4thICAAAE 2013 SEPTEMBER 22-25, Hammamet Tunisia

4th International Conference of the African Association of Agricultural Economists

icaaae.org

aaae-africa.org

Determinants of Relief Seed Use and Crop Productivity among Vulnerable Households in Zimbabwe

By:

Conrad Murendo
Kizito Mazvimavi
And
Machiweyi Kunzekweguta

162- Determinants of Relief Seed Use and Crop Productivity among Vulnerable Households in Zimbabwe

Conrad Murendo[*1], Kizito Mazvimavi[2] and Machiweyi Kunzekweguta[3]

[1]Department of Agricultural Economics and Rural Development, University of Göttingen, 37073 Göttingen, Germany. Tel.: + 49 (0) 551/39 4843; Fax: + 49 (0) 551/39 4823
[*]Corresponding author: cmurendo@hotmail.com
[2]International Crops Research Institute for the Semi-Arid Tropics. Patancheru 502324, Andhra Pradesh, India. Tel.: + 91 40 30713590; Fax: + 91 40 30713074.
[3]International Crops Research Institute for the Semi-Arid Tropics, P.O. Box 776, Bulawayo, Zimbabwe.

Abstract
 The study quantifies factors affecting use of relief maize seed and implications on productivity in Zimbabwe. It uses Tobit and multiple regression models to analyze data collected from relief recipient households in 2010. Regression analysis showed that time of seed receipt, land area, rainfall and hybrid seed had strong influence on relief seed utilization rates. This underscores the need for timely input distribution before the onset of the rainy season. Rainfall, basal fertilizers, use of hybrid seed and conservation agriculture were significant in increasing relief maize yield. These results are consistent with the current thrust on the green revolution for Africa, centered on promoting increased fertiliser use, conservation of soil and water and modern varieties as interventions for increasing agricultural productivity in Africa. Increased policy efforts should be placed on increasing access to hybrid maize seed and fertilizers as well as promoting conservation agriculture.
Keywords: Zimbabwe, Tobit, households, maize, seed, utilization.

INTRODUCTION

Agriculture dominates the economies of most African countries and is the engine for economic growth. It produces most of the food consumed in Sub-Saharan Africa and accounts for 70% of total employment, 40% of total exports and 34% of African GDP (World Bank, 2008). Agriculture is the main source of income in rural areas where more than 65 percent of total population lives (World Bank, 2008). Majority of these countries are characterised by an environment of increasing population pressure, food insecurity, declining levels of agricultural productivity, and rapid natural resource degradation. The major impediments to agricultural productivity include weather-related shocks, poor infrastructure, undeveloped markets, and weak governance and institutions (Asenso-Okyere and Jemaneh, 2012). The Horn of Africa and Sahel region are good examples of regions where droughts coupled with conflicts are negatively impacting household livelihoods (Save the Children & Oxfam, 2012). In Africa, increasing agricultural productivity remains a priority for poverty and food security reduction as recommended by the Millennium Development Goals.

Following these crises governments and non-governmental organizations (NGOs) have implemented agricultural input distributions (mainly seed and fertilizers) to allow farmers who have recently suffered production losses to re-establish their cropping operations and increase agricultural production and food security (Mazvimavi et al., 2012; Remington et al., 2002). These inputs are directly distributed to farmers or through vouchers mechanisms (Dorward et al., 2008; Dorward and Chirwa, 2009; Rohrbach et al., 2004). Key examples include the Malawi Subsidy programme (Dorward et al., 2008; Dorward and Chirwa, 2009) and voucher programmes in Horn of Africa (Ali, 2012; Save the Children & Oxfam 2012). The other form involves cash transfers and the Productive Safety Net Programme of Ethiopia is a distinct case study (Devereux et al., 2008; Gilligan et al., 2008; Hoddinott, 2008).

From year 2000 onwards, relief distributions in Zimbabwe have evolved from only direct distributions to including market friendly mechanisms like voucher redeemable at seed fairs and in retail shops (Mutonodzo and Magunda, 2012; Mazvimavi et al., 2012). The shift in the distribution system has been necessitated by the argument that direct free distribution undermines the development of agricultural input markets and does not offer farmers flexibility in input choice. Vouchers have been distributed to targeted resource constrained recipients, and are redeemable at designated seed fairs and retail shops (Rohrbach et al., 2004). These vouchers are for a fixed or non-fixed package of inputs. Such arrangements enhance the purchasing power of these farmers and empower them to acquire inputs of their choice. Under the Zimbabwe Emergency Agricultural Input Project (ZEAIP) of 2009/10,

vulnerable households received vouchers to acquire agricultural inputs at designated retail shops.

