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A1 FARMER IN BINDURA, ZIMBABWE**

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# ENTERPRISE COMBINATION IN A MAIZE BASED FOOD CROP FARMING SYSTEM: A CASE STUDY OF A MODEL A1 FARMER IN BINDURA, ZIMBABWE

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## ABSTRACT

The best crop combination that gives a farmer high returns is a decision that farmers often take by trial and error. The trial and error method does not result in optimal crop combinations. Linear programming technique can be applied successfully to determine optimal crop patterns. In this study a linear programming model was developed for a model A1 farmer in Bindura, Zimbabwe. Crops which were considered in this study were maize, soya beans and cotton. An assumption that the farmer can grow an intercropped mixture of maize and soya beans was made. This kind of a joint relation was modeled in the linear programming model by incorporating the intercropped mixture of maize and soya beans as a single activity. Two or more crops may be grown together as an intercropped mixture, often with beneficial effects on yields and drought tolerance. The model was solved using MS Excel (2007) a computer software package and an optimal cropping pattern was obtained. The model suggested the production of 8 hectares of intercropped maize and soya beans only. The model suggested no production of maize, soya beans and cotton. The optimal cropped acreage did not change as compared to the farmer's plan. As a result of the optimal solution, the farmer's income would be increased by \$2,850. The farmer's income would be increased from \$7,945 to \$10,795 showing an improvement of 36 percent. The results show that linear programming model suggestions are worthy applying.

**Keywords:** Linear Programming, Maize, Enterprise Combination, Model A1 Farmer, Income.

## 1. INTRODUCTION

Bamiro *et al* (2012) examined in their study the enterprise combination in cassava based food crop farming system in Ogun State, Nigeria. Bamiro *et al* (2012) said, "In southern ecological zones of Nigeria particularly in the southwest cassava is grown with crops like maize, melon, vegetable, yam, etc. Traditionally an average of three to five is combined ..." The best crop combinations that gives the farmer the desired result is a decision the farmers in the southern ecological zones of Nigeria they often take by trial and error (Bamiro *et al*, 2012). The trial and error method does not result in optimal crop combinations. The objective of the study by Bamiro *et al* (2012) was to provide answers to which enterprise combinations would be the most profitable venture. They actualized by a linear programming (LP) model the optimal cassava based combination which showed that cassava/maize and cassava/maize/vegetable were the optimal combination. The study by Bamiro *et al* (2012) created the initial basis of this study. Thus, the objective of this study was to develop an LP model that would help to determine the optimal crop combination of a Model A1 farmer in Bindura, Zimbabwe. The Model A1 is a model that is intended to decongest communal areas and is targeted at land-constrained farmers in communal areas (Zhikhali, 2008). Zhikhali (2008) says, "This model is based on existing communal area organization, whereby peasants produce mainly for subsistence."

Maize is a very important crop to Zimbabwe. Zikhali (2008) said, "Although the parcels are cultivated with a multi-cropping system, data revealed maize as the major crop ..." Maize is grown with crops like beans, cowpeas or

as a sole crop. Takim (2012) said, "Intercropping is the simultaneous growing of two or more crops in the same field" The use of intercropping by peasant farmers is a common practice (Takim, 2012). Intercropping has a lot of advantages like soil conservation, lodging resistance, yield increment and weed control (Takim, 2012). Saleem *et al* (2011) said, "Intercropping ... often results in a more efficient utilization of resources; cause stable yields and a method to reduce problems with weeds, plant pathogens and nitrogen losses" Kariaga (2004) demonstrated that the practice of planting maize as a sole crop is not sustainable. Kariaga (2012) recommended that the Kenyan government should have a policy which encourages farmers to intercrop maize with other low legumes like cow-peas and beans so that the nation does not suffer from food shortages.

Two or more crops may be grown together as an intercropped mixture, often with beneficial effects on yields and drought tolerance (Hazel and Norton, 1986). Joint relations of these kinds can be modeled by linear programming by incorporating single activities (Hazel and Norton, 1986). Hazel and Norton (1986) said, "Linear programming has proved a very flexible tool for modeling these and similar kinds of complexities" Linear programming was successfully applied in different countries to determine optimal cropping patterns. Igwe *et al* (2011) said, "Linear programming technique is relevant in optimization of resource allocation and achieving efficiency in production planning particularly in achieving increased agricultural productivity" Abdelaziz *et al* (2010) applied LP technique to determine the cropping pattern in North Darfur State, Sudan. The basic models gave a cropping pattern different from the farmers' production plans. The LP models solutions gave a profitable objective function compared to the farmers' production plans which actually gained them a loss (Abdelaziz *et al*, 2010). To find the effect of optimum allocation of resources in different situations, Dey and Mukhopadhyay (2010) formulated two crop plans using the LP technique. The net return earned from the first optimal plan exceeded that from the existing crop plan by 43 per cent. Ibrahim and Omotesho (2011) in their study determined an optimal enterprise combination for vegetable production under Fadama in north central Nigeria by the use of the LP technique. The optimal plan achieved 88 percent of the goals achieved (Ibrahim and Omotesho, 2011). Kaur *et al* (2010), Kebede and Gan (1999), Majeke (2013a), Majeke *et al* (2013b), Majeke *et al* (2013c), Mohamad *et al* (2011), Mohammed and Ndanitsa (2012) and Möhring and Zimmermann (2005) also successfully applied LP technique to obtain optimal cropping patterns.

