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Trends of Productivity of Water in Rainfed Crops in Ilorin South, Kwara State, Nigeria

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Abstract

In sub- Sahara, rain fed agriculture is the dominant source of food production. It is likely going to remain so for the next foreseeable future. However, yield from rain fed agriculture are often very low. But there is enormous opportunity to raise crop yield of rain fed agriculture especially by focusing on the aspect of increase productivity of water, formulate and adopt appropriate adequate option for increasing productivity of water in rain fed agriculture. The paper therefore, assessed the trend of productivity of water (PW) for each of the crop during the cropping season. Evapotranspiration occasioned by either mid cropping season, dry spell or early cessation of rainfall and low rainfall utilization are primary drive of production of water (PW) in rain fed agriculture in the area. Other factors that are usually put forward by agricultural stake holders in the region include poor soil nutrient

and lack of proper crop management. These are secondary and could be considered as spill over effects from these primary drives of productivity of water (PW).

Keywords: Cessation, crop yield, onset, productivity of water, water crop requirement.

Introduction

About 95% of the current world population growth occurs in tropical developing countries whose rural economy is based on rain fed agriculture (Rockstorm et al 2003). In Sub- Sahara Africa rain fed agriculture has been the dominant source of food production and it is likely going to remain so for the next foreseeable future since more than 95% of the agricultural farmland is under rain fed agriculture.

The common characteristics of rainfed agriculture especially in the tropical and semi arid ecosystem are low crop yields that are far below potential yields attainable in the regions and high no- farm water losses. In tropical and semi arid sub- Sahara Africa, cereal yields from rain fed agriculture are generally around 1 hectare against potential yield of 3 – 5 hectare attainable in the region (Barron, 2004).

The wide yield gap suggests that there is an enormous opportunity to raise crop yield of rain fed agriculture. According to Maccalla, 1994 and Young (1999), there is limited new land to be put under agriculture, contrary to the last three decades where the bulk of food production in Sub- Sahara came from expansion of agricultural lands. The opportunities to increase crop yield under rain fed agriculture strongly rest on focusing our attention on maximum yield per unit of water. In order to formulate and adopt appropriate and adequate option for increasing productivity of water in rain fed agriculture, it is worthwhile to look at the performance of this sector by carrying out a trend analysis using past event. Such insight would enable us identify possible factors that dictate productivity of water in rain fed agriculture and their magnitude.

The primary objective of this paper therefore, is to show the historical trends of productivity of water (PW) for selected crop commonly cultivated under rain fed and identify the forces dictating productivity of water.

The crops involved include groundnut, maize, sorghum, bean and potato in Ilorin South Local Government Area of Kwara State.

Objectives

The primary objectives of this paper are:

1. To show the historical trend of productivity of water (PW)
2. To select crop commonly cultivated under rain fed agriculture and identify the forces dictating productivity of water (PW)
3. To suggest an improved way which could lead to high production of food through rain fed agriculture.

