Impact of Improved Seeds on Small Farmers' Productivity, Income and Livelihood in Bara Locality of North Kordofan State, Sudan

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Abstract

This study was designed to test and identify the impact of improved seeds on small farmers' productivity, income and livelihood in Bara locality. Sixty households participants were randomly selected through a field survey during 2011 for 2008/2009, 2009/2010 and 2010/2011 cropping seasons. The study applied Multi-stage random sample technique. Based on existing farm situation and price level, the sampled farmers were obtained SDG 8604 as gross margin to cover all expenses. Results of this study also depicted that the required net income and off-farm income were 16293 and 11378 SDG, respectively. With respect to Linear Programming (LP) results, a total of SDG 8890 were obtained and all crops were entered and solved. The optimal plan and existing farm situation were changed by 3.3 and 5.6% for gross margin and cash income, respectively. Results of LP also indicated a positive change in production patterns of resource use; 3.3, 6.2, 3.5, 3.3 and 9.1% for land, cash income, labour, seeds supply and productivity, respectively under existing and optimal plan. Partial crop budgeting revealed that, all treatments were financially gave positive returns. Dominance analysis showed that cowpea ainelgazal, okra, roselle and sesame herhri crops were dominated by crops of millet ashana, watermelon, groundnut and guar, respectively. Marginal analysis exposed that, for every SDG 1.00 invested in improved seeds cultivation, farmer can expect to cover the SDG 1.00 and obtain an additional SDG 1.345; then, additional seed rate implies a further marginal rate of SDG 43.9. Sensitivity analysis for cost overrun and benefit shortfall by 10% indicated highly stability with marginal rate of returns of 1.22, 3.991 and 1.21 and 3.951% for watermelon and guar, respectively. The productivity of improved seeds compared to local ones was increased in some varieties and decreased among others. This study reached to some recommendations for improving crop productivity, production and livelihood of small farmers in Bara locality.

Keywords: Dominance, Marginal analysis, Roselle, Sesame, Millet, Watermelon, Groundnut, Guar.

1. Introduction

North Kordofan state is located between latitudes 11-16°N and longitudes 27-32°E. Bara locality lies between latitudes 13-14°N and longitudes 28-31°E. The State faces a number of complex and interconnected problems such as environmental, socio-economical and political problems. The majority of small farmers in Bara locality experience a situation of food insecurity, which is mainly attributed to successive crop failures. The project area was selected by the proceeding IFAD mission in the consultation process with federal and state government for its concentration of deprived population, relative lack of development but reasonable potential (IFAD, 1999). Improved seeds can achieve its purpose only if it is transferred to and adopted by farmers. Effective technology of improved seeds can result in higher agricultural production and increased incomes of farming families, which has positive impact on rural poverty. Improved crop yields will reduce costly imports of agricultural commodities and the cost of production of basic raw materials for agro-industries. In the long run the adoption of improved seed technology by farmers can make agro-industries more competitive in the international markets (Bauer, 2004).

Hazell (1986) reported that linear programming model is a method of determining a profit maximization combination of farm enterprises that is feasible with respect to a set of farm constraints. Grover et al., (2004) applied linear programming (LP) model to test the impact of improved seeds and the model was specified in terms of its objective function, activities and constraints under normal conditions to determine the optimum resource allocation for specific activities for improving the income level at the household level. Partial crop budgeting is another tool to determine the costs and benefits of the various alternatives (Cymmit, 1988). Ultimate goal of this research was to determine the relationship between improved seeds and farmers' productivity, income and livelihood. This study hypothesized that investors would get the benefit when grow improved seeds.

2. Econometric Methodology

Households' survey questionnaire regarding crop production activities was developed and tested in pre-survey to collect primary data through direct interviewing with IFAD farmers. A form of multistage random sampling of 60 respondents was selected covering ten villages of the two administrative units (Rural Bara and Tayba). Data were analyzed using descriptive analysis, linear programming model (LP), partial crop budgeting, dominance, and marginal and sensitivity analyses. Relevant secondary sources of data were used.

