17.7	1.37	18.77
150-300	Sandy Loam	22.6	9.8	1.48	18.94
300-450	Sandy Loam	21.3	8.0	1.48	19.68
450-600	Sandy Loam	18.4	6.9	1.37	15.76

Table 2e: Soil Physical Properties for Plot T5

Soil depth (mm)	Soil texture Class	FC (% by weight)	PWP (% by weight)	Bulk density g/cm3	TAWC (% Vol. basis)
0-150	Sandy Loam	32.0	20.0	1.43	17.16
150-300	Sandy Loam	30.7	20.3	1.33	13.83
300-450	Sandy Loam	35.5	25.5	1.41	14.10
450-600	Sandy Loam	34.6	23.8	1.46	15.77

Table 2f: Soil Physical Properties for Plot T6

Soil depth (mm)	Soil texture Class	FC (% by weight)	PWP (% by weight)	Bulk density g/cm3	TAWC (% Vol. basis)
0-150	Sandy Loam	36.6	26.0	1.50	15.98
150-300	Sandy Loam	30.3	22.8	1.75	13.18
300-450	Sandy Loam	32.7	22.6	1.53	15.45
450-600	Sandy Loam	36.6	23.6	1.53	19.91

Table 2g: Soil Physical Properties for Plot T7

Soil depth (mm)	Soil texture Class	FC (% by weight)	PWP (% by weight)	Bulk density g/cm3	TAWC (% Vol. basis)
0-150	Sandy Loam	24.7	15.4	1.83	17.02
150-300	Sandy Loam	21.6	10.8	1.77	19.12
300-450	Sandy Loam	29.2	20.4	2.21	19.45
450-600	Sandy Loam	34.0	23.3	1.76	18.83

Calibration of Gypsum Blocks

The calibration equation provides a clear interpretation of soil moisture content value for a given resistance value. The gypsum blocks calibration relationship of soil moisture content and electrical resistance reading was found to be :

$$Y=124.0X^{-0.27} \quad \text{……. (6)}$$

The coefficient of determination was obtained as 0.9370, this expression was used to estimate the soil moisture content (Y) when the resistance reading (X) is known.

Water Application

Each of the selected farmer abstracts irrigation water using a water pump through a 2" size rubber horse pipe from a combination of tube wells in the riverbeds. PVC pipes were then used to convey water to the plots. Irrigation water conveyed through PVC pipes to the desired inlet point within the farm was then distributed by gravity flow to irrigate all the furrows as presented in Table 3. This process was maintained throughout the growing season in all the selected (assessed) farmers' plots.

Irrigation Characteristics at the Study Area

Table 3 shows number of irrigations per season, seasonal averages of irrigation interval, pump discharge, application time and average depth of water applied per irrigation for all the selected plots. The seasonal averages were computed from the field data.

Similarly, Table 3 shows that the assessed farmer's plots were irrigated with a pump discharge ranging between 4.0l/s to 4.6l/s and the water application time also varies between 5hrs 6mins to 6hrs 2mins. The seasonal ranges of average application depth per irrigation were found to be between 32-44mm. It was also observed that majority of the farmers (T2, T3,T5 & T6) did reduce their irrigation application time at some point as the season progresses, even though marginally, which did not translate into any significant reduction in the amount of water applied per irrigation.Also, due to the relative locations of the farms to each other, different pumping heads and possible pump conditions may have contributed to the varying pump discharges. Stegman (1980) noted that high frequency irrigation is generally undesirable for gravity irrigation systems.

Therefore the farmers should be discouraged from this practice, not only because it may lead to excessive deep percolation loss, but also it may cause leaching of the small quantities of fertilizers applied by the farmers.