The study area

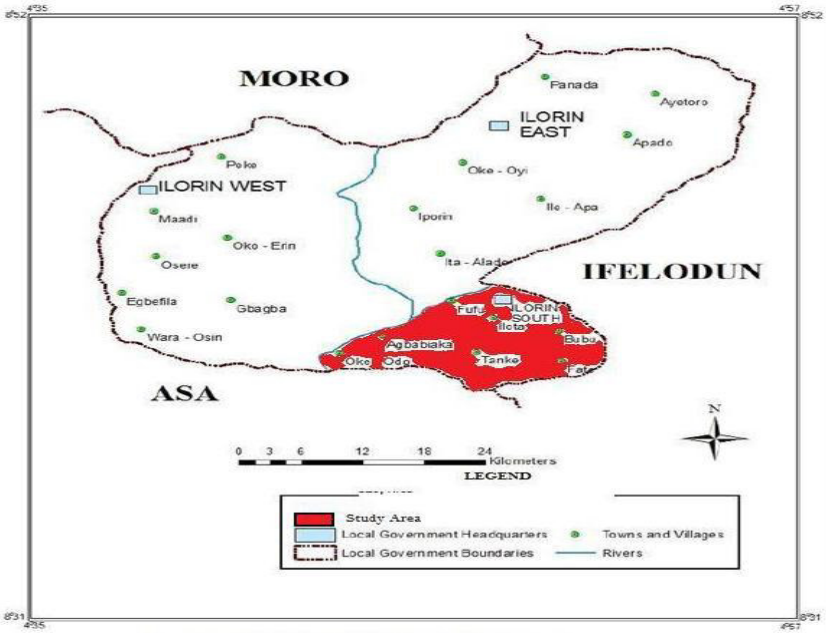


Fig.1:-MAP OF ILORIN SHOWING THE STUDY AREA

Ilorin is the capital of Kwara State. It is located on latitude 8° 31'N and 4° 35'E and longitude 4° 57'N and 8° 52'W with an area of about 100km square

(Kwara State Diary 1997). For administrative purposes, it is divided into Ilorin West, East and South.

It shares common boundaries with Moro, Ifolodun and Asa Local Government Areas. The study area covers a vast part of Fate, Tanke, Ilota, Bubu, Oke-Odo, Agbabiaka and Fufu. Fufu is the headquarters of Ilorin South Local Government.

The study area is characterized with two distinct seasons: wet and dry seasons. The dry season covers a period of about five (5) to six (6) months from November to March/April while the wet season is between four (4) and five (5) months from May to September and within these months rainfall is erratic.

There is the presence of scattered and short deciduous trees with both short and tall numerous grasses. The plant species include shea- butter, acacia and isobelina.

Data collection

In order to develop the historical trend of productivity of water (PW) for the rain fed crops, weather data comprising of rainfall, temperature, relative humidity, sunshine hours and wind speed were obtained from ADP office in Fufu the headquarter of the local government area and the Price Monitoring and Evaluation Unit/ Department of Kwara ADP weather survey. The average monthly rainfall distribution data was also obtained for the same unit.

The crop yield and area cultivated for these major rain fed crops were obtained from the Agricultural and rural management training institute (ARMTI). Field observations were also made at various places of the study area.

Data analysis

The weather data such as rainfall, maximum and minimum temperature, relative humidity, wind and sunshine hours obtained from the weather station was an input into the FAO CROPWAT model (Smith et al, 2000), to generate the crop water requirement and crop water use (actual evapotranspiration) for each crop from 1998- 2009 cropping season. The crop parameters required as input in the crop model include crop coefficient, rooting depth and depth of moisture extraction. These data were taken as the default data in the

CROPWAT data model. The only crop parameter' inputs are, planting date and the length of the cropping season which were later adjusted to the cropping calendar of the study area. In the simulation model, planting dates for the crop were assumed to onset date of rain. On the average, most of the rainfed crops are planted between the second decade of December and the first decade of January.

Results and discussion

Climatic data

Table 1.0 shows the mean monthly climatic data in Ilorin South Kwara State. The parameters examined were rainfall, maximum temperature, minimum temperature relative humidity, wind speed and sunshine respectively for the cropping season under consideration.

Table 1.0: Mean monthly climatic data in Ilorin South

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Rainfall (mm)	0.0	0.0	0.4	0.7	6.7	67.5	168.5	165.4	169.1	122.4	33.6	2.1
Max. Temp (°C)	28.9	29.7	28.5	30.9	29.5	30.2	30.4	29.8	28.3	30.6	30.9	32.3
Min. Temp (°C)	9.2	11.2	11.2	12.1	13.5	16.3	16.2	17.3	18.4	18.6	19.5	16.9
Rel. Hum. (%)	55.9	59.7	56.8	65.8	74.3	78.5	78.5	85.8	78.9	76.3	61.2	58.9
Wind Speed (Km/day)	119.6	117.9	68.1	174.7	91.3	102.9	70.6	71.3	79.6	138.2	217.0	183.2
Sunshine (hours)	10.7	9.7	10.7	10.5	9.4	8.9	7.7	5.1	5.8	7.3	9.6	9.8

Source: P.M.E. Department, Kwara Agricultural Development Program me (ADP)

Table 2.0 shows the rainfall data from 1998-2009 cropping season, the table shows a simple variation in the amount 869mm in 1998, 1085mm in 1999. The lowest value was recorded in 2003 with 113.2mm. This low value is attributed to the 2003 drought in the state. The highest rainfall value of 1853.6mm that was recorded in 2008 was due to the torrential rainfall of April, July, August and September of that year which was evenly distributed

and it would be recalled that this is responsible for the high yield in this particular year.