However, donors and researchers continue to question whether recipient households really utilize these inputs and whether they improve household crop productivity and food security. To our best knowledge, no study in Zimbabwe has addressed fully these important questions. This article analyses factors affecting use of relief maize seed and implications of relief seed on crop productivity. The article is organized as follows. We describe the methodology in section 2. The analytical framework is presented in the third section, followed by results and discussion of the findings in Section 4. We conclude with a summary and policy implications to relief seed utilization and crop productivity.

METHODOLOGY
Data and Sampling
Data for this article came from two waves of surveys carried out in 2009/2010 season by International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). The first survey; post-planting collected information on household socio-demographics, agricultural inputs acquisition and use and crop management activities was carried out in February 2010.

For the post- planting survey, a sample frame was drawn from 45 districts that participated in the relief maize seed distribution program. The districts were stratified by the country's different agro-ecological regions, and these were Natural Regions II, III, IV and V[1]. From each stratum 3 districts were purposively selected to give a total of 12 districts (Table 1). Within each selected district, 3 wards were sampled based on their participation in the relief maize seed distribution. In each ward, 3 villages were also randomly selected and 10 recipient households were randomly selected per village from a list of relief maize seed beneficiaries.

The second survey (post-harvest) which collected harvest data was done in May 2010 when most of the harvesting had been completed. This survey was done in six of the original survey districts and only a third of the households that participated in the post planting survey were interviewed. We deliberately choose these districts to include districts that had received hybrid and OPV maize seed and different natural regions. A smaller sample was used to enable comprehensive field area and yield measurements from relief program and comparison plots. Enumerators did actual field area measurements using their predetermined paces. In addition, yield quantities were obtained from respondent's harvest records[2] and triangulated with their recordings on the harvest sheets.

Table 1. Post-planting and harvest survey sample of districts and households interviewed

Natural Region (NR)	District	Post - planting survey	Post - harvest survey
II	Bindura	90	62
	Murehwa	88	-
	Zvimba	81	60
III	Hurungwe	90	60
	Chikomba	95	-
	Gokwe South	93	60
IV	Masvingo	90	62
	Mudzi	90	-
	Bulilima	92	-
V	Hwange	91	60
	Chipinge	85	-
	Gwanda	94	-
TOTAL		1079	364

Analytical Approach

We used two econometric models (a) Tobit regression and (b) Multivariate regression to estimate determinants of maize seed utilization and productivity respectively.

a) Determinants of household relief seed utilization

In literature there are 3 distinct approaches commonly used by authors to analyze household-level of modern input use in developing countries. Binary response (often, Probit or Logit) models have been used to explain whether or not farmers use a given input without analyzing their intensity of use (Akramov, 2009; Kaliba Verkuijl and Mwangi, 2000). Nkonya et al. (1997) used a Tobit model, which assumes same factors also determine both decisions while the third group (e.g., Winter-Nelson and Temu , 2005) of studies make use of a two-stage approach, which assumes that decisions on input use and intensity of use are affected by different underlying processes.

Because of the nature of our data the article's main goal is to explain the intensity of use modern inputs such as maize by vulnerable households in Zimbabwe. Thus, the dependent variable is maize seed utilization rate that has been computed as the proportion of amount of maize relief seed planted to the total amount received from relief organization thorough ZEAIP. From our data, farmers differed in the intensity of seed utilization and those farmers who did not plant the seed they received had a score of zero, and those planting all the relief maize seed had a score of one. The Tobit model has been chosen as a more appropriate econometric model since the seed utilization rate is censored. Tobin (1956), McDonald and Moffit (1980) and Green (2003) proposed a Tobit estimation method for analyzing intensity of use of a technology where the dependent variable is continuous with a cut off limits. The model is specified as:

$$y^* = \beta_0 + \sum_{j=1}^{k} \beta_j \, x_{ji} + \varepsilon_i$$

with

4

$$y^* = \min(y_i, 1)$$

Where y* is the seed utilization rate, *i* is the household (*i*=1,……,N), x_j is the vector of explanatory variables (j=1,….,k), β represents vector of parameters to be estimated, ε is N (0,σ2) distributed random error term. Vector β represents variables that describe the household's socio-economic, farm, environment, market and technology factors that are likely to influence maize seed utilization rates. The explanatory variables are described below.

