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AN AGRONOMIC AND ECONOMIC EVALUATION OF SOYABEAN PLANTING METHODS IN THE CENTRAL PROVINCE OF ZAMBIA

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SUMMARY

Soyabean (*Glycine max*) is a relatively new crop for small-scale farmers in Zambia which has been adopted following the introduction of new cultivars, greater opportunity to obtain credit, easier marketing and an attractive guaranteed price. However, low yields limit production partly due to the lack of a planting method that establishes optimal populations. The present method is to plough and plant in the same operation, dribbling the seed behind the ox-plough. This often leads to uneven depth of planting, and hence to poor seedling emergence and erratic stands. Alternative planting techniques evaluated on farmers' fields for three seasons (1985/86-1987/88) suggest that farmers should replace their practice of planting behind the plough with either hand seeding following a plough-harrow operation or the use of a modified ox-drawn planter (Taparia).

K. S. Chanda, M. Bezuneh, P. T. Gibson, F. J. Olsen y R. E. Hudgens: *Una evaluación agro-económica de los métodos de plantación de la soja en la Provincia Central de Zambia.*

RESUMEN

La soja (*Glycine max*) es un cultivo relativamente nuevo para los agricultores a pequeña escala en Zambia, adoptado tras la introducción de nuevos cultivares, mayores oportunidades de consequir crédito, mayor facilidad de comercialización y un precio garantizado atractivo. No obstante, los bajos rendimientos limitan la producción, debido en parte a la falta de un método de plantación que establezca poblaciones óptimas. El método actual consta de arar y plantar en una sola operación, dejando caer la semilla detrás del arado de bueyes. Esto a menudo significa que la profundidad de plantación es irregular y por ende que la emergencia de plantones es muy pobre, dando lugar a poblaciones erráticas. Las técnicas alternativas de plantación que se evaluaron en los campos de los agricultores durante tres temporadas (1985/86-1987/88) sugieren que los agricultores deberían sustituir la práctica común de plantar detrás del arado sembrando a mano, seguido por una operación con arado y grada, o el uso de un plantador modificado tirado por bueyes (Taparia).

INTRODUCTION

Soyabean (*Glycine max* (L.) Merr.) is a relatively new crop to Zambia especially for traditional and small-scale farmers (Zambia Ministry of Agriculture and Water Development, 1985). Several factors have encouraged its cultivation. Recently financial credit for small-scale soyabean production units has been provided by the Lint Company. Additionally, two soyabean cultivars, Hernon

147 and Magoye, which form nodules in association with indigenous rhizobia have been identified (Javaheri, 1985). These cultivars are especially suitable for small-scale farmers, who do not have easy access to rhizobium inoculum. Recently, the price of soyabeans has been very attractive so that there has been considerable interest in producing them as a cash crop.

The shortage of labour between late October and January, when all cash and staple crops are planted, is a major constraint to crop production in Central Province, Zambia (Zambia Ministry of Agriculture and Water Development, 1983). This contributes to poor seedbed preparation, resulting in a poor soil tilth with large clods. Most seed is planted by dribbling behind an ox-drawn plough because the method is fast and releases labour for other uses but seeding depth varies and is often too deep, resulting in poor seedling emergence and erratic stands. Fehr *et al.* (1985) reported an average soyabean emergence of 73% from planting at a depth of 5 cm and only 44% at a depth of 10 cm. An alternative method of planting soyabeans, named LIMA, involves preparing the land by hand-hoe, opening furrows by hand, distributing seed along the furrows, and covering by hand. The objective of this research was to evaluate different soyabean planting methods for farmers in Central Province, Zambia by comparing the resulting plant stands at harvest, yields and economic benefits.

MATERIALS AND METHODS

This study was conducted during the rainy season (November to April) from 1985/86 to 1987/88 in Kabwe Rural District, Central Province, Zambia. In the northern part of the District, the primary soil is Mushemi series (Kandilestalf, clayey, kaolinitic, isokyperthermic) and in the southern part Mutwale series (Oxic Palesustult, clayey, kaolinitic, isokyperthermic). On-farm research was carried out using farming systems methodology (Perrin *et al.*, 1976).