Table 3.0 shows the crop yield with the total area cultivated from 1998-2009 cropping season. The total area cultivated for each of the crop varied from year to year but it is in the average of 10,000 to 34,000 hectares for maize, 450 to 3,400 hectares for sorghum, 550 to 4,800 hectares for potato, 720 to 6,000 hectares for beans and 2,000 to 10,000 hectares for groundnut.

The amount of hectares of land cultivated for each crop is largely influenced by factors like the onset dates of rains, farmers, labours capacity and market value for the crops in the previous year.

The 2003 drought was largely responsible for the crop failure and low yield in this particular year. The season experienced the onset of rain such that the dry spells met the crop in their vegetative and early flowering stages which is known to be crucial in the plant growth. The delusion this year might be a responsible factor of low cultivated experienced in the next year (2004) either because they have lost their capital or are not willing to take risk any longer.

It was also observed that when there is early onset of rain and planting was done in first and second decade of December, early cessation in March or early April has little impact on crop yield, even though evapotranspiration is high. This is because grain crops like, maize, sorghum and beans would have entered their maturity stage at this period. This is a good explanation for the 2000 cropping season with a good yield despite high evapotranspiration rate.

Although, low yield in rain fed crops in the area is commonly attributed to farmers not planting high yielding crop varieties and not using fertilizers, high evapotranspiration rate was also noticed across the year and for all the crops, this may be a true cause of low yield at this particular time. Using high yield crop and application of fertilizer may still lead to a low yield if the requirements are not met. In many cases, the local varieties are more adaptable to moisture stress than the improved high yielding crop variety.

Table 2.0: Monthly rainfall distribution (mm) in Ilorin South 1998-2009 cropping season

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug	Sept.	Oct.	Nov.	Dec	Annual total (mm)
1998	33.5	-	NA	NA	214.7	176.3	285.7	NA	NA	159.7	NA	-	8690.0
1999	-	-	30.1	69.2	160.7	122.1	175.6	115.5	339.6	61.8	6.0	-	1085.0
2000	-	3.6	42.2	31.95	141.4	133.6	146.5	2050.02	299.6	117.2	17.05	-	1138.1
2001	12.04	23.1	30.4	78.75	108.1	180.78	158.69	118.14	200.52	173.6	0.9	-	1085.0
2002	-	-	47.47	76.1	150.8	164.1	138.48	200.7	227.78	163.2	29.13	-	1211.7
2003	NA	NA	32.1	69.9	98.2	120.4	84.9	24.8	37.8	42.1	0.4	14.0	513.2
2004	41.6	-	96.8	187.8	209.2	382.5	159.9	142.2	309.9	137.2	37.0	-	1704.0
2005	-	4.5	34.1	74.7	194.3	204.4	106.9	17.8	178.8	128	-	-	1103.0
2006	-	52.5	65.6	81.5	132.3	195.8	192.4	189.1	196.4	173.8	20.9	-	1292.0
2007	-	-	23.4	42.2	125.2	156.1	53.5	203.8	265.4	77.1	-	-	946.0
2008	-	-	88.05	70.38	117.7	95.28	121.6	149.48	194.55	67.56	2.4	-	1853.6
2009	10.2	4.6	33.4	78.2	160.2	310.3	124.2	141.2	210.4	38.3	14.1	-	1125.2

Sources: P.M.E Department, Kwara Agricultural Development Programme (ADP)