The socio-economic factors included are gender and age of household head (Ouma and De Groote, 2011), prevalence of ill persons as proxy for HIV/AIDS. The size of arable area owned (AREAHA) and Livestock Unit (LU) captured the farm specific endogenous capital variables. LU is used as a proxy for draft power in our study. Households that have draft power are inclined to use to use more seed as they plant bigger arable areas. While seed use is expected to be scale-neutral, we include a variable for farm size under the assumption that farmers that have more land (and are therefore wealthier) might use more seeds (Boughton, 2011; Doss and Morris, 2001; Pray et al., 2001). Rainfall derived from whether the district lies in high or low rainfall areas according to the natural regions was included in the model to assess the influence of environment on seed utilization rates. Higher seed utilizations are expected in high rainfall areas. Proxy variables have to be used in the analysis because of lack of adequate direct measures on some of the variables and because some factors are simply not observable. We included access to alternative seeds (RETAILSE) to capture the impact of markets. The impact of technology on seed utilization was embodied in two dummy factors: whether respondent is practicing conservation agriculture (CA) or whether relief seed was hybrid or OPV (VARIETY). Giller et al. (2009) noted that households practicing CA are mostly targeted for input assistance and based on the fact that inputs are used efficiency in CA systems.

b) *Determinants of household maize productivity*

Crop productivity or yield is the measurable production of a crop, and it includes biomass production and grain yield (Fageria, 2009). In our study we take a narrow approach and define crop productivity as referring only to grain yield. The survey provided plot-level data on inputs and outputs for the maize crop. Fageria (2009) noted that productivity is a function of environment, plant, management and socio-economic factors and their interactions. Many factors affect crop yields and according to Below (2011) there are seven major factors that affect maize yields which he has coined "The Seven Wonders of the Corn Yield World". These are weather, nitrogen, hybrids, previous crop, plant population, tillage and growth regulators (chemicals). All these factors interact with each other and maximum yields are attained when these factors are at optimum levels. We briefly describe these factors:

Weather. Drought, rain, temperature and frost affect crop yields. While farmers have least control over weather, it has the most impact on the yield of the crop. Rainfall is a major variable influencing smallholder crop yields in Zimbabwe. We used a dummy variable (RAINFALL) for one high rainfall area and zero otherwise with the expectation that farmers in high rainfall areas attain higher yields.

Nitrogen. Mineral nutrition is vital factor affecting yield of annual crops (Ouma and De Groote, 2011). Nitrogen is affected by the previous crop as well as weather and moisture (Below, 2011) and is the most limiting nutrient for crop production in most parts of the world (Fageria et al., 2011). In our study we used manure (MANURE), basal fertilizer

(BASALDRESSING) and topdressing fertilizer (TOPDRESSING) to capture plant nutrition. We postulate that they are positively related to maize yields.

Hybrids. According to Below (2011) hybrid seed will continue to have large influence on yields owing to continual technological advancements as well as breeding research. In our study we used a dummy variable (HYBRID) for hybrid maize seed and zero otherwise (Open pollinated varieties (OPV) or recycled). We also included source of seed (RELIEF MAIZE SEED), with dummy one as relief maize seed and zero for non-relief maize seed.

Tillage. The timing and method of tillage used is vital for maize yields. In our study area, farmers are using conservation or conventional tillage methods. Most of the vulnerable households in our sample are encouraged to use conservation agriculture as it improves soil fertility and structure (Giller et al., 2009). We captured tillage technique (CA) as a dummy variable for one seed planted on conservation agriculture plot and zero otherwise. Time of planting is crucial for maximizing yields. Research in Zimbabwe has shown that grain yields decrease with sowing dates (Makadho, 1996). We included time of planting (TIMING) to capture this aspect.

Chemicals. Below (2011) argues that plant productivity is enhanced if there are no weeds and or pest problems in maize fields. In Zimbabwe smallholder farmers rarely use herbicides as they depend on manual weeding to keep their crops weed free. We included weeding frequencies (WEEDING) per plot to capture the variable weed management.

Plant population and the previous crop. Plant population can cause an increase or decrease in yield, especially when the population is too low. If the previous crop was a legume which fixes nitrogen then there is possibility of increased yields because of soil fertility. However in our case we excluded these two variables as the majority of smallholder farmers practise maize monoculture and on relatively small pieces of land.

From the maize yield data we used multiple linear regression analysis to evaluate the impact of the above mentioned factors on maize yields. The regression model is specified as:

$Yield = \beta_0 + \beta_1 (RAINFALL) + \beta_2 (MANURE) + \beta_3 (BASALDRESSING) + \beta_4 (TOPDRESSING) + \beta_5 (HYBRID) + \beta_6 (RELIEF\ MAIZE\ SEED) + \beta_7 (CA) + \beta_8 (TIMING) + \beta_9 (WEEDING) + \epsilon$

Where *Yield* is the maize yield in kg/ha,

$\beta_{1,....,}\beta_9$ are parameters to be estimated and, ϵ is the error term.

Multiple linear regression was used because the dependent variable of interest (yield) is continuous (Green, 2003).

RESULTS AND DISCUSSION

Targeting of relief beneficiaries
Relief maize seed sought not to help all communities and or farmers where seed markets were missing but the vulnerable households. A list of proxy variables for identification of vulnerable households was used. These were: female-headed household; child headed household; elderly, widows and widowers; household with orphans or chronically ill persons; household with limited cash income, and no formal employment; household with no cattle or limited assets; and household with high dependence ratio.

