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EVALUATING FACTORS INFLUENCING THE VARIATION OF IRRIGATED WHEAT YIELDS A CASE STUDY OF CHINYAMATUMWA IRRIGATION SCHEME IN ZIMBABWE

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ABSTRACT

Irrigated agriculture is one of the major economic activities for generating employment, income and foreign currency earnings. It contributes towards the achievement of food security in semi-arid areas where mid season droughts are experienced and offers a chance to modernise peasant agriculture. However, it is constrained by biophysical and socio-economic factors. This study analyses the influence of plot size, distance from the main canal, seed sowing rate, fertilizer input supply and farmer experience on irrigated wheat crop yields in Chinyamatumwa smallholder irrigation scheme in Bikita District of Zimbabwe. The irrigation scheme gets its water from a dam via a night storage dam. Data were collected from 48 randomly selected farmers representing a sample size of 43%. Data were entered and analysed in a spreadsheet, Statistical Package for Social Scientists (SPSS) Version 13.0. Research findings indicate significant ($P<0.05$) differences among mean wheat yields as a result of the variations in plot sizes and amount of fertilizer supplied. Based on research findings of the study, it implies that stakeholders should increase sizes of irrigated plots by expanding the scheme in order to obtain high yields. In addition, farmers should increase the amount of fertilizer supplied to improve the levels of soil fertility.

Key words: irrigation, significance, variables, wheat, Chinyamatumwa

INTRODUCTION

Most governments in arid and semi-arid regions are supporting the development of irrigated agriculture either at small or large scale levels. This is aimed at mitigating the adverse impacts of climate and variability on the social, economic, political and environmental well being of their populations. Irrigation development serves to achieve double or treble cropping per year, utilise land and water resources more efficient than rainfed farming (Makadho, 1994, Pazvakavambwa and van der Zaag, 2002). Despite the considerable potential of irrigation, several smallholder irrigation projects in developing countries have been labelled 'socio-economic failures' (Makadho, 1994; Chancellor and Hide, 1997). Poor performance of most smallholder irrigation systems (assessed in terms of water delivery, agricultural production and socio-economic indicators) is largely affected socio-economic and biophysical factors (Fig. 1).