Table 3.0: Crop and area cultivated for each crop 1998 – 2009

	1998				1999				2000		
Crop	Area (Ha)	Production (ton)	Yield (t/ha)	Crop	Area (Ha)	Production (ton)	Yield (t/ha)	Crop	Area (Ha)	Production (ton)	Yield (t/ha)
Maize	10000	15000	1.50	Maize	34984	31486	0.90	Maize	28771	74805	2.60
Sorghum	1000	1000	1.00	Sorghum	3364	4586	1.36	Sorghum	992	1248	1.26
Potato	550	2750	5.00	Potato	4820	28636	5.94	Potato	1660	16600	10.00
Beans	900	360	0.40	Beans	6060	4545	0.75	Beans	5897	5787	1.00
G/Nut	2700	1080	1.40	G/Nut	9200	4740	0.52	G/Nut	8364	10037	1.20
	2001				2002				2003		
Crop	Area (Ha)	Production (ton)	Yield(t/ha)	Crop	Area (Ha)	Production	Yield(t/ha)	Crop	Area (Ha)	Production (ton)	Yield(t/ha)

						(ton)					
Maize	21300	51120	2.40	Maize	22700	52210	2.30	Maize	20451	12140	0.59
Sorghum	578	1072	1.85	Sorghum	490	390	0.80	Sorghum	680	1000	1.47
Potato	556	8891	15.91	Potato	685	6165	9.00	Potato	1294	2348	1.81
Beans	786	780	0.99	Beans	760	608	0.80	Beans	906	725	0.80
G/Nut	2800	2240	0.80	G/Nut	2885	2019	0.70	G/Nut	3200	2240	0.70
	2004				**2005**				**2006**		
Crop	**Area (Ha)**	**Production (ton)**	**Yield(t/ha)**	**Crop**	**Area (Ha)**	**Production (ton)**	**Yield(t/ha)**	**Crop**	**Area (Ha)**	**Production (ton)**	**Yield(t/ha)**
Maize	12841	35798	2.79	Maize	25665	17223	0.67	Maize	27700	55400	2.00
Sorghum	757	1011	1.34	Sorghum	800	730	0.91	Sorghum	500	400	0.80
Potato	876	4818	5.50	Potato	1159	8229	7.10	Potato	735	8820	12.00
Beans	770	646	0.84	Beans	840	934	1.11	Beans	800	640	0.80
G/Nut	1238	2478	2.00	G/Nut	3000	2100	0.70	G/Nut	2300	2100	0.91
	2007				**2008**				**2009**		
Crop	**Area (Ha)**	**Production (ton)**	**Yield(t/ha)**	**Crop**	**Area (Ha)**	**Production (ton)**	**Yield(t/ha)**	**Crop**	**Area (Ha)**	**Production (ton)**	**Yield(t/ha)**
Maize	28000	50400	1.80	Maize	22346	67035	3.00	Maize	29841	29841	1.97
Sorghum	565	452	0.80	Sorghum	730	660	0.90	Sorghum	847	792	0.94
Potato	700	4900	7.00	Potato	1000	6700	6.70	Potato	836	4824	5.77
Beans	880	704	0.80	Beans	834	800	9.96	Beans	924	1024	1.11
G/Nut	2700	2430	0.90	G/Nut	2940	14710	0.50	G/Nut	2381	2341	0.94

Table 4.0 shows the crop water use, evapotranspiration and crop water productivity (PW) for the rain fed crops for the cropping seasons. Crop water were found to be appreciably lower than crop water requirement for all crop in all the cropping season under consideration except 2008 cropping season where the difference were quite smaller. Crop water use was within 180mm to 375mm for maize, 160mm to 360mm for sorghum, 320mm to 450mm for potato, 220mm to 320mm for beans and 175mm to 430mm for groundnut all per season. The lower range values were obtained in 1995 due to the low amount of rainfall experienced in the year while the upper values were obtained in 2008 cropping season due to the early onset of rain and all appreciable amount of rainfall.