Our results show that on average 38.6% of the relief beneficiaries were female headed households. The proportion of female headed households varied from 22% (in Hurungwe) to 48% (in Chikomba) where the higher percentages were in areas located in high rainfall areas (Table 2). This is a common targeting criteria used by NGOs indicating vulnerability. The average age of the farmers across the survey districts was 53.8 years. This indicates a reasonably active age for the targeted farmers in terms of capacity to farm. The results show further indicators of HIV/AIDS affected households being targeted. On average 12% of the relief seed beneficiaries had at least one chronically ill person within their household; a commonly used proxy indicator for HIV/AIDS. The average household size across the districts was six.

The selection of vulnerable households appears to be accurate in targeting households with higher dependency ratio. A dependency ratio of greater than one means that the economically active adults have to look after more children and the old. The ratio is used as a proxy to indicate the "demographic squeeze" caused by HIV/AIDS. This works in two ways: first by decreasing active adults, and second by increasing dependents (as when household takes in orphans). The majority of the relief maize seed beneficiaries were farmers with no or limited access to draft power. Only 38% of the beneficiaries had access to draft animals. In terms of targeting food deficient households, The average per capita maize production was about 114.4kg, which indicated a deficit from the standard estimate of about 165kg per capita food consumption necessary for food security (FAO, 2010). However, in the high rainfall areas (NRII), the per capita food production averaged about 163kg. A significant number of beneficiaries (48%) practicing conservation agriculture (CA) were commonly targeted by NGOs for input assistance. CA is considered to increase yields, to reduce labour requirements, improve soil fertility and reduce erosion (Giller et al., 2009).

Table 2. Household head characteristics by district

Natural Region	District	Female headed households (%)	Age of household head (years)	Presence of ill persons (%)	Household size	Draft access (%)	Dependency ratio (persons)	Previous year per capita production (kg)	CA farmers (%)
NR II	Bindura	45.6	57.0	14.4	6.0	23	1.63	94.3	37.9
	Murehwa	44.3	55.9	3.4	5.7	42	1.86	116.8	69.4
	Zvimba	40.7	59.1	13.6	5.3	31	1.56	277.9	92.5
NR III	Hurungwe	22.0	48.0	12.1	6.7	23	1.60	151.4	97.8
	Chikomba	48.4	56.1	8.4	5.4	42	2.33	95.0	11.7
	Gokwe South	32.6	49.0	9.8	6.0	31	1.90	116.0	22.1
NR IV	Mudzi	39.3	50.9	15.7	6.0	30	1.78	46.7	80.7
	Bulilima	45.7	58.1	17.4	6.2	38	2.09	22.5	16.5
	Masvingo	38.9	50.1	11.1	5.2	32	1.93	153.7	16.7
NR V	Hwange	28.9	53.7	21.1	6.7	51	1.77	90.0	42.9
	Chipinge	37.7	52.7	7.1	7.4	49	1.71	142.8	70.9
	Gwanda	38.5	55.1	9.4	6.0	62	1.88	65.5	20.0
NR II – V		38.6	53.8	12.0	6.1	37.8	1.8	114.4	48.3

Distribution of relief maize seed

The relief maize seed program was successful in distributing 10kgs of improved maize seed to vulnerable households in all the districts. The program distributed only two maize varieties, a hybrid SC513 and ZM521, an open pollinated variety (OPV). Timing of seed deliveries has in past relief programs been a concern as farmers often got input packs late into the season. Late input deliveries have commonly been caused by logistical constraints in procuring and transporting inputs to communities due to seed shortages in the local market, sometimes forcing imports from neighboring countries in the region. The effectiveness of input use can easily be compromised when inputs come late.

According to the survey results, the timing of relief maize seed distribution was appropriate to meet the expected planting period. Most areas received the relief maize seed in November (86% of households) and by the first week of December, all seed had been distributed (Table 3). In high rainfall areas of Natural Regions II and III, over 96% of the seed was received by November.

In the low rainfall areas, a significant amount of seed was distributed in December. The areas that had the highest proportion of relief maize seed beneficiaries receiving seed in December were Gwanda (63%), Chipinge (34%), and Bulilima (26%). These areas are far from Harare where distribution logistics where mainly implemented and this partly explains the delay in distribution in these particular areas. A larger proportion of the distributed seed was planted between November and December. Of the relief maize seed maize seed received, 94% of the seed was planted by December. In some areas a small proportion of farmers planted in January and February. This was due to dry spells that earlier affected parts of the country, forcing farmers to delay planting or to replant. In Chipinge, replanting was common and some farmers were still planting during the time of the survey in February.