Table 3: Seasonal average values of irrigation interval, pump discharge, application time, and depth of water applied for the assessed farmer's plots T1,T2…T7

Plot	No of Irrigation	Irrigation interval (days)	Pump discharge (l/sec)	Application time (hrs)	Average depth of water Applied/irrigation (mm)
T1	16	4	4.5	6.2	44
T2	16	4	4.1	5.6	40
T3	16	4	4.5	5.6	36
T4	16	5	4.0	5.7	37
T5	16	4	4.3	5.6	36
T6	16	4	4.6	5.9	32
T7	16	4	4.6	5.6	37

Table 4 shows the irrigation activities, it was observed that the plots were irrigated with average irrigation interval of 4-5 days. It was also observed that there was not much difference between the irrigation intervals at the initial stage of the crop growth and throughout the remaining growth stages. This implied that the farmers were maintaining the same irrigation intervals throughout the four growth stages of the tomato crop in all the selected crops. It also means that all the plots were operated on similar frequency of irrigation.

The farmers were irrigating about twice every ten days throughout the growing season. This may be based on their presumption that the more water they apply the higher the crop yield. It was also observed, through interaction, that the few situations in which some farmers extended their irrigation interval beyond four days was actually based on some external factors beyond their control like pump break downs, fuel scarcity and the inability to procure fuel in good time which makes some farmers to reschedule their irrigation interval.

Table 4: Water application depth (mm) per irrigation for the season

Plot	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	Total
T1	43	43	44	44	43	44	44	44	44	43	45	45	45	43	45	44	703
T2	47	47	47	45	42	38	38	37	37	37	37	40	39	38	37	36	642
T3	39	39	40	35	36	34	35	34	35	34	33	39	35	34	34	34	570
T4	38	38	36	32	32	32	32	31	31	32	31	31	37	32	36	36	537
T5	43	43	40	35	33	33	35	32	34	32	32	31	37	35	36	35	566
T6	34	34	32	33	30	30	29	30	30	31	32	28	31	30	29	29	492
T7	39	39	39	36	35	35	35	33	34	35	34	33	39	35	39	35	575

Determination of Irrigation System Performance

Table 5 shows Seasonal values of application efficiency (AE), Distribution uniformity (DU) and Adequacy of irrigation (AI) for the selected assessed farmers' plots which quantitatively describes the desired effectiveness of irrigation that maximizes net farm profit. The seasonal average were computed from the field data set.

Table 5 shows all the selected plots had an average seasonal AE in the range of 74 to 92%, DU in the range of 72 to 89%, and AI in the range of 63 to 92%. Similarly, the highest AE was obtained in plot T6 (92%) and the highest DU and AI obtained in plots T3 (89%) and T7 (92%) respectively. Irrigation with highest AE, DU, & AI are not always desirable, since they do not always maximize net farm profit. Whereas the lowest AE (74%), DU (72%) and AI (63%) occurred in plot T1. It was also observed from Table 4 that all the selected plots were operated with application efficiencies above 60%. A well designed and properly managed surface system can attain efficiencies of 60% or better (James, 1988).

Table 5: Seasonal values of AE, DU and AI of irrigation for the selected plots T1, T2…T7

Plot	Application efficiency (%)	Distribution uniformity (%)	Adequacy of irrigation (%)
T1	74	72	63
T2	86	74	88
T3	88	89	87
T4	91	75	82
T5	89	77	91
T6	92	73	75
T7	88	77	92

The results also revealed that water distribution uniformity and adequacy of irrigation were above 70% and 60% respectively in all the selected plots. Distribution uniformity is the most commonly used uniformity index in surface irrigation application. Even though the DUs are better than the value of 70% reported by Pitts *et al.* (1996) in the irrigations systems of Western United States, they fall outside the acceptable limits, which was set by FAO to be 80% (FAO, 1989). High adequacy of irrigation is often associated with enormous wastage especially for gravity irrigation systems. This was another indication that the farmers were over irrigating in most of the periods. An effective irrigation practice, according to James (1988), is one that offers the best combination of Application efficiency, Distribution Uniformity and Adequacy of Irrigation that maximizes farm profits rather than simply maximizing the performance parameters. Maximizing performance parameters provided a poor basis for managing an irrigation system to optimal profit or any other value such as production per unit of energy input. This was reported by Keller et al., (1980).