Evapotranspiration rate ranges from 115.61mm to 202.7mm for maize, 4.46 to 206.5mm for sorghum, 74.46 to 199mm for potato, 29.1 to 61.8mm for beans and 43.6 to 315.3mm for groundnut. The evapotranspiration rate is associated with low rainfall midseason drought and early cessation of rainfall. The 2003 cropping season was characterized by the onset of rain with only 60mm depth recorded in December, low rainfall in March recording 84.6mm depth and early cessation rain in August. The late onset of rain is responsible for the delay of cultivation and planting. The low rainfall in March and early cessation of rain might have led to high transpiration rate and consequently low yield. The same trend was noticed in 1999 and 2005 cropping season which also recorded very high evapotranspiration rate and low yield in crop.

The graph shown in the annex 1 reveals that there is no significant difference in the number of hectares of land cultivated and the yield obtained while the graphs in annex 2 showed that there is a significant difference in the yield obtained and the mean annual rainfall. Years with meaningful annual rainfall showed a correspondent increase in yield.

Table 4.0: Crop water use, evapotranspiration and crop water productivity

1998

Crop	RR (mm)	RRe (mm)	CWR (mm)	ETa (mm)	ETd (mm)	T (t/ha)	PWrr (kq/rr)	Pwrre (kq/m)	Pwwta (kq/m)
Maize	509.3	399.5	378.3	319.5	5889	1.50	0.295	0.376	0.376
Sorghum	491.9	388.7	360.3	324.7	35.51	1.00	0.203	0.257	0.308
Potato	467.5	371.2	484.7	347.1	137.6	5.00	107	1.347	1.441
Beans	419.4	331.9	3465	274.2	7226	0.40	0.095	0.121	0.147
G/Nut	541.89	426.8	470.6	365.5	105.1	0.40	0.074	0.094	0.109

1999

Crop	RR (mm)	RRe (mm)	CWR (mm)	ETa (mm)	ETd (mm)	T (t/ha)	PWrr (kq/rr)	Pwrre (kq/m)	Pwwta (kq/m)
Maize	370.3	304	388.2	2765	111.7	0.90	0.243	0.295	0.326
Sorghum	365.9	300.3	369.3	271.5	97.8	1.36	0373	0.454	0.502
Potato	378.8	311.3	476.1	311.4	164.8	5.94	1.568	1.908	1.908
Beans	33.32	262.3	333.7	243.9	89.8	0.5	0.214	0.286	0.308
G/Nut	370.8	340.5	485.1	284.7	200.3	0.52	0.139	0.515	0181

2000

Crop	RR (mm)	RRe (mm)	CWR (mm)	ETa (mm)	ETd (mm)	T (t/ha)	PWrr (kq/rr)	Pwrre (kq/m)	Pwwta (kq/m)
Maize	587.9	410.2	378.9	261.8	117.2	2.60	0.442	0.634	0.993
Sorghum	599.4	420.5	359.2	263.4	95.8	1.26	0.3	0.3	0.478
Potato	543.6	3937	484.8	307.2	177.6	10.00	1.84	2.54	3.255
Beans	523.3	362.43	344.3	265.8	78.5	1.00	0.191	0.276	0.376
G/Nut	636.9	451.8	471.8	3084.4	163.4	1.20	0.188	0.266	0.387

2001

Crop	RR (mm)	RRe (mm)	CWR (mm)	ETa (mm)	ETd (mm)	Y (t/ha)	PWrr (kq/rr)	Pwrre (kq/m)	Pwwta (kq/m)
Maize	487.5	353.3	0.164	248.3	141.1	2.40	0.492	0.679	0.967
Sorghum	487.5	353.3	0.80	2343	134.9	1.85	0.38	0.525	0.792
Potato	521.6	3837	244.4	372.9	1444	1599	3.66	4.168	4.293
Beans	510.5	3732	252.4	410.3	20.5	0.99	0.196	0.268	0.2441
G/Nut	4875	3533	46581	252.4	234.4	0.80	0.164	0.226	0.3171