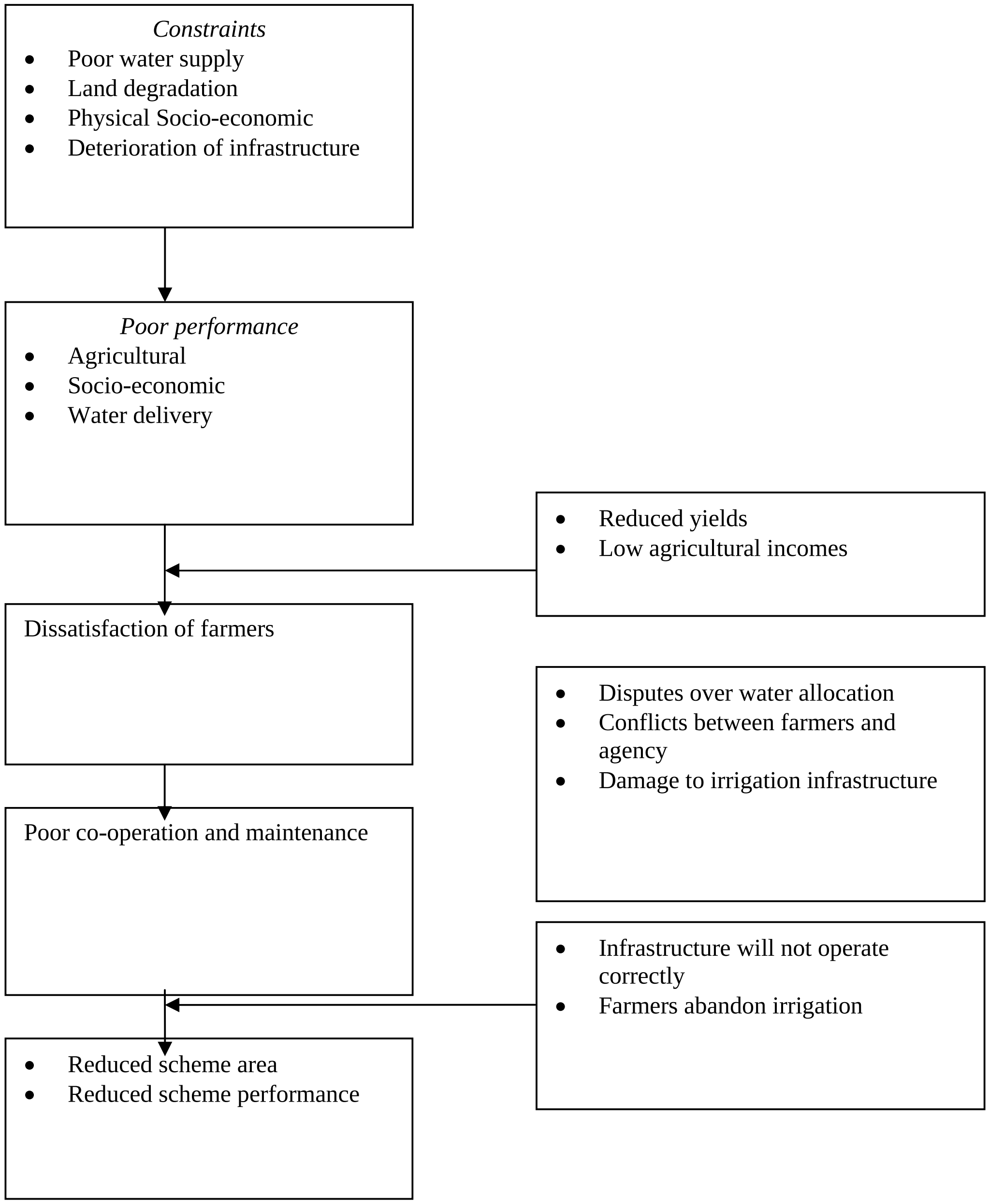

Fig. 1. Causes and effects poor irrigation performance in a smallholder irrigation scheme

Source: Chancellor and Hide (1997, p. 8).

The under-performance of smallholder irrigation schemes in most developing countries is largely a result of complex interrelated factors. These include; inadequate inputs, inaccessible markets (Adams, 1990; Meinzen et al., 1994; Makadho, 1994; Rukuni et al., 1994), government policies on land tenure which do not create a condusive environment for successful operation of irrigation schemes (Tafesse, 2003), sub-standard infrastructure (Croxall and Smith, 1984; Motsi et al., 2001; Manzungu, 1999a).

Poor water management, unclear irrigation scheduling and inefficient water use at the scheme and plot levels are cause of concern for the success of smallholder irrigation schemes in Africa (Motsi et al., 2001). Studies found that inequitable water allocation often result in farmers close to water sources achieving crop yields twice as compared to those located at tail ends of distribution channels (Manzungu, 1999b; Pazvakavambwa and van der Zaag, 2002: Samakande, 2002). In addition, due to poor water management, water delivery to tail end farmers was unpredictable, and thus adversely affecting their crop yields. At the plot level, some farmers have been observed to apply 50%-150% more water than needed by the crops although excess water depressed crop yields due to water logging, erosion of land and soil salinisation (Seckler, 1999; Motsi et al., 2001; Tafesse, 2003). Environmental factors such as water scarcity, poor soil fertility, poor water quality, land degradation, temperature, pests and diseases also adversely affecting crop production. Thus, environmental factors such as; water scarcity, poor water quality, land degradation, planted area, temperature, soil fertility, pests and diseases have adversely affected crop production in some smallholder schemes in Zimbabwe (Manzungu and van der Zaag, 1996; Mate 1996).

Nevertheless, there is still lack of research on the performance of smallholder irrigated agriculture in Africa, whether on technical, socio-economic and water delivery performance. It is against this background that a study was conducted to investigate factors influencing wheat yields in Chinyamatumwa smallholder irrigation scheme in Zimbabwe. It was hypothesised that there wheat yields were significant related to sizes of irrigated plots, distances from main irrigation canal, sowing rates, farmer experience and fertilizer input supply. The wheat crop was selected because it is grown by almost all farmers in the scheme during the winter season for animal food, commercial purposes and a major ingredient in most bread. In addition, the crop is grown and harvested almost at during same period.