Table 3. Timing of relief maize seed distributions across sample districts

Natural region	Month when maize seed was distributed (Cumulative %)			
	District	October	November	December
II	Bindura	6.7	92.1	100
	Murehwa	1.2	95.4	100
	Zvimba	0	100	100
III	Hurungwe	6.7	100	100
	Chikomba	4.4	95.6	100
	Gokwe South	2.1	95.7	100
IV	Mudzi	13.5	97.8	100
	Bulilima	21.1	74.4	100
	Masvingo	37.8	92.2	100
V	Hwange	13.3	82.2	100
	Chipinge	4.7	65.9	100
	Gwanda	1	37.5	100
NR II – V		9.4	85.8	100

Utilization of relief maize seed

On average 90% of the seed received was planted by the time of implementing the post planting survey (Table 4). Utilization or planting rates varied from 60% in Bulilima to 100% in Bindura. The average utilization rate in drier agro ecological zones tended to be relatively lower, a factor generally attributed to the dry spell that affected the southern region of Zimbabwe in December 2009. Farmers in Bulilima, Hwange, Chipinge and Gwanda were severely affected by the drought forcing them to reduce area planted to maize crop. However the high rainfall areas: Hurungwe (95%), Zvimba (99%) and Bindura (100%) had higher utilizations when compared to relatively drier areas like Bulilima (60%), Hwange (79%) and Chipinge (66%). In Murehwa the utilization rate of relief maize seed was 88% and this could be attributed to a wide scale availability of agro dealers selling seed in the area. Also farmers in Murehwa had ready access to the capital city (Harare) seed markets.

Table 4. Average quantity of relief maize seed received and planted per household

Natural Region (NR)	District	Quantity of seed received (kg)	Quantity of seed planted (kg)	Total seed delivered (MT)	Weight based on seed delivered	Weighted mean seed planted	Proportion of seed planted for 12 districts (%)
II	Bindura	10.0	10.0	60.00	0.047	0.471	
	Murehwa	10.0	8.8	64.00	0.050	0.442	
	Zvimba	10.1	10.0	10.00	0.008	0.079	
III	Hurungwe	10.2	9.6	36.00	0.028	0.271	
	Chikomba	10.1	9.7	140.00	0.110	1.066	
	Gokwe South	9.9	9.7	474.27	0.372	3.612	
IV	Masvingo	9.9	8.2	133.60	0.105	0.860	
	Mudzi	10.0	8.9	71.34	0.056	0.499	
	Bulilima	7.7	4.6	70.09	0.055	0.253	
V	Hwange	9.9	7.9	56.29	0.044	0.349	
	Chipinge	10.6	7.0	66.00	0.052	0.363	
	Gwanda	9.9	8.8	92.00	0.072	0.636	
Total		9.9	8.7	1273.59	1.000	8.901	89.9

Determinants of household maize relief seed utilization

Results of the Tobit model show that gender and age of the household head do not seem to be important factors in determining the utilization rate of relief seed (Table 5). However, the model results suggest a negative relationship between age and seed utilization, and this may not be a surprise as older household members usually plant small plots because of labor constraints and diminished physical effort. The presence of HIV/AIDS (ILLPERSON) in the household does not appear to limit seed utilization. The timing of receiving relief seed (WHENREC) also has a strong influence on seed utilization. Farmer receiving seed late are less likely to plant all the seed. This is common because of reduced rainfall potential as the season progresses, making it less for crops to survive. The total land available to the farmer (AREAHA) has a very strong influence on seed utilization. Farmers with more access to land are likely to fully utilize their relief maize seed. Rainfall availability also has positive and significant influence on relief maize seed utilization. The results show that seed utilization rates were higher in districts lying in Natural Regions II and III. Access to alternative seed markets (RETAILSE) led to less utilization of relief seed. Livestock units are positively related to relief seed utilization but not significant. Households with better access to draft power are likely to till large plot sizes and plant on time. Conservation technology (CA) had no significant impact on seed utilization. We however expect the technology to have higher impacts in terms of yields. The model also shows a very strong positive effect of hybrid seed (VARIETY) on relief seed utilization. Farmers who accessed hybrid seed had higher seed utilization rates than those who obtained OPV. This is partly because hybrid seeds where distributed mostly in high rainfall areas, which did not suffer from drought spells. Also it is important to note that all hybrid seed was grown in-country and was delivered early. All OPV seed was imported from Zambia and Malawi and was the last seed to be delivered. Therefore it would appear that that VARIETY could be confounded with WHENREC. In addition, the

majority of farmers having a higher preference for hybrid maize seed, this is likely to have a positive impact on utilization rates.

Table 5. Estimated Tobit model for factors influencing maize seed utilization rates

Variable	Coefficient estimate	Standard error	Asymptotic t-ratio
Constant	1.081	0.060	17.90
GENDER	0.062	0.015	0.41
AGE	- 0.000	0.001	- 0.26
ILLPERSON	0.006	0.022	0.26
WHENREC	-0.011	0.005	-2.260**
AREAHA	0.049	0.019	4.130**
RAINFALL	0.123	0.017	7.44**
RETAILSE	-0.048	0.017	-2.81**
LU	0.004	0.010	0.38
CA	-0.005	0.015	-0.34
VARIETY	0.062	0.016	3.8**

Log likelihood function = 76.049342
** Significant at 5% level.