2.1 Linear programming model

Pomeroy et al., (2005) stated that linear programming requires the information of the farm and non-farm activities and options with their respective resource requirements and any constraints on their production, the fixed requirements and other maximum, minimum constraints that limit family or farm production, cash costs and returns of each activity and defined objective function. In this context, a linear programming model has been developed to determine the area to be used for different crops for maximum contribution and for improving farmers' income. The model expressed as follows:

2.1.1 Objective equation:

$$Maximise\ Z = \sum_{j=1} C_j X_j$$

Subject to:

$$\sum_{j=1} a_{ij} X_j \leq b_{i=1\ to\ n}$$

Xj ≥ 0 all j = 1 to *m* non-negativity constraint activities

where:

Z = Gross margin

C_j = Price of production activities

X_j = level of jth production activity

a_{ij} = the ith resource required for a unit of jth activity

b_i = the resource available with the sample farmers

j = refers to number of activities from 1 to n

i = refers to number of resources from 1 to m

2.1.2 Constraints

(i) Land:

$$\sum a_{ij}X_j \le OL \text{ and } \sum a_{ij}X_j \le RL,$$

where:

OL and RL are the size of holding owned and rented land, respectively.

(ii) Family labour:

$$\sum at_j\text{-}htX_j \le Lt, htX_j \le At$$

where:

Lt and At = available family labor and hired labor in the tth period.

ht = is the amount of hired labor required in the tth period for j^{th} activity.

At_j = is the amount of labor required in the tth period for j^{th} activity.

(iii) Working capital:

$$\sum k_{ij}X_j \le WK$$

where:

WK = is the amount of available working capital.

K_{ij} = is the amount of working capital required for production and non production activities.

Working capital is the value of inputs (purchased or owned) allocated to an enterprise with the expectation of a return at a later point. The cost of working capital is the benefit given up by the farmer by trying up the working capital in the enterprise for a period of time (Cimmyt, 1988).

(v) Seed supply:

$$\sum P_iX \le IMPS$$

where:

IMPS = is the amount of improved seeds supply available with the sample farmers.

P_{ij} = is the amount of seed supply required for production activities.

(vi) Crop Productivity:

$$\sum S_{ij} \le PD$$

where:

PD = is the amount of seed productivity available with the sample farmer.

S_{ij} = is the amount of seed productivity required for production activities.

2.2 General formula of objective function:

Maximize Z $= aX_1+bX_2+cX_3+dX_4+eX_5+fX_6+gX_7+hX_8+iX_9+jX_{10}+kX_{11}+ lX_{12}$

where:

a, b, c, d, e, f, g, h, I, j, k and l are coefficients of objective function.

2.3 General formula of the inequalities:

$aX_1+bX_2+cX_3+dX_4+eX_5+fX_6+gX_7+hX_8+iX_9+ jX_{10}+kX_{11}+ lX_{12} \le RHS$

where:

a, b, c, d, e, f, g, h, i, j, k and l are the coefficient of the constraints inequalities and RHS is the right hand side.

The improved production activities and decision variables used in the study are: X_1 = Millet ashana, X_2 = Cowpea ainelgazal, X_3 =Okra Khartoum-red, X_4 = Roselle X_5 = Watermelon cashair, X_6 = Sesame hirhri, X_7 = Groundnut sodri, X_8= Guar improved.

2.4 Farm model

This model was conducted to identify and analyze the empirical crop-mix problem of farmer who has to allocate his fixed resources like land, labor and working capital for different crops. The link between the tableau and algebraic formulations of the model can be illustrated as: eight crops can be grown and each of which has specified per hectare requirements. Production of one hectare requires 3, 5, 5, 5, 5, 4, 4, 4, and 4.4, 33, 32, 9, 9, 26, 57, and 21, man hours and working capital for the above decision variables, respectively. A total of 60 man hours of labor is potentially available, being the amount provided by family workers during season. The activity gross margins in the objective function are differed for each unit hectare (Table 1).