Location of the study site

Chinyamatumwa smallholder irrigation scheme is situated in Bikita District in Masvingo Province, Zimbabwe (Fig. 2). The scheme was developed in 1992 to ensure food security in this drought prone area comprising sandy clay soils and receiving less than 500 mm of rainfall per annum. It measures 37 ha in size and agricultural production started in 1994.

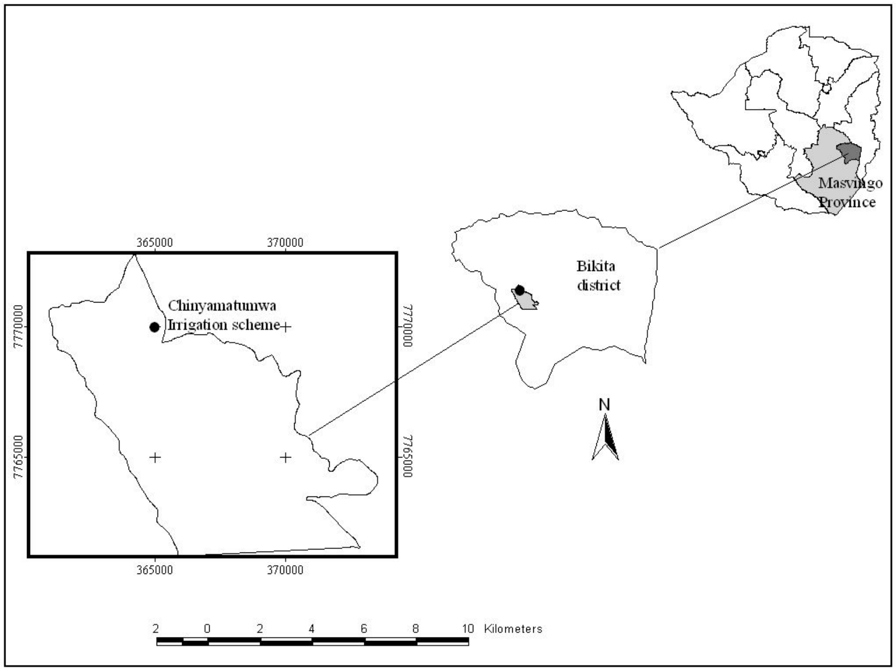

Fig. 2. Map of Zimbabwe showing the extract map of Bikita District and the location of Chinyamatumwa irrigation scheme.

The scheme's cropping calendar allows three crops to be planted in each plot annually. The general pattern is maize during summer (October-March), beans (April-May) and wheat in winter (May–September). Actual planting dates adhered to by farmers vary from season to season due to the availability of water. Like all other government owned smallholder irrigation schemes in Zimbabwe, Chinyamatumwa was designed so that adequate water is available 90% of the times (AGRITEX, 1980). Irrigation water supply is pumped from a dam across a river into the night storage reservoir. From the night storage reservoir water is released into the scheme lined canals on a daily basis. Farmers use siphons to draw water from the canals and irrigation is scheduled in fixed rotation. However, schedules are subject to disruption in the event of moisture stress.

At the time of study, there were 112 plot holders whose plot sizes varied from 0.1 ha to 0.5 ha. The land belongs to the Ministry of Agriculture and Mechanisation hence farmers do not hold title deeds but have user rights to use the land. Their right to use the plots is not guaranteed as the relevant authorities can revoke the irrigators' rights to use the plots. The irrigation management committee in partnership with government extension personnel are responsible for tenant discipline, input purchases, marketing, organising of labour for scheme maintenance and participation in decisions relating to the running of the scheme. A water bailiff controls water allocation. In addition to artificial fertilisers, some farmers use animal manure to improve soil fertility.

MATERIALS AND METHODS

A relev´e sheet was designed and used to gather data pertaining agricultural productivity and confounding factors within the scheme for the 2008 wheat cropping season. The type of data that the relev´e sheet was intending to capture comprised farming experience (number of years the farmer had been practising irrigated wheat farming), wheat yields (t/ha), size of plots (ha), fertilizer supply (kg/ha) and seed sowing rates (kg/ha). Farmers were randomly selected and interviewed in the scheme as they were engaged on preparing their plots for maize cultivation in October 2008. It was assumed that recall data by farmers on wheat yields and factors of production was reliable. Field measurements were done to estimate distances of irrigation plots from the main canal using a measuring tape. The main canal is the one which gets its water directly from the night storage reservoir and feeds into field canals. All the data collected were coded and entered into SPSS 13.0 software for statistical analysis. The one-way analysis of variance (ANOVA) test was applied to determine whether significant ($P<0.05$) differences exist between wheat yields and other confounding factors *viz* distances from main canal, amounts of fertilizer supplied, seed sowing rate, farming experience and crop acreages existed. Once significant differences among the means have determined, the post hoc range test (Benferroni) and pair wise multiple comparisons were applied to determine which specific pairs of means significantly differ.