Determinants of household maize productivity
Farmers planting hybrid maize seed received from ZEAIP attained high yield gains during the 2009/2010 cropping season. On average for the six districts covered by the post-harvest survey, relief maize seed hybrid seed had 1747kg/ha compared to the 1252kg/ha for the non-relief maize seed hybrid (Table 6). Relief distribution of improved maize seed enabled households to achieve average maize yields of 1411kg/ha compared to 620kg/ha from recycled seeds. The differences in yields could be attributed to the level of crop management applied to different seed by source.

Table 6. Yields for hybrid versus open pollinated variety of maize

Districts	Relief Maize Seed		Non Relief Maize Seed		
	Hybrid (SC513)	OPV (ZM521)	Hybrid	Improved OPV	Recycled
Hwange	1404	809	1024	651	461
Masvingo	-	982	1068	-	-
Gokwe	-	1044	955	412	758-
Bindura	1670	-	1606	-	869
Hurungwe	1567	1328	1099	789	573
Zvimba	2049	-	1538	589	497
Total	1747	1076	1252	660	620

Farmers tend to intensify management and apply fertilizers to improved relief seed. The regression results for factors influencing maize yield are presented in Table 7. The results show standardized B coefficient and the t-statistic to measure the level of significance of different variables in the model. The results show that for all maize, manure and fertilizer application had a strong influence on maize yields. Poor soil fertility is a hindering factor in maize production in most parts of Zimbabwe. Therefore soil fertility enhancing products like

fertilizers and manure are crucial for plant nutrition and affect yields. These results resonate with Fageria (2009 and 2011) and Below (2011) on the importance of nutrition. Weeds compete with crops for vital nutrients and water affecting the general health and growth of crops. As such weeding is a critical component of crop management, and in the model weeding has a strong impact on the maize yields. The regression results show that rainfall had a strong influence on maize yields. Rainfall is a vital input influencing maize yields in rain-fed agricultural systems practiced by smallholder farmers in Zimbabwe, with no access to irrigation. Time of planting, type of seed and conservation agriculture appear to have no impact on all maize yield levels. For all the maize sources, there are no significant yield differences, whether the seed came from relief maize seed or not. This could be attributed to the fact that farmers in the survey sample had multiple sources of seed, including retail outlets that supplied both improved hybrid and OPV maize seed. For seed acquired through relief program, the results show that hybrid maize, conservation agriculture, basal dressing and rainfall were significant in influencing yield gains. Conservation agriculture has generally been associated with increased yields in Zimbabwe (Nyathi, 2009; Mazvimavi and Twomlow, 2009; Mazvimavi et al., 2008). CA plots are small and easy to manage and farmers are biased towards these plots in terms of seed allocation, crop protection and other good husbandry practices. Farmers usually have a rational tendency to plant relief seed on their conservation agriculture plots as these receive good husbandry. Basal dressing improves soil fertility and had a positive impact on relief maize seed maize growth and productivity. Contrary to expectation, time of planting, topdressing fertilizer, weeding and manure were not significant in the relief maize seed model.

Table 7. Regression analysis for factors influencing maize yield

Variable	All Maize seed (relief & non-relief)		Relief Maize Seed Only	
	Coefficient estimate	t-value	Coefficient estimate	t-value
Constant		3.632		2.297
TIMING	- 0.024	- 0.812	- 0.041	- 0.975
HYBRID	0.052	1.718	0.246	5.647**
CA	- 0.021	- 0.654	0.096	2.062**
MANURE	0.093	2.923**	0.065	1.409
BASAL DRESSING	0.128	4.031**	0.147	3.464**
TOP DRESSING	0.122	3.460**	0.029	0.563
RAINFALL	0.108	3.373**	0.198	4.192**
WEEDING	0.066	2.124**	0.033	0.778
RELIEF MAIZE SEED	0.015	0.472	-	-

** Significant at 5% level.

Impact of relief maize seed on food security
According to FAO/WFP (2010) per capita cereal consumption of 165kg is recommended to meet cereal consumption requirements per annum in Zimbabwe[3]. In our questionnaire we asked the cereal harvest obtained by household in the previous season (2008/2009) and survey results show that relatively fewer households produced enough grain during this period. This can be attributed to the general seed and fertilizer shortages in the country during

that period. This justifies why ZEAIP was implemented to address these shortages and help vulnerable households with seed. Despite the poor rains the proportions of households that produced enough grain increased from 30% in 2008/2009 to 48% in 2009/2010 season (Table 8). Improved seed distributions also attributed to such an increase considering that relief maize seed accounted for 41% of the total area planted to maize. In one district only 18% of the households produced enough grain to meet consumption requirements of 165kg per capita during 2009/2010 cropping season. The district lies in the Southern parts of the country which was severely affected by poor rains. This implies that the food insecure households had to supplement their food needs through purchases, food relief and gifts from friends and relatives.