2002

Crop	RR (mm)	RRe (mm)	CWR (mm)	ETa (mm)	ETd (mm)	Y (t/ha)	PWrr (kq/rr)	Pwrre (kq/m)	Pwwta (kq/m)
Maize	1262	446.9	378.9	310.7	68.2	2.30	0.188	0.515	0.74
Sorghum	12704	463.5	360.3	311.2	49.6	080	0.063	0.173	2.257
Potato	1264	477.6	461	362.9	98.5	9.00	0.175	1.885	2.48
Beans	935.7	350.5	310.4	237.5	727	0.80	0.085	0.228	0.357
G/Nut	1271.6	464.7	473.5	371.7	101.7	0.70	0055	0.151	0.188

2003

Crop	RR (mm)	RRe (mm)	CWR (mm)	ETa (mm)	ETd (mm)	Y (t/ha)	PWrr (kq/rr)	Pwrre (kq/m)	Pwwta (kq/m)
Maize	360	276.1	3894	186.8	202.6	0.59	0.333	0.435	0.642
Sorghum	342.7	262.5	372.5	165.9	206.5	1.47	0.472	0.616	0.975
Potato	392.2	3174	5174	3174	199.9	1.81	1.531	1.89	1.89
Beans	375.1	301.3	340.8	278.9	16.8	0.80	0.213	0.266	0.287
G/Nut	3427	2625	49.12	175.9	315.3	0.70	0.267	0.267	0398

2004

Crop	RR (mm)	RRe (mm)	CWR (mm)	ETa (mm)	ETd (mm)	Y (t/ha)	PWrr (kq/rr)	Pwrre (kq/m)	Pwwta (kq/m)
Maize	530.7	389.9	387.6	264.3	123.3	279	0.295	0.401	0.591
Sorghum	519.8	3874	369.2	244.7	124.6	1.34	0.257	0.349	0456
Potato	570.9	421.1	4614	3754	86	5.50	0.967	1.306	1465
Beans	502.36	3674		262.9	52.3	0.84	0.167	0228	0.319
G/Nut	532.3	391.2	484.2	269.5	24.7	2.00	0.175	0.234	0.339

2005

Crop	RR (mm)	RRe (mm)	CWR (mm)	Eta (mm)	ETd (mm)	Y (t/ha)	PWrr (kq/m)	Pwrre (kg/m)	Pweta (kq/m)
Maize	347.6	283.2	383.6	195.5	188.03	-0.67	0.193	0.237	0.343
Sorghum	354.5	289.3	363.6	197.2	1664	0.91	0.257	0.315	0.463
Potato	382.5	12.4	489.4	277.9	2114	7.10	1.856	2.2743	2.551
Beans	339.5	293.1	340.8	224.3	1164	1.11	0.328	0.407	0496
G/Nut	395.2	2934	478.6	211.4	2672	0.70	0.195	0239	0.331

2006

Crop	RR (mm)	RRe (mm)	CWR (mm)	Eta (mm)	ETd (mm)	Y (t/ha)	PWrr (kq/m)	Pwrre (kg/m)	Pweta (kq/m)
Maize	578.4	427.3	378.9	339.9	394	2.00	0.346	0468	0.588
Sorghum	5714	425.5	360.3	3207	39.6	0.80	0.14	0158	0.246
Potato	607.3	4479	461.8	415	46.72	12.00	1.976	2.65	2.891
Beans	520.3	379.7	310.4	304.3	6.1	0.80	0.154	0.211	8.263
G/Nut	587.3	4414	4736	354.2	119.4	0.91	0.155	0.207	025

2007

Crop	RR (mm)	RRe (mm)	CWR (mm)	Eta (mm)	ETd (mm)	Y (t/ha)	PWrr (kq/m)	Pwrre (kg/m)	Pweta (kq/m)
Maize	631.8	441.8	378.9	316.8	622	1.80	0.285	0.407	0.568
Sorghum	685.5	474.4	360.3	320.3	319.5	0.80	0.117	0.169	0.25
Potato	645.7	455.7	461	390.6	70.1	7.00	1.084	1.541	1.792
Beans	552.7	237.5	310.4	286.1	24.3	0.80	0.145	0213	0.28
G/Nut	771.3	526.7	473.6	396.9	76.1	0.90	0.177	0.171	0.227

