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Full Length Research Paper

Comparative performance of direct seeding and transplanting green maize under farmer management in small scale irrigation: A case study of Zanyokwe, Eastern Cape, South Africa

M. Fanadzo, C. Chiduza* and P. N. S. Mnkeni

Department of Agronomy, University of Fort Hare, Private Bag X1314, Alice 5700, South Africa.

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An on-farm experiment was conducted at Zanyokwe irrigation scheme (ZIS) in the Eastern Cape Province of South Africa (SA) to evaluate comparative performance of direct seeded and transplanted green maize under farmer management. Results indicated that the mean labour requirements for establishment were 212 h ha^{-1} with transplanting and 1.9 h ha^{-1} with direct seeding. Crop stand significantly increased from 48 to 97% when maize was transplanted rather than directly seeded. Variable costs were R5 462 and R1 896 ha^{-1} for transplanted and directly seeded maize, respectively. The corresponding net benefits were R15 005 and R6 232 ha^{-1}, respectively. All farmers were in favour of transplanting, citing bigger cobs, early maturity and the absence of bird damage with transplanted maize, and this was supported by results of statistical analysis. A follow-up survey conducted during the subsequent summer growing season indicated that of the six farmers, only one continued with transplanting. The results suggest that although transplanting might be a better alternative to direct seeding for the study area, the technology is unlikely to succeed unless the labour intensiveness of manual transplanting can be solved.

Key words: Direct seeding, transplanting, farmer management, crop stand, green maize, economics, adoption.

INTRODUCTION

Green maize is one of the most important crops in smallholder irrigation schemes (SIS) in SA (Department of Agriculture, 2006; van Averbeke, 2008). A number of varieties are recommended and these include SR 52, SC 701, HL 19, HL 23, PAN 93, PAN 6549, PAN 8M-95, SNK 2665, SNK 2147, ETZ 200, ETD 538, ETD 634, ETD 646 and ETC 791 (National Department of Agriculture, 1998; van Averbeke, 2008). However, successful production of maize in many SIS is hampered by bird damage to emerging seedlings causing low stand establishment. In the Eastern Cape, bird damage was reported to be the main biological constraint in six SIS (van Averbeke et al., 1998). Fanadzo et al. (2009) also noted high levels of damage to maize seedlings at ZIS, indicating a persistence of the problem.

Transplanting is a strategy that is commonly used to establish crops when conditions are less favourable for direct seeding. In SA, maize transplanting is used by some commercial farmers for production of green maize. On - farm researcher - managed trials conducted at ZIS showed a significant difference in plant stand between transplanted and direct seeded maize (Fanadzo et al., 2009). In that study, transplanting achieved a stand of 99% of target compared with 81% using direct seeding.

The reduction in crop stand with direct seeding was as a result of bird damage to emerging seedlings.

*Corresponding author. E - mail: cchiduza@ufh.ac.za.

Abbreviations: SA, South Africa; **ZIS,** Zanyokwe irrigation scheme; **SIS,** smallholder irrigation schemes.

One advantage that can be derived from transplanting relates to savings in re-planting, depending on the magnitude of damage to emerging seedlings. This would include seed and labour costs needed for re-planting. Each surviving seedling adds to income, as cob number of appropriate size is an important determinant of income in marketing green maize. Survival of transplants is improved by the selection of strong and healthy seedlings (FAO, 2003). With good establishment, more cobs are attained as a result of increased plant population and therefore more profit is realised. Transplanting can also be used to overcome unfavourable conditions such as low soil temperature and cold winds during planting time (Dale and Drennan, 1997). Soil temperatures experienced during early spring in the Eastern Cape result in delayed emergence of direct seeded maize and slow growth of emerging seedlings. Early green maize crops often fetch high prices owing to scarcity of the commodity at the time of maturity in November/December. Transplanting can offer the opportunity to produce a green maize crop for this early market and thereby increase farmer income in SIS such as ZIS.