Six different soyabean planting techniques were evaluated: (i) seed dribbled behind the plough in alternate furrows and covered with soil thrown by the plough as it opened the next furrow; (ii) seedbed prepared using oxen; seed planted using the seed box of a 'Taparia' maize planter modified after the first year by removing a piece of metal (1.5 cm^2) from the centre of the bottom of the lever of the fertilizer hopper; the seed was placed in this hopper, which was calibrated to obtain the desired seeding rate; (iii) seedbed prepared using oxen; seed then dribbled into a furrow made by an ox-drawn implement and covered using a light ox-drawn harrow (plough-harrow); (iv) seedbed prepared by hand-hoe; seed placed in furrows opened by hand and then hand covered (LIMA method); (v) seed planted in every third furrow using a 'Sebele' maize planter behind an ox-drawn plough; and (vi) hill planting; land ploughed and harrowed by oxen, then six seeds dropped in hills spaced 25 cm apart.

Since the farming system in Kabwe Rural District is characterized by widespread ownership of cattle for draught purposes, the emphasis in this evaluation of planting techniques was on methods involving animal power.

The plots measured 5 by 20 m and were set out in a randomized complete block design with four replications. Row width was 50 cm. Two sites were used in the first year and four in the next two years. They were located both on crop land and on fallow or virgin ground and included both soil groupings. Planting dates ranged from mid-December to early January. Weeding was done by hand as needed. The soyabean cultivar Hernon 147 planted at 500 000 seeds ha^{-1} was used each year. Stand counts were obtained at harvest. The soyabeans were hand harvested, threshed, and the yields adjusted to 12.5% moisture. Marginal and risk analyses were carried out for the 1986/87 and 1987/88 cropping seasons in order to compare and assess the different soyabean planting methods and to make recommendations to farmers.

RESULTS AND DISCUSSION

Neither the Taparia nor the Sebele planter operated satisfactorily in the first cropping season. The Taparia was subsequently modified but the Sebele planter was dropped from the study because it was not readily available in Zambia and because it could not easily be modified to improve its performance.

Although dribbling soyabean seed behind the plough is labour saving, it consistently resulted in the smallest plant densities at harvest as well as the poorest grain yields of any of the planting methods evaluated (Table 1). The modification of the ox-drawn Taparia planter gave improved plant stands as well as grain yields. The LIMA method, used mainly by hand-hoe farmers, resulted in good soyabean stands and yields but was very labour intensive. The plough-harrow technique resulted in good stands and yields in each year of the study.

Hill planting was assessed during the 1987 cropping season and was found to be quite labour intensive. Javeheri and Nkumbula (1984) compared the performance of soyabean cultivars using two planting methods (drilling and hill planting) and found no yield differences.

One of the objectives of the present study was to determine which method

Table 1. *Soyabean yield (t ha^{-1}) and plant populations at harvest (10^5 plants ha^{-1}) with different planting methods*

	1986		1987		1988	
	Plant population	Yield	Plant population	Yield	Plant population	Yield
Seed dribbled behind the plough	1.3	0.57	1.1	0.40	1.9	2.15
Ox-drawn planter (Taparia)	1.8	0.79	3.1	0.86	2.3	2.30
Plough-harrow	3.4	1.41	2.7	0.79	2.9	2.50
LIMA	3.0	1.76	2.7	0.86	–	–
Sebele planter	1.9	1.12	–	–	–	–
Hill planting	–	–	2.3	0.85	–	–
SED	0.50	0.31	0.46	0.10	0.19	0.10

of soyabean planting generated the highest marginal rate of return to cash and labour invested. The basic concerns of traditional (subsistence) and small-scale farmers in adopting any new technology are often expressed in terms of the additional benefits and the stability of the benefits. Farmers ask whether the new alternative (method) offers enough additional benefit to warrant additional investment, and how risky (or stable) the new alternative is in relation to their existing practice.