RESULTS AND DISCUSSION

Profile of the respondents

Data were collected from a randomly selected sample comprising 48 farmers in representing a sampling fraction of 43%. The ages of the respondents varied from 18 years to 68 years, with the average age being 47 years.

Effect of plot size on wheat yields

Fig. 3 shows variations in wheat yields as a result of different plot sizes cultivated. Thus, as the plot size increases there is a corresponding increase in wheat yields. Significant differences in mean wheat yields exist between plots of sizes 0.1 ha and 0.4 ha ($P=0.004$) and 0.2 ha and 0.4 ha ($P=0.021$). The average wheat yield was 3.9 t/ha.

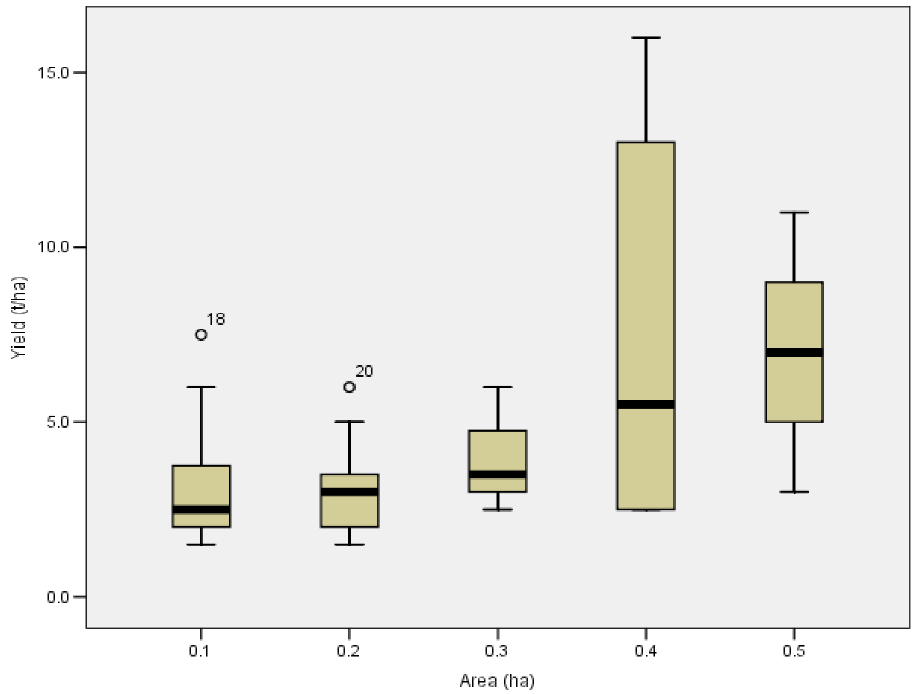

Fig. 3. Differences among wheat yields obtained from different cultivated acreages.

Effect of distance from the main canal on wheat yields

The average distance of the plots from the main canal was 144 m. Fig. 4 shows decreasing yields with increasing distance from the main canal. However, the variations are not significant (P=0.783).