The use of transplants shortens the growth period in the field and, consequently, even late-maturing, high yielding cultivars can be produced during the growing season as defined by either rainfall or temperature (Dale and Drennan, 1997). Depending on the age of transplants, time to harvest of maize was reduced by one to three weeks in the USA and 10 to 12 days in France (Waters et al., 1990). In ZIS, transplanted maize developed more rapidly, reaching flowering stage 11 to 15 days earlier than direct seeded maize depending on rate of nitrogen fertilisation (Fanadzo et al., 2009). Furthermore, the reduced crop cycle in the field can result in savings in water used for the production of green maize compared with production using direct seeding. Where farmers use energy to pump and pay for water, such savings would increase the profit realised by farmers.

To succeed, technologies not only have to be improved compared with those previously used, but they also have to be appropriate for the level of farmers' skills and resources, amongst other factors. Keeping in mind that it is the farmer who must ultimately make decisions concerning adoption or rejection of technologies, farmer-managed trials provide the opportunity for farmers to become the primary evaluators of new technology (Hildebrand and Poey, 1985).

Though transplanting maize seedlings offers a number of advantages as described above, one question that remained unknown was the feasibility of using the technology under farmer management with regard to the labour requirement and returns realised in comparison with direct seeding. The latter practice is mechanised in most SIS and requires little labour input. Studies in ZIS (Fanadzo, 2007) showed that labour was a constraint that compromised the management of crops in the scheme. Therefore, a farmer-managed experiment was conducted in ZIS to: (i) compare the productivity of green maize established through transplanting and direct seeding, and; (ii) to investigate and establish the economics of using transplanting in comparison with direct seeding.

MATERIALS AND METHODS

Study site and background

ZIS (32°45´S; 27°03´) is located in the central part of the Eastern Cape Province of SA, at an altitude ranging from 440 to 640 m above sea level. The area has a warm temperate climate with mean annual rainfall of approximately 575 mm, of which about 445 mm is received in summer (van Averbeke et al., 1998). The low rainfall necessitates supplementary irrigation for crop production. The estimated Class A annual evaporation is approximately 1800 mm and frost may occur from mid-June to mid-August (van Averbeke et al. 1998). The predominant soil types are the Oakleaf and Dundee soil types (Soil Classification Working Group, 1991). In terms of suitability for irrigation, these soils are rated moderate to moderately high (Loxton et al., 1983).

Selection of participating farmers

"ZIS is composed of six villages and 75% of farmers are located in two villages, that is, Lenye and Burnshill, which were selected for this study. The majority of the farming households are low - income and resource – poor" (Njokweni, 2004). Agronomic studies conducted in Burnshill village in 2006/07 summer season showed that transplanting offered a solution to improving the poor stand observed in maize fields as a result of bird damage. The annual review of these trials in 2007 was attended by 25 farmers from the two villages and 14 of these volunteered to test the transplanting technology under farmer management. A sample of six farmers was selected from the 14 based on the ability to meet cost of land preparation, fertiliser, labour as well as evidence of record keeping.

Treatments and plot size

The trial comprised of two establishment methods as treatments; direct seeding and transplanting of maize seedlings. The variety used was SC701 obtained from Seed-Co® (South Africa). This variety was selected as the most popular by ZIS farmers for green maize production in trials conducted in the scheme in 2005/06 (Fanadzo et al., 2008). Each farmer received 4 000 two-week old seedlings purchased from a commercial nursery at R0.12 cents per seedling. For the direct seeded plot, each farmer received 8 kg of seed. The farmers established both plots on the same day and managed them uniformly following own farm practices. Seedlings were transplanted manually whereas seeds were planted using a tractor-drawn planter. Plot sizes for transplanted maize ranged from 0.07 to 0.14 ha, depending on the target population, whilst for direct seeded maize all plots were 0.3 ha in size. Four of the six farmers transplanted seedlings one day after delivery on 22 November 2007 and the remainder four days after receipt of seedlings on 26 November 2007.

Fertiliser management

Basal fertiliser was applied as compound fertiliser 2:3:4 (30) at rates varying from nil to 16.7 kg N ha^{-1} with a mean of 12.7 kg N ha^{-1} (Table 1). Basal fertiliser was spot-applied and banded in planting furrows with transplanting and direct seeding, respectively. Three

Table 1. Fertiliser management across the six farms.