The objective of this study was to develop an LP model that would determine the optimal crop pattern for a Model A1 farmer in Bindura, Zimbabwe. An assumption that the farmer can grow an intercropped mixture of maize and soya beans was made. This kind of a joint relation was modeled in LP by incorporating the intercropped mixture of maize and soya beans as a single activity.

## 2. LINEAR PROGRAMMING FORMULATION

The Model A1 farmer had 8 ha of arable land for the 2011/12 season. The land was meant for maize, soya beans and cotton production. The expected income from maize was \$285 per ton, \$530 per ton from soya beans and \$160 net income per ha from cotton. The problem is to determine the optimal cropping pattern. The farmer had a plan to allocate 4 ha of land for maize, 3 ha for soya beans and 1 ha for cotton production.

The farmer must make a decision on how many hectares of land that should be allocated for maize, soya beans and cotton production that yields maximum profit subject to resource constraints such as land and labor. Suppose the farmer could grow an intercropped mixture of maize and soya beans. This has a beneficial effect on yield and drought tolerance (Hazel and Norton, 1986). Therefore, the decisions of the farmer were:

$x_1$  = hectares allocated for maize production.

$x_2$  = hectares allocated for intercropped mixture of maize and beans.

$x_3$  = quantity of maize to be sold.

$x_4$  = quantity of maize transferred for food consumption.

$x_5$  = hectares allocated for soya bean production.

$x_6$  = quantity of soya beans to be sold.

$x_7$  = hectares allocated for cotton production.

The objective was to maximize income subject to land, labor and food consumption constraints.

**Table 1.** Linear Programming Matrix

	Maize (ha)	Maize/ Soya Beans (ha)	Sell Maize (ton)	Transfer Maize (ton)	Soya Beans (ha)	Sell Soya Beans (ton)	Cotton (ha)	
Objective function (dollars)	-900	-1100	285		-740	530	160	Maximize
<b>Resources</b>								<b>Available</b>
Crop Land (ha)	1				1		1	≤ 8
Labor (days)	30				30		35	≤ 312
Maize Accounting (ton)	-8	-5	1	1				≤ 0
Maize Consumption (ton)				-1				≤ -1
Soya Beans Accounting (ton)		-2			-3	1		≤ 0

Table 1 represents the LP matrix and the right hand side represents the constraints on the resources. The following represents the LP model:

$$\text{Max } z = \sum_{j=1}^7 c_j x_j$$

subject to

$$\sum_{i=1}^5 a_{ij} x_j \leq b_i,$$

$$x_j \geq 0,$$

where,

$z$  = the objective function (\$),

$c_j$  = income per unit of  $j^{\text{th}}$  activity (\$),

$x_j$  = the level of the  $j^{\text{th}}$  activity,

$a_{ij}$  = the  $i^{\text{th}}$  resource required per unit of the  $j^{\text{th}}$  activity and,

$b_i$  = the supply level of the  $i^{\text{th}}$  resource.

### 3. RESULTS AND DISCUSSION

The LP model was solved using MS Excel (2007) a computer software package and the resulting optimal cropping pattern in comparison to the farmer's plan are presented in Table 2. The model suggested the production of intercropped maize and soya beans only. The LP model suggests no production of maize, soya beans and cotton. The optimal cropped acreage did not change as compared to the farmer's plan.

**Table 2.** Comparison of Cropping Pattern under Optimal Solutions with the Farmer's Plan

Activities	Farmer's plan (ha)	LP solution (ha)	% of Farmer's plan
Maize	4	0	0
Maize/Soya Beans	0	8	∞
Soya Beans	3	0	0
Cotton	1	0	0
Total	8	8	100

As a result of the optimal solution, the farmer's income would be increased by \$2,850. Income increased from \$7,945 to \$10,795 showing an improvement of 36%. The optimal income level as compared to the one planned by the farmer is presented in Table 3. The results show that the LP model suggestions are profitable.

**Table 3.** Comparison of Income Level under Optimal Solution with the Farmer's Plan

Income		
Farmer's plan (\$)	Optimal solution (\$)	% of Farmer's plan
7,945	10,795	136

#### 4. CONCLUSION

In this study a linear programming model was developed for a model A1 farmer in Bindura, Zimbabwe. Crops which were considered in this study were maize, soya beans and cotton. An assumption that the farmer can grow an intercropped mixture of maize and soya beans was made. This kind of a joint relation was modeled in the linear programming model by incorporating the intercropped mixture of maize and soya beans as a single activity. The model was solved using MS Excel (2007) a computer software package and an optimal cropping pattern was obtained. The model suggested the production of 8 hectares of intercropped maize and soya beans only. The model suggested no production of maize, soya beans and cotton. The optimal cropped acreage did not change as compared to the farmer's plan. As a result of the optimal solution, the farmer's income would be increased by \$2,850. The farmer's income would be increased from \$7,945 to \$10,795 showing an improvement of 36 percent. The results show that linear programming model suggestions are worthy applying.

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