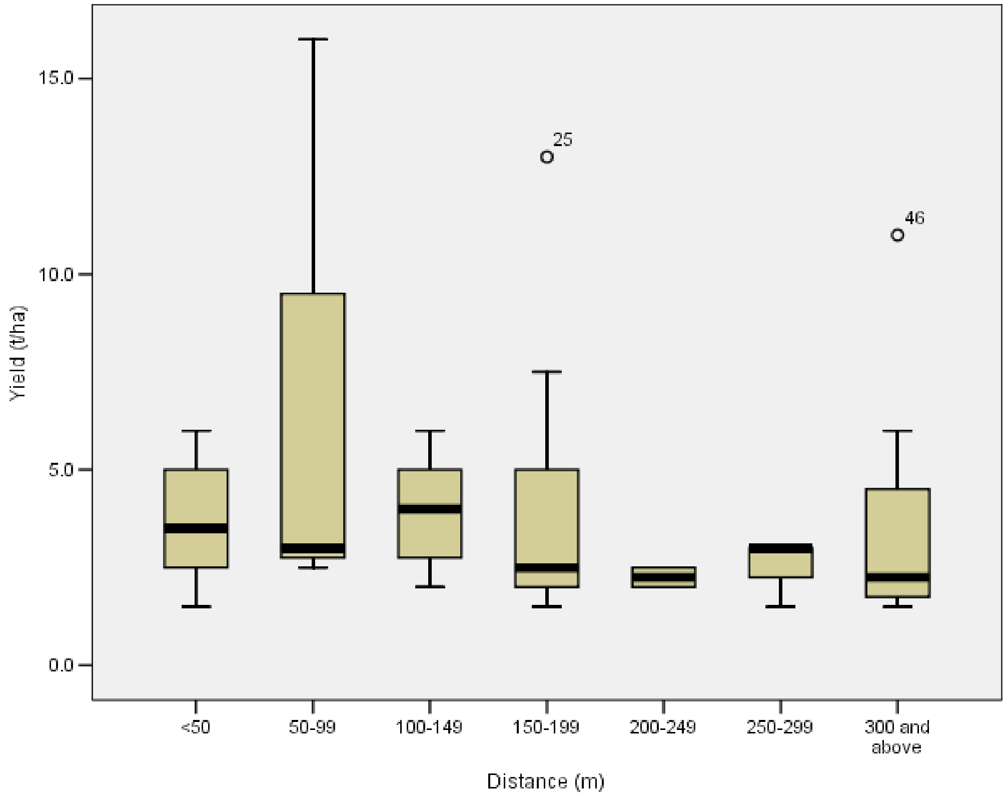

Fig. 4. Wheat yields harvested from plots located at different distances from main canal.

Effect of sowing rate on wheat yield

The average amount of seed supplied to the field was 240 kg/ha. Fig. 5 shows the variations in wheat yields as a result of different quantities of seed sowed. The ANOVA test show no significant (P=0.631) variations in mean wheat yield as a result of different sowing rates.

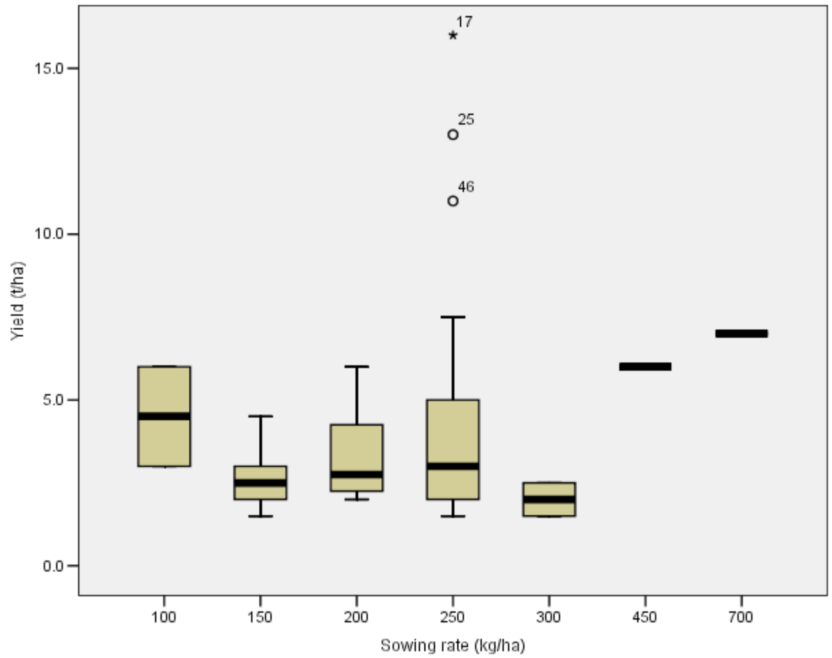

Fig. 5.Variations of wheat yields as a result of different amounts of seed sowed.

Effect of farmer's experience on wheat yields

Experience was defined as the number of irrigation seasons one has accumulated practicing winter wheat irrigated agriculture. The average number of years famers had been practicing irrigated wheat cultivation was 9.6 years. Fig. 6 shows variations in wheat yields with respect to farmer experience.