Farmer	Fertiliser N (kg ha^{-1})		
	Basal N	Top dressing	Total
Farmer A	16.7	70.0	86.7
Farmer B	13.3	70.0	83.2
Farmer C	Nil	Nil	Nil
Farmer D	16.5	Nil	16.5
Farmer E	13.3	70.0	83.3
Farmer F	16.7	115.0	131.7
Mean	12.7	54.2	66.9

Table 2. Post-plant weed control by the different farmers.

Farmer	Post-plant weed control	Frequency and timing	Cost of control (R ha^{-1})
Farmer A	Hand hoeing	Once at 3 WAE[1]	2 500
Farmer B	Combination of atrazine at 5l ha-1 and inter-row cultivation	Twice at 2½ and 5½ WAE	564
Farmer C	Sprayed atrazine at 5l ha-1	Once at 3 WAE	364
Farmer D	Nil	-	0
Farmer E	Combination of atrazine at 5l ha-1 and inter-row cultivation	Twice at 3 and 6 WAE	564
Farmer F	Hand hoeing	Twice at 2 and 5 WAE	3315

[1]WAE = weeks after establishment.

farmers, Farmer A, Farmer B and Farmer E used lime ammonium nitrate (LAN with 28% N) as a topdressing fertiliser while Farmer F used urea (46% N). Topdressing fertiliser application ranged from nil to 115 kg N ha^{-1} with a mean of 54.2 kg N ha^{-1} (Table 1). Farmer C applied neither basal nor topdressing fertiliser to his maize while Farmer D only applied basal dressing.

Weed control

None of the farmers exercised some form of weed control prior to planting/transplanting. Methods and the cost of weed control varied among farmers, and hand hoeing was the most expensive method of control (Table 2).

Measurements

Crop stand was measured in net plots at 21 days after planting/transplanting. Net plots consisted of five rows, each measuring 20 m in length with an inter-row of 0.9 m in the centre of the field yielding a net plot area of 90 m^2. Farmers maintained records for labour used and time taken for planting/transplanting, fertiliser application, pest and weed control and harvesting in the plots on their farms. They also maintained a record of sales and income achieved from the green maize. Casual labour was paid at R25 per day as per farm practice in the scheme. When the maize was ready for marketing, cob size was measured on twenty randomly selected plants in the net plot area of each of the two plots on each farm. Passive evaluation (Hildebrand and Poey, 1985) was conducted through a focus group discussion held with the six farmers after conclusion of green maize sales to assess farmer perceptions of comparative performance of transplanting and direct seeding and technology preference during the year of the trials. Active evaluation (Hildebrand and Poey, 1985) was done during the subsequent year to assess adoption of technologies by farmers.

Data analysis

Analysis of variance was performed on crop stand at 21 days after establishment, cob length at maturity and percent sales of the green cobs using Genstat Release 7.22 DE. For percent cob sales, data were arc-sine square root transformed for mean separation (Steel and Torrie, 1984). Regression and correlation analysis was also performed on these parameters. Least significant difference (LSD) was calculated at 5% confidence level to compare treatment means using Student's t-test (Ott, 1998). Descriptive analysis was applied for data from the focus group discussion and involved a summary of major themes (Goldenkoff, 2004).

RESULTS

Target population and labour for crop establishment

With transplanting, target plant population was highly variable and ranged from 27 778 to 55 556 plants ha^{-1}, whilst with direct seeding the target was constant at 41 152 plants ha^{-1} (Table 3). Transplanting had higher labour requirements averaging 212 h ha^{-1} compared to direct seeding which required an average of 1.9 h ha^{-1} with direct seeding (Table 3).

Crop establishment

Crop establishment varied with establishment method

Table 3. Labour requirements and cost, and target population at crop establishment.