Table 8. Changes in cereal production in 2008/2009 and 2009/2010 cropping seasons

Natural Region	District	2008/2009		2009/2010	
		Per capita Cereal production (kg)	Proportion of households that produced enough, ≥165kg/pc	Per capita Cereal production (kg)	Proportion of households that produced enough, ≥165kg/pc
NR II	Bindura	102.06	16.7	243.29	53.7
	Zvimba	240.73	54.4	333.18	71.7
NR III	Hurungwe	141.88	28.2	192.07	46.6
	Gokwe South	126.61	23.6	242.03	53.4
NR IV	Masvingo	143.80	26.7	115.20	18.0
NR V	Hwange	148.80	34.8	220.88	43.5

Conclusion
The relief programme increased vulnerable household's access to maize seed. Vulnerable households utilized the relief seeds, with high utilization rates of 90%. Regression analysis showed that time of seed receipt, land area, rainfall and hybrid seed had strong influence on relief seed utilization rates. These results have manifold policy implications. The implications are that there is need for timely input distribution to ensure farmers plant with the first effective rains. There is also great need for collaboration amongst farmers, NGOs, seed houses and related stakeholders to enable timely implementation of relief programmes. Timely input distribution helps farmer's decisions on crop planting. Secondly relief distributions should focus more on distributing hybrid maize seed. Rainfall, basal fertilizers, use of hybrid seed and conservation agriculture were significant in increasing relief maize yield. Maize productivity was even enhanced when fertilizers were applied to the hybrid maize seed. These are key results, as the emerging discussions on a green revolution for Africa, as well as the continued food crisis discussions, are prompting increased fertiliser use, conservation of soil and water and use of modern varieties as interventions for increasing agricultural productivity in Africa. Increased policy efforts should be placed on increasing access to hybrid maize seed and fertilizers as well as promoting conservation agriculture technology.

Acknowledgements

Endnotes

[1]Zimbabwe is divided into five agro-ecological regions also known as Natural Regions I to V. Natural Region I and II receive the highest rainfall (at least 750 mm per annum) and are suitable for intensive farming. Natural Region III receives moderate rainfall (650–800mm per annum) and Natural Regions IV and V have fairly low annual rainfall (450–650mm per annum) and are suitable for extensive farming (Vincent and Thomas, 1960).

[2]During the post planting survey, respondents in 6 selected districts were left with harvest sheets to record yields on plots planted to the relief maize seed and another comparison plot with non-relief maize seed.

[3]FAO/WFP (2010) suggested a cereal utilization of 165 kg/capita/year.

Reference

Akramov KT (2009). Decentralization, Agricultural Services and Determinants of Input Use in Nigeria. International Food Policy Research Institute (IFPRI) Discussion Paper 00941. Washington DC, USA.

Ali D (2012). A deadly delay: risk aversion and cash in the 2011 Somalia famine. Humanitarian Exchange Magazine., (54) May 2012.

Asenso-OkyereK, and Jemaneh S (2012). Increasing Agricultural Productivity & Enhancing Food Security In Africa: New Challenges & Opportunities. Synopsis Of An International Conference. International Food Policy Research Institute. Washington DC, USA.

Below F (2011). Farm Progress Show. Seven wonders of the corn yield world. International Invited Presentations. Decatur, Illinois: USA.

Boughton D, Mather D, Jayne T (2011). Smallholder Maize Marketing in Mozambique, Kenya and Zambia. Paper presented on Dialogue on Promoting Agricultural Growth in Mozambique. July 20, 2011. Maputo, Mozambique.

Devereux S, Al-Hassan R, Dorward A, Guenther B, Poulton C, Sabates-Wheeler R (2008). Linking social protection and support to small farmer development. Paper commissioned by the Food and Agriculture Organization of the United Nations (FAO). Rome.

Dorward A, Chirwa E (2009). The agricultural input subsidy programme - 2005 to 2008: Achievements and challenges. School of Oriental and African Studies, London.

Dorward A, Guenther B, Sabates-Wheeler R (2008). Linking social protection and support to small farmer development: Malawi case study. Paper commissioned by the Food and Agriculture Organization of the United Nations (FAO). Rome.

Doss CR, Morris ML (2001). How does gender affect the adoption of agricultural innovations? The case of improved maize technology in Ghana. Agric. Econ., 25: 27-39.

Fageria NK (2009). The Use of Nutrients in Crop Plants. New York. CRC Press.