2.5 Partial crop budgeting

Partial budgeting technique was used for the analysis of data. The technique involved selecting of those costs that vary with particular treatment being analyzed and the net benefits of each treatment (Mahmood et al., 2000).

2.6 Dominance analysis

Dominance analysis is carried out in order to rank the treatments in order of increasing costs that vary. Any treatment has net benefits that are less than or equal to those of treatment with lower cost that vary i9s dominant (marked with D).

2.7 Marginal analysis

Marginal analysis is conducted to know returns to investment and thus the less benefited treatments were eliminated by making the use of dominance analysis. Marginal rate of return indicate what farmers can expect to gain, on average, in return for their investment when they decide to change from one practice to another (Cymmit, 1988). Marginal values were calculated as:

$$\text{Marginal rate of returns (MRR)} = \frac{\text{Incremental net bene its}}{\text{Incremental net costs}} \text{X } 100\%$$

2.7.1 Maximizing TPP:

when:

$$\frac{\partial \text{TPP}}{\partial x} = \text{MPP} = 0$$

where:
TPP = Total physical productivity (output price per unit).
MPP = Marginal physical productivity.
x = Input used (cost price per unit).

2.8 Sensitivity analysis

The sensitivity analysis was done to check risk factors which cause price variability. The analysis was done assuming costs over run by 10% keeping the benefits same, and then by assuming benefits reduction by 10% keeping costs same.

2.9 Crop productivity

Productivity is the amount of output per unit of input. It refers to the volume of output produced from a given volume of inputs or resources. Productivity used to know and explore the trend of improved seeds versus local.

3. Results and Discussion

The existing farm situation of small holders was estimated in order to explore the potential for improvement in agricultural production, productivity, labor use efficiency and hence the gross margins per unit of land at household micro level. Farmers derived income from both farm and non-farm activities. Based on the existing farm situation and prevailing price levels, the sample farmers were obtaining SDG 8604 as gross margin to cover all expenses including subsistence and livelihood requirements and hired labor expenses. Results revealed that, farmers obtained net cash income and off-farm income of SDG 16293 and 11378, respectively (Table 2).

Based model was solved and the algebraic versions depend on linear programming model. With respect to unit area hectare, the results of optimal solution or farm plan for crops indicated that all crops were optimally emerged with a total gross margin of SDG 8890. Watermelon and guar were the most profitable with gross margin of SDG 4496 and 2130, respectively (Table 3).

Farm income upon the optimal plan under reallocation of resources indicated an improvement in gross margin and cash income per hectare by 3.3% and 5.6% or by 0.033 and 0.056 units, respectively (Table 4). Resource productivity in terms of gross margin for land, cash income, labor, seed supply and productivity were increased in optimal plan by 3.3%, 6.2%, 3.5%, 3.3%, and 9.1%, respectively; over existing farm situation. The available labor productivity of gross margin per man hour (GM/MH) was the total of man equivalent for the representative farm (Table 5).

Partial crop budgeting showed that all improved crops gave positive returns, this is actually due to higher field prices and lower costs of production in such seasons (Table 6). Total costs include: Costs of seeds, costs of seed dressing, costs of insecticide, cash labor and family labor, costs of by-product and rental costs in SDG/ha. Dominance analysis revealed that okra khartoum-red, cowpea ainelgazal, roselle and sesame herhri were dominated and eliminated by millet ashana, watermelon cashair, groundnut sodri and guar, while the net field benefit were highest for T8 (Guar improved), followed by T7 (Groundnut Sodri), T6 (Watermelon Cashair) and T1 (Millet Ashana). Therefore, these treatments were accepted as the best (Table 7).

Bearing in mind the minimum acceptable rate of returns was assumed to be 100%. Analysis of marginal rate of returns revealed that, T6 was higher than minimum acceptable rate of returns. However T6 and T8 were emerged as the best among the alternatives, thus every SDG 1.00 invested in improved seeds cultivation, farmer can expect to recover the SDG 1.00 and obtained additional SDG 1.345. Hence, increasing seed rate implies a further marginal rate of SDG 43.9 (Table 8).