Farmer	Establishment labour requirement (hrs ha^{-1})		Establishment labour cost(R ha^{-1})		Target population (plants ha^{-1})	
	TR[1]	DS[2]	TR	DS	TR	DS
Farmer A	185.0 (578)	1.6 (350)	578	350	37 037	41 152
Farmer B	208.0 (650)	3.2 (700)	650	700	39 683	41 152
Farmer C	250.0 (781)	1.6 (350)	781	350	55 556	41 152
Farmer D	227.0 (709)	1.6 (350)	709	350	50 505	41 152
Farmer E	208.0 (650)	1.6 (350)	650	350	39 683	41 152
Farmer F	194.0 (606)	1.6 (350)	606	350	27 778	41 152
Mean	212.0 (663)	1.9 (408)	663	408	41 707	41 152

[1]TR = Transplanted; [2]DS = Direct seeded.

Table 4. Crop establishment (percentage of target population) with transplanting and direct seeding.

Farmer	TR	DS	Action with respect to direct seeded maize
Farmer A	98	85	Generally satisfactory
Farmer B	98	5	Replanted and gap-filled replanted maize
Farmer C	98	85	Generally satisfactory
Farmer D	95	20	No resources for replanting
Farmer E	98	5	No resources for replanting
Farmer F	95	90	Satisfactory
Mean	97	48	-

Table 5. Length of maize cobs (cm) under different establishment methods across farms.

Farmer	Transplanted maize	Directly seeded maize
Farmer A	33	25
Farmer B	36	35
Farmer C	25	17
Farmer D	26	18
Farmer E	36	33
Farmer F	36	33
Mean	32	26.5

and across farms (Table 4). Unlike in transplants, seedling establishment in direct seeded maize was highly variable with a range of 5 to 90%. The reduction in crop stand with direct seeding was a result of birds that fed on emerging seedlings. The birds either picked up the sown seed from the field before emergence or damaged the young seedlings by discarding the aerial portion and feeding on the remaining seed. Farmer B, one of the farmers who achieved a 5% stand in direct-seeded maize had to replant the whole area while Farmer D and Farmer E could not replant despite achieving low stands because they lacked extra seed, fertiliser and cash for extra land preparation. After replanting, Farmer B still had to gap-fill after the second crop gave a stand of 70%. Regression analysis between crop stand and establishment method showed a significant ($p < 0.05$, $r = 0.95$) increase in crop stand with transplanting. Analysis of variance indicated that crop stand significantly ($p < 0.05$) increased from 48 to 97% when maize was transplanted rather than direct seeded.

Cob length

Average cob length varied across farms and between establishment methods (Table 5). Regression analysis indicated significant correlations between cob length and establishment method and between cob length and fertiliser rate ($p < 0.01$; $r = 0.83$). Analysis of variance showed that transplanted maize produced significantly ($p< 0.01$) longer cobs of 32 cm than direct seeded maize, which produced cobs that were 27 cm long.

Table 6. Summary of maize sales by farmers.

Farmer	Transplanted maize			Directly seeded maize		
	Percent sales	Average price cob^{-1}	Gross income (R ha^{-1})	Percent sales	Average price cob^{-1} (R)	Gross income (R ha^{-1})
Farmer A	0	-	0	3	1.50	1 395
Farmer B	74	R2.00	59 028	70	1.50	43 341
Farmer C	3	R2.00	2 778	0	-	0
Farmer D	0	-	0	0	-	0
Farmer E	61	R2.00	48 472	0	-	0
Farmer F	23	R2.50	12 528	5	2.50	5 144
Mean	27	R2.08	20 468	13	1.83	16 626

Table 7. Partial budget on green maize production through transplanting and direct seeding.

Costs that vary (R ha-1)	Farmer A		Farmer B		Farmer C		Farmer D		Farmer E		Farmer F	
	TR[1]	DS[2]	TR	DS	TR	DS	TR	DS	TR	DS	TR	DS
Crop establishment	578.00	350.00	650.00	700.00	781.00	350.00	709.00	350.00	650.00	350.00	606.00	350.00
Seeds/seedlings	4 800.00	1 275.45	4 800.00	2 550.90	4 800.00	1 275.45	4800	1 275.45	4 800.00	1 275.45	4 800.00	1 275.45
Variable costs	5 378.00	1 625.45	5 450.00	3 250.90	5 581.00	1 625.45	5 509.00	1 625.00	5 450.00	1 625.45	5 406.00	1 625.45
Gross benefits (R ha^{-1})	0.00	1 395.00	59028.00	43341.00	2 778.00	0.00	0.00	0.00	48472.00	0.00	12528.00	4 032.00
Net benefits (R ha-1)	-5 378.00	-230.45	53578.00	40090.10	-2 803.00	-1 625.45	-5 509.00	-1 625.45	43022.00	-1 625.45	7 122.00	2 406.00

