INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Irrigation, Conservation Agriculture and Crop Yield Response in a Selected District in Zimbabwe

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Abstract:
Zimbabwe's low-potential zones can be identified with a soaring prevalence of scarcity, shortage, deficiency and lack; depressed rural proceeds, earnings and revenues; low farm yields; and food unavailability. These factors combine to collectively contribute to cause complications, frustrations, hitches and snags to efforts to earn a decent living, income, occupation and employment in the rural areas. Not much is recognized about the effects of farm skills, knowledge, expertise, machinery, tools and equipment on crop output, efficiency, yield and production, and food availability in the semi-arid, low-rainfall and parched segments of land situated in between the higher rainfall districts of Zimbabwe. This research investigated the interaction between selected farm technologies (water harvesting, conservation agriculture, fertilizer/ manure application, and irrigation) and farm yield, production and food availability among households in Ward 11 of Makonde District in Zimbabwe. The data collection method used entailed questionnaire interviews of 60 households chosen through stratified random sampling. Data analysis was conducted in SPSS. Hypothesis testing was conducted by means of the independent samples t-test and one-way between groups analysis of variance. Utilization of conservation agriculture led to significantly greater maize yields. The t-test to determine the effect of utilizing irrigation technology on yields showed that there was a significant difference between mean yields of those practicing irrigation and conservation agriculture, and mean yields of non-adopters. It is thus recommended that development factors like capital, income, wealth and assets for agricultural growth and expansion in low-rainfall districts such as Makonde need to be directed and concentrated towards farm technologies like irrigation and conservation agriculture.

Keywords: *technology, utilization, crop, yields, food availability, Zimbabwe*

1. Introduction

Zimbabwe's low-potential zones can be identified with a soaring prevalence of scarcity, shortage, deficiency and lack; depressed rural proceeds, earnings and revenues; low farm yields; and food unavailability (Nyagumbo et al., 2009). These factors combine to collectively contribute to cause complications, frustrations, hitches and snags to efforts to earn a decent living, income, occupation and employment in the rural areas. Studies conducted in higher-rainfall zones of Zimbabwe have found that appropriate use of agricultural technologies tend to enhance and develop rural incomes, employment and revenues. Unfortunately, not enough has been recognized about the effects of farm skills, knowledge, expertise, machinery, tools and equipment on crop output, efficiency, yield and production, and food availability in the semi-arid, low-rainfall and parched segments of land situated in between the higher rainfall districts of Zimbabwe. Differences in the quality of the agro-ecological and climatic resource base between wetter and drier areas within the northern and north-western districts are thought to result in variations in yield response of crops between semi-arid and high-potential zones. Yield response in the latter zones has already been investigated by numerous studies; however, there is a paucity of related studies in the semi-arid zones that occur in irregular pockets within the high potential zones.

In the southern and central parts of the country, low-potential, low-rainfall zones occur, not as little sporadic semi-arid pockets of terrain slotted in and inserted amidst high potential, high rainfall regions, but as extensive expanses of continuously dry areas. In these zones, quite a number of scientific investigations on farming skills and productivity-enhancing techniques, and the effects of agricultural technology utilization on crop yields and food availability, have been implemented in the Masvingo, Midlands, Matabeleland North and South Provinces (Mazvimavi and Twomlow, 2008; Snapp et al., 1997; Nyagumbo et al., 2009). Similar research in the semi-arid areas of northern and western Zimbabwe has been piece-meal and scanty. The aim of this research was therefore to separate and examine the effects of farming technologies on crop yields and food availability among communal area households in a semi-arid ward (Natural Region IV) of Makonde District in northern–western Zimbabwe. Farmland in the study district comprises of three distinct categories: Model A1 in which average farm size is approximately six hectares; Model A2 of larger than six hectares per farm; and communal areas, with the smallest farm sizes. Communal areas have been historically neglected in terms of the development of roads, communications and transport networks.

2. Research Methodology

2.1. Sampling
Study households were chosen by means of the stratified random sampling method. Initially, the same technique was employed in choosing the study district, and also the ward. One district, one ward, and 60 households within the ward were ultimately chosen.

2.2. Data Collection
Information gathering was carried out in August and September 2015. Questionnaire interviews were implemented among leaders of each of the 60 households.

2.3. Data Analysis
SPSS was employed for data capture, scrutiny, examination and investigation. Hypothesis-testing was conducted by means of the independent samples t-test and ANOVA.