The various soyabean planting methods differed greatly in their labour requirements, with the LIMA being the most labour-intensive (Table 2).

In 1987, the ox-drawn Taparia planter generated the largest mean net benefit, the largest minimum net benefit and the smallest standard deviation (Table 3). It was the only undominated treatment, i.e. the only treatment for which there was no alternative with smaller variable cost and larger net benefit. The plough-harrow technique was the next best treatment. All other methods, including the usual farmer practice of dribbling seed behind the plough, showed minimum net benefits. The ox-drawn planter (Taparia) planting method again gave the largest net benefit in 1988. It also generated the largest minimum net benefit and had almost the same standard deviation as the other two methods. The marginal analysis provided further evidence to support the ox-drawn planter (Taparia) as the preferred planting method. Its rate of return for each additional Kwacha invested was ZK 63.3 and 2.9 over and above the dribbling-behind-the-plough method in 1987 and 1988, respectively. Both the ox-drawn planter and the plough-harrow methods might be selected instead of the farmer's own practice, though it is assumed that traditional and small-scale farmers are unlikely to commit any of their resources unless there is at least a 40% rate of

Table 2. *Average labour demand (man days ha^{-1}) for five soyabean planting methods†, 1987*

	Seed dribbled behind the plough	Ox-drawn planter (Taparia)	Plough harrow	LIMA	Hill planting
Land preparation including dribbling seed behind the plough	3 (Ox)	3 (Ox)	3 (Ox)	28 (H)	3 (Ox)
Harrowing	–	1 (Ox)	1 (Ox	–	1 (Ox)
Opening hills or furrows	–	–	25 (H)	25 (H)	13 (H)
Planting	–	1 (Ox)	21 (H)	21 (H)	21 (H)
Covering seed	–	–	–	17 (H)	17 (H)
Harrowing to cover seed	–	–	1 (Ox)	–	–
Weeding	23 (H)	9 (H)	7 (H)	7 (H)	5 (H)
Harvesting	4 (H)	10 (H)	9 (H)	10 (H)	10 (H)
Threshing and cleaning (a man-day/90 kg bag)	4	10	9	10	9
Total	34	34	76	118	79

† (Ox) Indicates an operation done by oxen, (H) indicates an operation done by hand.

Table 3. *Summary of risk and marginal net benefit analysis (100 ZK ha^{-1})† of soyabean planting methods in 1987 and 1988 (mean of four sites)*

	Mean net benefit	Standard deviation	Total variable cost	Marginal net benefit compared with dribbling	Minimum‡ net benefit	Extra return (ZK ha^{-1}) per Kwacha invested compared with dribbling
			1987			
Seed dribbled behind plough	1.0	2.6	4.7	–	−1.4	–
Taparia ox-drawn planter	7.3	3.7	4.6	6.3	5.0	63.3
Plough harrow	3.6	3.8	7.8	2.6	0.8	0.8
Hill planting	1.6	2.9	10.6	0.6	−0.9	0.1
			1988			
Seed dribbled behind plough	39.7	14.2	6.9	–	25.0	–
Taparia ox-drawn planter	46.0	17.9	8.3	6.3	27.5	4.5
Plough harrow	42.0	16.7	7.9	2.3	26.7	2.3

† US $1 = 8 Zambian Kwacha (ZK).
‡ Calculated from the worst observation of the experiment.

return. However, both the risk and the marginal analysis suggest that use of the ox-drawn planter (Taparia) is the superior planting method.

Soyabeans planted by the plough-harrow method and ox-drawn modified Taparia planter performed better than those planted using the traditional method of dribbling seed behind the plough. In all three years of the study, the plough-harrow method gave significantly better crop stands than dribbling seed behind the plough and resulted in better yields in two of the three years. Both agronomic and economic analyses indicate that farmers in Zambia with oxen would benefit from adopting either the plough-harrow method of planting soyabeans or the modified Taparia planter method.

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