The sensitivity analysis of costs over run ensured that treatment six and eight significantly remain same (watermelon and guar) and thus T8 was considered as the best with MRR 3991% and T6 rank second with MRR 122.3% (Table 9). Sensitivity analysis that assumed benefits shortfall; indicated that T6 and T8 were the best among alternative with MRR 121.1% and 3951%. Based on the analysis of partial budget T8 was highly stable (Table 10). In spite of low rainfall, pests and diseases damage, productivity of improved seeds trend versus local goes further in some varieties and declined in others (Figure 1).

4.Conclusion

Analysis of data Showed that improved seeds were most economically for small farmers. The optimal base model showed improvement in gross margin, farm income, resource use, and production patterns. Partial crop budgeting revealed that, all improved crops financially gave positive returns. Marginal rate of returns revealed that farmer can benefit from improved seeds. Sensitivity analysis showed that Guar improved and Watermelon cashair were highly stable. Crop productivity trend goes up in some improved varieties compared to the local ones.

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Table 1: Linear programming tableau

Row name	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	RHS
Objective function Max Z	989	92	57	701	1648	361	2105	2653	
Resources (constraints):									
Land/ha	1	1	1	1	1	1	1	1	7
Labor/MH	3	5	5	5	5	4	4	4	60
Working capital/SDG	4.4	33	32	9	9	26	57	21	2007
Seed supply kg/ha	4	0.4	0.2	0.2	0.4	0.8	40	0.1	48
Productivity kg/ha	71	60	30	92	98	84	205	101	741
Average cultivated area/ha	1	0.26	0.11	0.67	2.73	1.1	0.18	0.80	3

Source: Field survey, 2011.
SDG: Sudanese Gienh.

Table 2. Sources of cash income and expenses of the sampled farmers (Averages taken from 2008/2009 to 2010/2011) in SDG

Particulars	SDG*
1. Gross margin:	8604
1.1 Improved seed	8604
2. Off-farm income	11378
3. Total income (1 + 2)	19982
4. Expenses:	3689
4.1 Subsistence	3498
4.2 Hired labor	191
Farm cash income (1 - 4.1)	5106
Net cash income (3 - 4)	16293

Source: Field survey, 2011.
*One US$ = 5.2 SDG.

Table 3: Optimal solution or farm plan for the base model in SDG/ha

Improved crop	Unit Area/ha	Objective coefficient	Optimal solution
Millet ashana	1	989	989
Cowpea ainelgazal	0.26	92	24
Okra Khartoum-red	0.11	57	6
Roselle improved	0.67	701	469
Watermelon cashair	2.73	1647	4496
Sesame hirhri	1.1	360	396
Groundnut sodri	0.18	2105	379
Guar improved	0.803	2653	2130
Final value			8890

Source: Field survey, 2011.

Table 4: Change in farm income under optimal base model over existing plan (Sample holdings from 2008/2009 to 2010/2011 cropping seasons) in SDG

Particulars	Existing	Optimal value	% increment
Gross margin	8604	8890	3.3
Subsistence	3498	3498	
Cash income	5106	5392	5.6

Source: Field survey, 2011.

Table 5: Marginal value productivities of various resources under existing and optimal plan (Sample holding from 2008/2009 to 2010/2011 cropping seasons) in SDG

Particular	Existing	Optimal value	% increment
Land Gm/ha	1229	1270	3.3
CI/ha	1.6	1.7	6.2
Labor Gm/MH	143	148	3.5
Seed supply Gm/ha	179	185	3.3
Productivity Gm/ha	11	12	9.1

Source: Field survey, 2011.

GM: Gross margin, ha: hectare.