3. Results and Discussion

3.1. Cropping Patterns and Food Grain Consumption
The researcher expected to confirm from the study results that the households in the low-rainfall survey ward in Makonde district would plant crops with different physiological characteristics such as varying crop water requirements, and the length of the growing season or the time needed to reach physiological maturity. Such behaviour is common among small farmers in Africa and the developing world to hedge themselves against the possibility of hunger or famine in the event that the unpredictable effects of the weather may cause yields of some of their crops to fail to reach satisfactory levels. The researcher also expected that drought-tolerant crops like millet and sorghum would be the principal crops in the study area in terms of area planted and levels of production.

Breakdown, scrutiny and examination of study data indeed confirmed the researcher’s pre-survey expectation that farmers in the area (Ward 11) grew crops of a varied nature, as indicated in Table 1. Sorghum was the dominant crop, and it was grown by 58 percent of farmers in the 2014/15 planting season, followed by millet, which was grown by 50 percent of farmers.

Crop	Sample farmers growing crop (count)	Percent of farmers growing crop (n = 60)
Maize	29	48
Sorghum	35	58
Millet	30	50
Groundnuts	16	27
Bambara nuts	8	13
Sunflower	10	17
Cow peas	25	42
Cotton	22	37

Table 1: Crops planted in the 2014/ 15 season in Ward 11 of Makonde District
Source: Survey data, 2015

Nevertheless, figures of total crop output for the entire sample and average output per farmer indicate the dominance of maize in the cropping pattern, with values 27.125 tonnes and 0.936 tonnes respectively (Table 2). This demonstrates the superiority of maize in terms of farmer preferences for home consumption, over other factors determining resource allocation, such as farmers’ risk aversion. Higher production levels could also be explained by the greater performance of maize in terms of yields, following an above normal rainfall season.

Crop	Number of farmers growing crop	Total crop output (Tonnes)	Average output per farmer (Tonnes)	Total number of people on farms per crop	Grain consumption (Kilograms per person in 2015)
Maize	29	27.125	0.936	145	187.070
Sorghum	35	0.051	0.001	175	0.300
Millet	30	0.095	0.030	150	0.640
Groundnuts	16	0.452	0.030	64	7.060
Bambara nuts	8	0.029	0.004	48	0.010
Sunflower	10	0.008	0.0008	50	0.160
Cow peas	25	3.139	0.125	100	31.390
Cotton	22	5.210	0.227	88	n/a

Table 2: Crop output and grain consumption (2014/15 planting season)
Source: Survey data, 2015

The overriding importance of maize as the preferred staple among rural dwellers in Southern Africa has been revealed by a number of studies. Besides its value for consumption purposes, maize can also be sold on the market to earn farming households a cash income. Less important crops such as millet, groundnuts, bambara nuts and cowpeas are grown for household nutrition, cash generation and feed for chickens and goats in times of drought (FAO, 1997). They are also crucial as a medium of exchange for seasonal agricultural inputs and small animal stock which furnish rural households with animal protein (Truscott, 1986).

The grain consumption figures of study households were also determined and they are indicated in the last column of Table 2. Judging by any recommended yardsticks, be they national, regional or international, these figures, even for the maize staple grain, spell out a situation of extreme hunger and food insecurity. Several basic suppositions or postulations have been made in calculating grain consumption figures. First, it was assumed that households use grain specifically and exclusively for direct or indirect human food needs. Secondly, it was assumed that food consumption items were derived primarily from own production. Thirdly, it was assumed that the quantities of grain bought (if any) were equal to grain quantities disposed of by the households on the market.

Semi-arid areas such as Ward 11 qualify in the category of “disaster areas” with regard to farm output levels and food availability and access. Consequently, humanitarian institutions are engaged in food aid distribution in Ward 11.

Therefore, it is critical, vital and imperative to enhance production using recommended farming techniques for all crops grown in the area, such as the four discussed below. This option is more sustainable and efficient than the temporary, provisional and transitory option of food aid distribution.

3.2. Agricultural Technologies

The researcher expected to confirm from the research findings that the utilization of agricultural technologies would enhance crop yields. The implications of technology utilization on agricultural performance were explored and examined with regard to the use of for water harvesting, conservation agriculture, soil fertility amendment, and irrigation.

3.2.1. Conservation Agriculture

Conservation agriculture is by and large characterized as any cultivation progression that lessens or decreases the deficit or deficiency of soil fertility and soil moisture, and diminishes soil erosion. In the semi-arid areas of Zimbabwe and the neighbouring countries, the fundamental and essential constituent elements of conservation agriculture being encouraged and supported by Non-Governmental Organizations amongst communal farmers are the removal of grass, herbs, wild plants and weeds from the fields during winter, hollowing out and breaking up earth to create little soil sinks or bowls for sowing seeds and plant establishment, spreading of crop remains over the soil surface, placing and positioning animal dung, compost and artificial inorganic or organic soil fertility amendments in the excavated little bowls in the ground, opportune and appropriate removal of weeds, and regularly changing the type of crops planted on a particular field from season to season (Twomlow et al., 2008). The intension of encouraging and supporting conservation agriculture in the semi-arid areas of the southern African region is to sustain crop production by preserving, protecting and safeguarding frail, weak, infertile and erodible soils, and lengthening episodes in which soil moisture, dampness and humidity are accessible and reachable by the planted crops (Gollifer, 1993; Twomlow and Hagmann, 1998).