[1]TR = Transplanted maize; [2]DS = directly seeded maize

Table 8. Adoption of technologies by the six farmers in 2008/09.

Farmer	2008/09 action	Reason for action
Farmer A	Direct seeded 2 ha	Could not use transplanting because of the large area planted.
Farmer B	Transplanted 10 000 seedlings and direct seeded 1.4 ha	Good performance from transplants the previous season. Seedlings were established on a smaller area because of seedling cost and labour cost at establishment
Farmer C	No green maize production	Lacked cash to buy seeds or seedlings
Farmer D	No green maize production	Lacked cash to buy seeds or seedlings
Farmer E	Direct seeded 0.2 ha	Could not use seedlings because of shortage of labour for establishment
Farmer F	Quitted farming because of illness	Suffered stroke during 2007/08 season

Green maize sales

Details of green maize sales are presented in Table 6. Establishment method had no significant ($p > 0.05$) effect on percent cob sales. Percent cobs sold tended to be higher when seedlings were used instead of seeds ($r = 0.95$), but this was not significant at 5% level. All but one farmer relied on hawkers who purchased the green cobs from the field.

Economic analysis

Economic analysis was performed by constructing a partial budget (CIMMYT, 1988) as presented in Table 7. The partial budget indicated that only two farmers, Farmer B and Farmer F, realised positive net benefits regardless of establishment method. They were also the only farmers who realised positive net benefits with direct seeding. With respect to transplanted maize, three farmers realised positive net benefits while the other three had negative net benefits. For Farmer B, who realised the highest net benefits regardless of establishment method, the net benefits realised from transplanted maize were R13 487.90 higher than those realised from direct seeded maize for the planting season.

Passive evaluation of technologies

Interviews during the focus group discussion conducted after the conclusion of sales indicated that, regardless of establishment method, all farmers were in favour of green as opposed to grain maize production as had been the practice in the scheme. There were three widely noted benefits of green over grain maize production: (1) green maize was more profitable, (2) maize grown for green cobs had a shorter production cycle, leaving enough time to prepare for winter planting, and; (3) there was no need to invest in labour for harvesting, processing and packaging as customers purchased the green cobs from the field. When the two methods of establishment were compared, all farmers were in favour of transplanting. All farmers agreed that transplanted maize produced bigger cobs relative to direct seeded maize, developed more rapidly and matured earlier than direct seeded maize, and furthermore, resulted in better crop stand due to the absence of bird damage.

Participants commented that the absence of bird damage in transplanted maize meant savings in time, labour, money and other resources as there was no need to replant or gap-fill, operations which would require additional land preparation, planting and seed. It was also cited that weed management was easier in transplanted maize because of the rapid growth of the maize. Commenting on the labour requirements for transplanting, farmers agreed that this was not a major concern as they used the same strategy in cabbage and other vegetable crops, but still realised higher profits. However, they expressed concern that that the labour intensiveness of transplanting might limit the area planted to the crop given the serious shortage of labour in the irrigation scheme, particularly in summer. Another concern raised by farmers with regard to green maize production was the need for transport to take the produce to market as customers purchasing at the farms did not purchase the whole harvest of cobs.