Seasonal Irrigation Water Use, Crop Water Use and Crop Yield

Crop water use is an important parameter in crop production under irrigation. The water utilization by crop is generally described in terms of crop water use efficiency (CWUE). CWUE can be taken as a factor used for assessing either the total dry matter production of crop (in economic terms) or the proportion of dry matter production harvested as economic yield through the use of water in form of evapotranspiration. The number of irrigations per season, seasonal irrigation water applied, seasonal crop water use, crop water use efficiency, and measured crop yield for all the selected plots are presented in Table 6.

Table 6: Seasonal irrigation water use, Crop water use, Crop yield and Crop water use efficiency of irrigated Tomato crop for the 2009/2010 dry season.

Plots	No. of irrigations	IWU mm/Season	CWU mm/Season	Crop yield (t/ha)	CWUE (Kg/ha-mm)
T1	16	703	355	22.3	62.8
T2	16	642	399	16.6	41.6
T3	16	570	396	19.6	48.7
T4	16	537	443	18.6	42.0
T5	16	566	399	19.2	48.1
T6	16	492	369	19.7	53.4
T7	16	575	412	20.2	49.0

From Table 3.5, it can be deduced that the tomato yield harvested and measured was between 16.6 to 22.3 t/ha, with seasonal crop water use ranging from 355 mm/season to 443 mm/season.Plot T2 had the lowest crop yield of 16.6 t/ha with seasonal crop water use of 399 mm/season. The maximum yield recorded was 22.3 t/ha from plot T1, with a corresponding seasonal crop water use of 355 mm/season. According to Doorenbos and Kassam (1979), tomato grown under good management practices could consume as much as 400-600 mm of water, giving yields of 45-65 t/ha. Earlier reports (IAR, 1994) also indicate the possibility of attaining up to 40 t/ha for tomato grown under irrigation in the Guinea Savanna Zone of Nigeria. This shows that there is the possibility of increasing the crop yield beyond the 22.3 t/ha when the agronomic practices and the irrigation water management are improved. The factors that contribute to higher yield in crop production are root growth and soil environmental conditions, which sometimes soil temperature influences. Higher soil temperature, in arid and semi arid regions,is experienced in the rootzone during dry season farming and was found to be an important factor adversely affecting root and shoot growths, dry matter production and subsequent yields of the crop, (Gupta and Gupta 1983). Also, the observed variations in seasonal water use as shown in Table 6 indicate that the irrigation practice was highly variable in terms of water application regimes. The irrigation water applied ranges from 492mm/season to 703mm/season, with plot T5 having the lowest and plot T1 recording the highest respectively. The length of the growing season was not the same due to different agronomic practices. This may have contributed to the unequal amounts of moisture consumed by the crops in the selected farms.

Furthermore, Table 6 shows the crop water use efficiencies (CWUE) for selected plots in the study area. The crop water use efficiency was used to assess the performance of an irrigation practice in terms of crop yield produced at least possible water consumed. It can be seen from Table 6 that Plot T1 gave the highest crop yield water use of 63Kg/ha-mm and a seasonal consumptive use of 355mm. Previous reports by Omotowoju (1992) points out that an irrigation schedule that would reduce consumptive use whilst maintaining yield reduction at the bearest minimum would generally improve CWUE of agricultural crops. However, none of the farms appear to have efficiently utilized irrigation water for production of marketable crop yield. This is so because their CWUE's falls below the FAO range of 100 to 120 kg/ha-mm for tomato as reported by Doorenbos and Kassam (1986). Similarly, Mofoke (2000) reported a range of 27 to 123 kg/ha-mm for eight *Fadama* farms in Samaru, Zaria and also, Othman (2001) reported a CWUE of 71.16 kg/ha-mm in Bauchi.

CONCLUSION

Evaluation of Farmers Practice within Pampaida Millennium Village was evaluated, a total of 7 tomato farmers were selected out of 45 farmers for the assessment exercise, in this research reported herein, in terms of crop water use efficiency and effectiveness of irrigation; it can be concluded that, for irrigation of a Tomato field, water application depth should be within 42mm for Tomato in Pampaida Millennium Village. Furthermore, to avoid over irrigation at the initial and late crop growth stage for Tomato crop, farmers should apply water less 42mm in Pampaida Millennium Village.

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