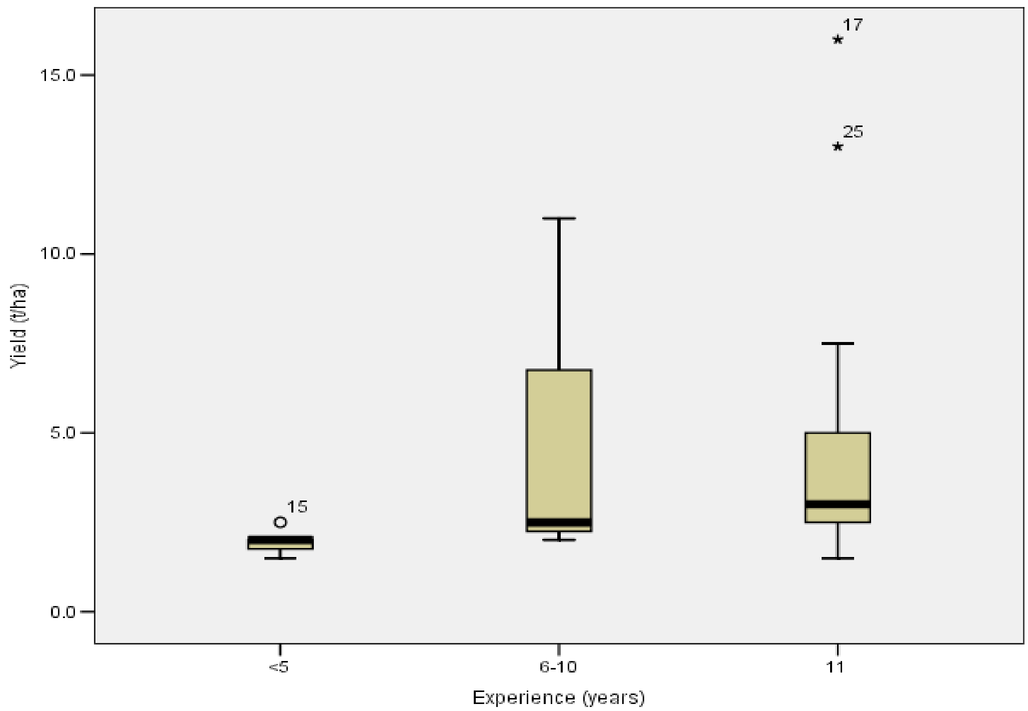

Fig. 6. Variations of wheat yields as a result farming experience

As the years of irrigation farming increase yields also tends to increase. Thus, irrigators become used to winter wheat growing. However, no significant differences (P=0.132) exist in mean wheat yields obtained by farmers who had been farming for different years.

Effect of fertilizer quantity on wheat yields

On average, 154 kg of fertilizers were applied by farmers on one hectare of land. Fig. 7 illustrates significant (P=0.010) variations of wheat yields as a result of differences in the amount of fertilizers (compound D and ammonium nitrate) supplied into the fields.