An independent samples t-test was performed to contrast maize crop yields obtained by smallholders carrying out conservation agriculture with farmers not applying it. The statistical output pointed towards a significant difference between the two groups of farmers, and in favour of farmers implementing conservation agriculture. Test results for adopters of CA exhibited a mean maize yield of 3.29 tonnes per hectare, with a standard deviation from the mean of 1.04 tonnes. Mean maize yield for non-adopters of CA was much lower, at 0.89 tonnes per hectare and a standard deviation of 0.1 tonnes. The results were significant at the two-tailed level of 0.001, and can therefore be accepted with a very high degree of confidence. The results are shown in Table 3.

Statistic	**Adopters of CA**	**Non-Adopters of CA**
Mean yield (t/ha)	3.29	0.89
t-value	3.78	
Standard deviation	1.04	0.1
Significance level (2-tailed)	0.001	

Table 3: Maize yields for adopters and non-adopters of conservation agriculture (N=60)
Source: Survey data, 2015

3.2.2. Irrigation

The major objective of encouraging and supporting the adoption of irrigation technology is to raise and enhance crop productivity. An independent samples t-test was performed to contrast maize crop yields obtained by smallholders carrying out irrigation with farmers not applying water to their crops. The statistical output pointed towards a significant difference between the two groups of farmers, and in favour of farmers implementing irrigation. Test results for adopters of irrigation exhibited a mean maize yield of 3.10 tonnes per hectare, with a standard deviation from the mean of 0.9 tonnes. Mean maize yield for non-adopters of irrigation technology was much lower, at 0.70 tonnes per hectare and a standard deviation of 0.2 tonnes. The results were significant at the two-tailed level of 0.002, and can therefore be accepted with a very high degree of confidence. The results are shown in Table 4.

Statistic	Adopters of CA	Non-Adopters of CA
Mean yield (t/ha)	3.10	0.70
t-value	3.35	
Standard deviation	0.9	0.2
Significance level (2-tailed)	0.002	

Table 4: Maize yields for adopters and non-adopters of irrigated agriculture (N=60)
Source: Survey data, 2015

These results compare favourably with those of other studies conducted in Zimbabwe under similar conditions. For instance, a close scrutiny and examination of the productivity of the maize crop in ten communal irrigation schemes showed a tendency towards significantly greater yields in the schemes than under rain-fed agriculture in the adjoining areas (Jimat, 2008).

3.2.3. Water Harvesting

Less than 5 percent of sample households had adopted water harvesting technology during 2014 and 2015. Maize yields of households using water harvesting technology were not significantly higher than non-adopters at the 0.05 level of significance. There are three apparent reasons for this outcome. The first reason could relate to the texture of the soils in Ward 11 not being conducive to the efficient and successful application of the technology (Nyagumbo et al., 2009). The second relates to the extreme steepness of the slopes, another unconducive condition for water harvesting (Anderson et al., 1993). The third reason is that rainfall in Ward 11 is lower than the threshold for successful water harvesting.

3.2.4. Soil Fertility Amendment

Although adopters of soil fertility amendment technology obtained greater maize yields than non-adopters, the results were not significant at the 0.05 level, probably due to rainfall amounts not being adequate to make the plant benefit from the increased fertility of the soil, or the application of fertilizers, dung and manure at levels well below the recommended rates. Application rates below recommended rates in semi-arid areas are due to economic bottlenecks that inhibit smallholder farmers from procuring adequate amounts of soil fertility amendment compounds and materials (Snapp et al., 1997). Shortage, lack, insufficiency and restricted access to these compounds and materials could be other reasons (Chibidu, 1995; Hagmann and Murwira, 1996; Ahmed et al., 1995; Bisanda and Mwangi, 1996).

4. Conclusion

Research findings from the study have shown greater agricultural productivity through the use of conservation agriculture and irrigation technologies among communal farmers in semi-arid Ward 11 of Makonde District in Zimbabwe. Nevertheless, a very small percentage of farmers use these technologies, leading to the prevailing hunger, low food consumption, and food insecurity. Irrigation development and conservation agriculture are among the recommended measures to increase yields in the fight against hunger and food insecurity.

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