2008

Crop	RR (mm)	RRe (mm)	CWR (mm)	Eta (mm)	ETd (mm)	Y (t/ha)	PWrr (kq/m)	Pwrre (kg/m)	Pweta (kq/m)
Maize	756.6	578.8	380.1	3745	5.61	3.00	0.397	0.518	0.501
Sorghum	7575	522.9	361.8	357.3	4.46	0.90	0.119	0.173	0253
Potato	6623	468.1	517.4	442.9	745	670	1012	1.431	1.513
Beans	5753	405.8	344.3	315.2	29.1	0.96	0.167	0.236	0.304
G/Nut	813.4	567.2	4736	430.1	43.58	0.50	0.061	0088	0116

2009

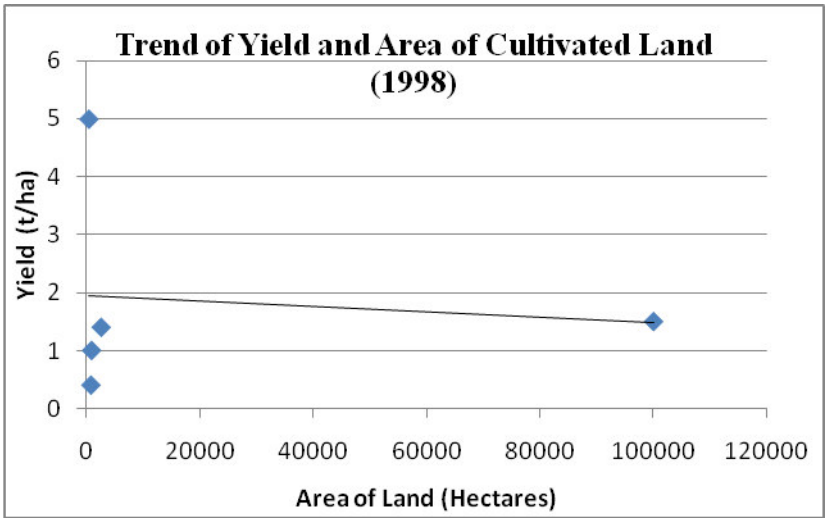
Crop	RR (mm)	RRe (mm)	CWR (mm)	Eta (mm)	ETd (mm)	Y (t/ha)	PWrr (kq/m)	Pwrre (kg/m)	Pweta (kq/m)
Maize	624.3	483.4	492.4	468.2	68.2	1.97	0.128	0.414	0.612
Sorghum	682.4	732.8	624.5	324.1	52.3	0.94	1.211	1124	1.321
Potato	468.2	621.3	461.2	228.4	60.1	577	0.412	0.148	0168
Beans	324.4	632.1	2148	274.2	49.4	1.11	0.214	0.122	0.128
G/Nut	438.1	522.	612.4	312.4	39.6	0.98	0.221	0148	0.149

RR: Total rainfall (from planting to harvesting) (mm)

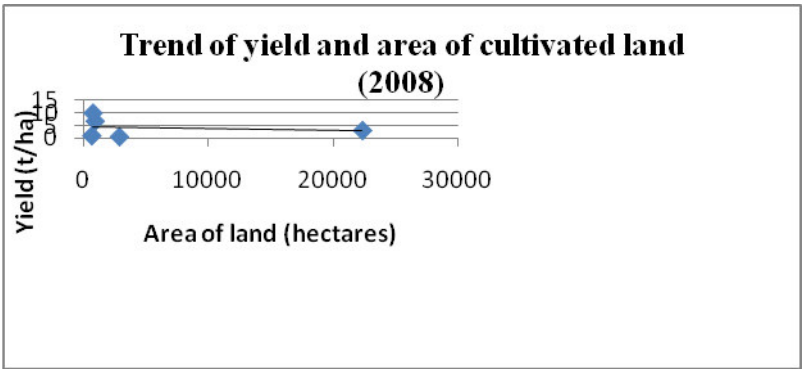
RRe:	Total effective rainfall (mm)
CWR:	Cropped water requirement (mm)
Eta:	Crop water use (mm) Actual crop evapotranspiration
ETd:	Evapotranspiration rate (mm)
Y(t/ha):	Productivity of water (rainfall) (kg/m)
PWrre:	Productivity or water (effective rainfall)
PWeta:	Productivity of water (Evapotranspiration)