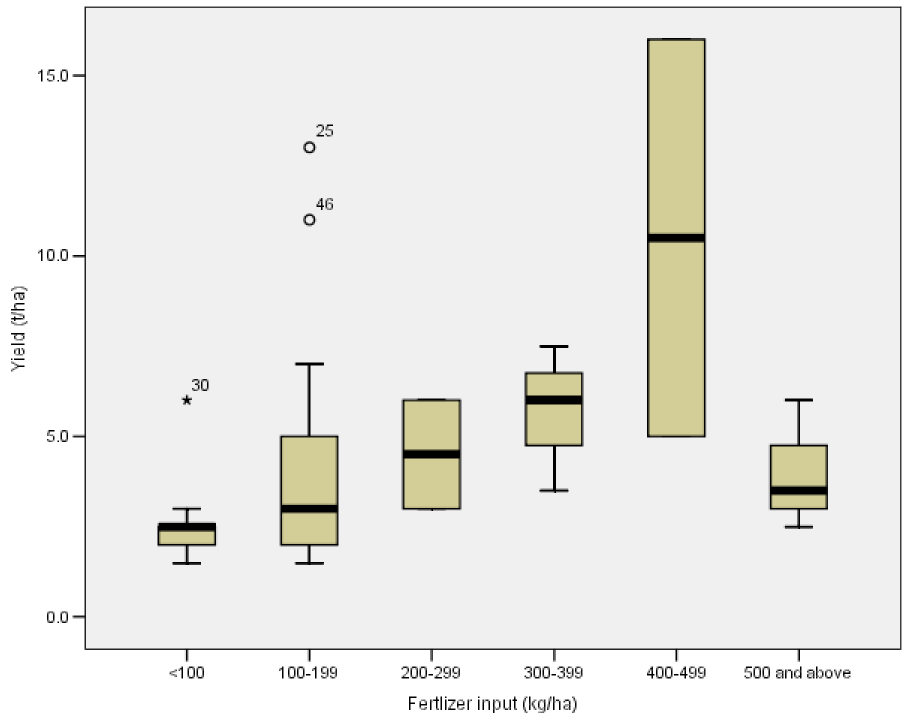

Fig. 7. Variations of wheat yields due the amount of fertilizer supplied.

From Fig.7, it is clear that as amount fertilizer supplied to the fields was increased, there is a corresponding increase in yields but to a certain levels (500 kg/ha) when yields go down. This can be the effect of over application of fertilizers resulting in diminishing returns. Using the post hoc test, it was revealed that significant differences in yields occur in plots which were supplied with less than 100 kg/ha and 400-499 kg/ha of fertilizers (P=0.004), and those supplied with 100-199 kg/ha and 400-499 kg/ha (P=0.020).

OBSERVATIONS

In this study, the question of whether wheat yields are significantly affected by acreage, distance of plots from main water canal, experience of farmers, amount of fertilizers supplied and seed sowing rate was addressed. Chinyamatumwa irrigation scheme in Zimbabwe was used as a case study to understand whether the four variables could be used to explain wheat yield variations. Findings from box plots results show that wheat yield variations were affected by the four variables. Separate studies based on experimental plots have also documented significant negative linear relationships between irrigated crop yields with distance from the main canal (van der Zaag, 1996). The inverse relationship between crop yields and distance of plot from the main canal has been attributed to availability of adequate and reliable water supply to head irrigators at the expense of tail enders. This means that plots close to the main canal produce high yields, while areas further away from the main canals tend to yield less output. Thus, such results are consistent with the irrigated crop yield-distance from canal relationship.

Moreover, as the amount of fertilisers applied increased, wheat yields respond positively. Fertilisers add nutrients for the crop which facilitate plant growth and therefore an increase in primary productivity. Significant differences in yields occur in plots which were supplied with less than 100 kg/ha and 400-499 kg/ha of fertilizers (P=0.004), and those supplied with 100-199 kg/ha and 400-499 kg/ha (P=0.020). This is due to the significant contribution of fertilizers to yields. The results also indicate that the sizes of irrigated acreages affect the amount of yields obtained. As plot sizes increase yields have also increased. However, studies have shown that in times of water shortage, it becomes economic to reduce acreages in order to spread water scarcity equitably over all the plots. This often improves crop yields since a smaller area is put under crops. Irrigation turns will become faster as compared to when all cropland was cultivated (Magadlela, 1996).Results obtained in this study were collected during a single season which may result in findings being season dependent. It is important to note that multiple season data could be tested to determine whether the four variables considered affect wheat yields.

CONCLUSION

The smallholder irrigated agriculture is a panacea for achieving the Millennium Development Goals (MDGs) in most arid and semi-arid regions, is of socio-political significance and a flagship of national development. Benefits derived from irrigation projects include; modernising peasant agriculture, reducing government food relief, providing economic growth and employment opportunities in rural areas, export earnings, more varied diets and better health standards government. However, the success of irrigated agriculture is significantly influenced by environmental factors, timely cropping operations, and availability, quantity and quality inputs. Findings show that variations in wheat yields is as a result of variations of plot sizes, sowing rates, famer experience and fertilizer input supply. Based on research findings of the study, for sustainability the scheme and farmers' livelihoods in Bikita stakeholders should increase sizes of irrigated plots by expanding the scheme in order to obtain high yields. In addition, farmers should improve the amount of fertilizer supplied to improve the levels of soil fertility. Variations in the two factors significantly affect mean wheat yields.

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