Table 6: Partial crop budgeting for different improved crops in Bara Locality (Averages taken from 2008/2009 to 2010/2011cropping seasons) in SDG

Improved variety	Yield kg/ha	Adjusted yield kg/ha	Gross field benefit SDG/ha	Total costs SDG/ha	Net benefit SDG/ha
Millet ashana	71	57	789	19	770
Okra Khartoum-red	30	24	90	26	64
Cowpea ainelgazal	60	48	68	24	44
Roselle improved	92	74	542	55	487
Sesame hirhri	84	67	279	161	118
Watermelon cashair	98	78	1305	239	1066
Groundnut sodri	205	164	1673	541	1132
Guar improved	101	81	2122	551	1571

Source: Field survey, 2011.

Table 7: Dominance analysis of improved seeds in SDG hectare

Treatments		Total costs	Net field benefits
T1	Millet ashana	19	770
T2	Cowpea ainelgazal	24	44 D
T3	Okra Khartoum-red	26	64 D
T4	Roselle improved	55	487 D
T5	Sesame herhri	161	118 D
T6	Watermelon cashair	239	1066
T7	Groundnut sodri	541	1132
T8	Guar improved	551	1571

Source: Field survey, 2011.

Table 8: Marginal analysis of improved seeds in SDG per hectare

Treatments	Total costs	Marginal costs	Net field benefits	Marginal net field benefit	MRR = V/III*100%
I	II	III	IV	V	
T_1	19	-	770	-	-
T_6	239	220	1066	296	134.5
T_7	541	302	1132	66	22.0
T_8	551	10	1571	439	4390

Source: Field survey, 2011.

Table 9: Sensitivity of marginal analysis for costs over run in SDG per hectare

Treatments	Total costs	Marginal costs	Net field benefits	Incremental net benefits	MRR = V/III* 100%
I	II	III	IV	V	
T_1	20.9	-	770	-	
T_6	262.9	242	1066	296	122.3
T_7	595.1	329.2	1132	66	20.0
T_8	606.1	11	1571	439	3991

Source: Field survey, 2011.

Table 10: Sensitivity of marginal analysis for benefits reduction in SDG per hectare

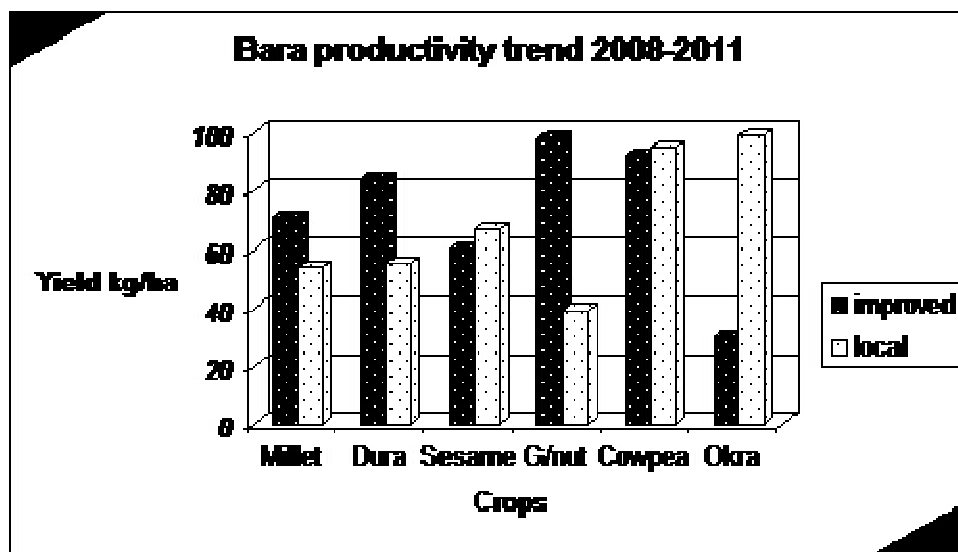| Treatments	Total costs	Marginal costs	Net field benefits	Incremental benefits	MRR = V/III* 100%
I	II	III	IV	V	
T_1	19	-	693	-	-
T_6	239	220	959.4	266.4	121.1
T_7	541	302	1018.8	59.4	19.7
T_8	551	10	1413.9	395.1	3951

Source: Field survey, 2011.

Figure 1. Bara productivity trend of crops, 2008-2011.
Source: Field survey, 2011.