Summary

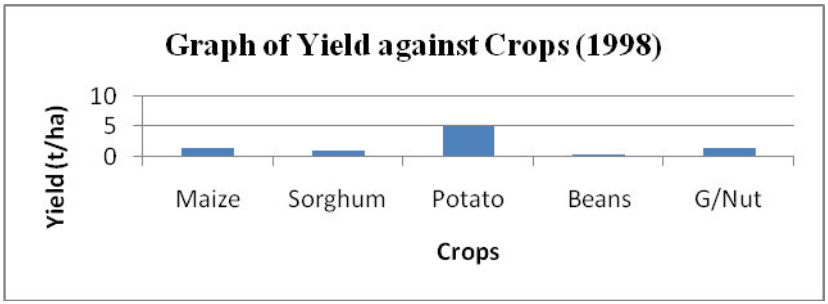
The trend of productivity of water under rainfall agriculture is influenced by evapotranspiration rate which is a factor determined by mid-cropping season, dry spell and early cessation of rain. Poor rainfall utilization efficiency and early planting also dictate the trend or productivity of water. High productivity of water (PW) may not necessarily be an improvement in efficiency of water utilization or an indicator or an increased benefit. In crop production and low PW may not necessarily be due to poor yield by low rainfall utilization efficiency.



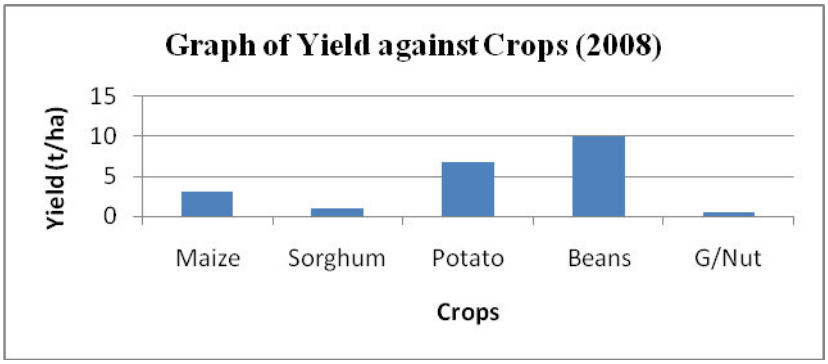
Annex 1(i)



Annex 1(ii)



Annex 2(i)



Annex 2(ii)

References

Barron, J. (2004). *Dry spell mitigation to upgrade semi arid rain fed agriculture: wear harvesting and s, it nutrient: management for small holder maize cultivation in Macacos, Kenya*. Doctoral thesis, Natural Resource Management. Department of System.

Kwara State Diary (2007). *The Government and People of Kwara State of Nigeria*. Ilesanmi Printing Press.

McCalla, A.F. (1994). Agriculture and food needs to 2025: why we should be concerned. Consultative Group on International Agricultural Research (CGIARR). Washington D.C

Rockstrom, J. (2003). Green water security for food makers of tomorrow: window opportunity in drought prone Savanna. Water science and Technology. 43 (4) 71- 78

Rosegrant, M.W, Cai, X, Cline, S. and Nakagawa, N. (2000). The role of rain fed agriculture in the future of global food production: PTD paper No 90, Environment and Production TechnologyDivision, International food Policy Research Institute Washington D.C. USA.

Young, A. (1993). Is there really spare land? A critique estimates available cultivate land in developing countries. Environment, development and sustainability. (pp13- 18).