Fageria NK, dos Santos AB, Coelho AM (2011). Growth, Yield And Yield Components Of Lowland Rice As Influenced By Ammonium Sulfate And Urea Fertilization. J. of Plant Nutri., 34:371–386.

FAO/WFP (2010). Crop and Food Security Assessment Mission to Zimbabwe. FAO/WFP Special Report. Food and Agriculture Organization of the United Nations and World Food Programme. Rome.

Giller KE, Witter E, Corbeels M, Tittonell P (2009). Conservation Agriculture and Smallholder Farming in Africa: The Heretics View. Field Crops Res., 114:23-34.

Gilligan DO, Hoddinott J, Alemayehu Seyoum T (2008). The impact of Ethiopia's Productive Safety Net Programme and its linkages. IFPRI Discussion Paper 00839. International Food Policy Research Institute. Washington DC, USA.

Green WH (2003). Econometric Analysis. Fifth Edition. Pearson Education. Upper Saddle River. New Jersey.

Hoddinott J (2008). Social safety nets and productivity enhancing investments in agriculture. Paper presented at the international conference: Convergence between Social Service Provision (SSP) and Productivity Enhancing Investments (PEI) in Development Strategies.University of KwaZulu-Natal. Pietermaritzburg, South Africa.

Kaliba ARM, Verkuijl H, Wilfred M (2000). Factors Affecting Adoption of Improved Maize Seeds and Use of Inorganic Fertilizer for Maize Production in the Intermediate and Lowland Zones of Tanzania. J. Agric. Appl. Econ., 32: 35-47.

Makadho JM (1996). Potential effects of climate change on corn production in Zimbabwe. Clim Res., 6:147-151.

Mazvimavi K, Pedzisa T, Murendo C, Minde IJ, Ndlovu PV (2012). Cost effectiveness of seed fairs relative to direct distribution in Zimbabwe. Develop. in Pract., 22(7): 978-990.

Mazvimavi K, Twomlow S (2009). Socioeconomic and Institutional Factors Influencing Adoption of Conservation Farming by Vulnerable Households in Zimbabwe. Agric. Syst., 101:20–29.

Mazvimavi K, Twomlow S, Belder P, Hove L (2008). An Assessment of the Sustainable Adoption of Conservation Farming in Zimbabwe. Global Theme on Agro Ecosystems. Report Number 39. Zimbabwe. ICRISAT. 60pp.

McDonald JF, Moffitt RA (1980). The Uses of Tobit Analysis. The Rev. of Econ. and Stat., 62(2):318-2.

Mutonodzo-Davies C, Magunda D (2012).The Politics of Seed Relief in Zimbabwe. Policy Brief 049. Brighton: Future Agricultures Consortium.

Nkonya E, Schroeder T, Norman D (1997). Factors Affecting Adoption of Improved Maize Seeds and Fertilizer In Northern Tanzania. J. Agric. Econ., 48 (1):1-12.

Nyathi P (2009). Conservation Agriculture in Semi- Arid Zimbabwe: An Analysis of the Effects of Tillage and Fertilizer Application on Maize (Zea mays l.) Yield. MSc Thesis. University of Reading, UK. 96pp.

Ouma J.O, De Groote H (2011). Determinants of improved maize seed and fertilizer adoption in Kenya. J. Agric. Dev. Econ., 3(11): 529-536.

Pray C, Ma D, Huang J, Qiao F (2001). Impact of Bt cotton in China. World Dev., 29 (5): 813-825.

Remington T, Maroko J, Walsh S, Omanga P, Charles E (2002). Getting Off the Seed and Tools Treadmill with CRS Seed Vouchers and Fairs. Disasters., 26(4): 316–328.

Rohrbach D, Charters R, Nyagweta J (2004). Guidelines for Agricultural Relief Programs in Zimbabwe. ICRISAT. Zimbabwe. 62 pp.

Save the Children & Oxfam (2012). A Dangerous delay, the cost of late response to early warnings in the 2011 drought in the Horn of Africa. A Joint Agency Briefing Paper. Available at: http://policy-practice.oxfam.org.uk/publications/download?Id=441302&dl=http://oxfamilibrary.openre

pository.com/oxfam/bitstream/10546/203389/9/bp-dangerous-delay-horn-africa-drought-180112-summ-en.pdf.

Tobin J (1956). Estimation of relationships for limited dependent variables. Econome., 26: 24-36.

Vincent V, Thomas RG (1960). An Agricultural Survey of Southern Rhodesia: Part I: Agro-ecological survey, Salisbury: Government Printers.

Winter-Nelson A, Temu A (2005). Impacts of prices and transaction costs on input usage in a liberalizing economy: evidence from Tanzanian coffee growers. Agric. Econ., 33 (3): 243–253.

World Bank (2008). World Development Report: Agriculture for Development, Washington, DC: World Bank.