Active evaluation of technology adoption

Semi-structured interviews conducted during the subsequent summer season indicated that the overall number of green maize producers in the study area had increased from eight in 2007/2008 to 10 in 2008/2009. Of the six farmers previously involved in the trials, only three continued with green maize production, two did not plant the crop, while the sixth was no longer involved in farming. Of the three producers in 2008/2009, one farmer used a combination of transplanting and direct seeding, while the other two only used direct seeding (Table 8). The farmer who continued with transplanting in 2008/09 was the same one (Farmer B) who realised the highest net benefits regardless of establishment in 2007/2008. The reason cited by this farmer for transplanting on a smaller area of about 0.25 ha compared with 1.4 ha for direct seeded maize was the unavailability of labour for establishing a bigger area. The reason cited by the other two farmers for not using seedlings was that labour for establishment was difficult to source and could be expensive especially for bigger areas of 2 ha as was the case with Farmer A. All farmers still agreed that seedlings were better than direct seeding; however, finance was a limitation in terms of buying the seedlings and/or establishment labour. Two farmers, who were not part of the farmer-managed trials had initially tried using seedlings, but discontinued after the alleged poor performance of the transplants. Reasons cited for poor performance included poor quality of seedlings, heavy stalk borer attack on transplanted maize and slow growth of early-planted seedlings.

DISCUSSION

The results of this study indicated that it might be viable to use seedlings for green maize production in places where bird damage to seed or emerging young seedlings is a problem. In this regard, the viability relates mainly to superior crop stand, and hence more cobs per unit area with transplanted maize compared with direct seeded maize. Other superior attributes of transplanted seedlings include the shorter duration for cob production and longer cobs compared with direct seeding at lower levels of fertilisation. Improved crop stands and bigger cobs with transplanted seedlings translate to more marketable cobs per unit area, and hence more profit. Since transplanted maize is harvested earlier than directly seeded maize, this may translate into higher cropping intensities as more crops can be grown at one given time on a specific piece of land. This leaves farmers with enough time to prepare for the next crop, allowing farmers to be more efficient in their farming operations. The major limitation of using seedlings may be the high labour requirements for establishment through transplanting.

The study indicated a stand reduction by as much as 95% with direct seeding due to birds that fed on the planted seeds or emerging seedlings. In such situations, direct seeding was very costly because of the need to replant, a process that required additional input costs (that is seed, planting labour, water and additional land preparation in some cases). This, in many cases, would lead to late operations, which would affect the timely planting of the next crop, hence lowering cropping intensities. In this study, despite the fact that three farmers had achieved low crop stands of up to 20% of the target, only one farmer managed to replant whilst the other two farmers could not re-seed due to lack of additional resources. For the farmer who replanted, he still had to gap-fill, indicating how serious bird damage is in the study area. The study indicated that the plant density using transplanting was highly variable and could be as low as 27 778 plants ha^{-1} while with direct seeding, the population was constant at 41 152 plants ha^{-1}. The Department of Agriculture (2003) recommends a plant population of 45 000 to 65 000 plants ha^{-1} for medium to late maturing cultivars under irrigation in SA. This indicates that with the exception of the two farmers, Farmer C who targeted 55 556 plants ha^{-1} and Farmer D who targeted 50 505 plants ha^{-1} with transplanted maize, the rest of the farmers were using lower plant populations because of lack of knowledge or skill. With direct seeding, all farmers used a below-optimum plant population for the same reason of lack of skill, and this was caused by the maize planter calibrated to plant at 41 152 plants ha^{-1}. Calibrating the maize planter operating in the scheme to plant at the recommended population is expected to result in a higher number of cobs per unit area leading to higher gross margins with good stand establishment and subsequent management. The rate of N fertilisation was generally low for all farmers for the variety used. Though no fertiliser N recommendations are available specifically for green maize production in SA, the Fertiliser Society of South Africa (2007) recommends 220 kg N ha^{-1} or more for optimum grain production under the study area conditions and for the variety used. To obtain 100% marketable cobs using the same variety and in the same study area, Fanadzo et al. (2009) reported that the optimum N rates required were 149 kg N ha^{-1} with direct seeding and 98 kg N ha^{-1} for transplanted maize. This means that transplanted maize can be grown at lower fertiliser rates than direct seeded maize. Cob length increased with higher N rates indicating that application of low fertiliser rates limited green maize productivity regardless of establishment method. However, since observed trends indicated that transplanted maize generally yielded longer cobs that direct seeded maize at similar rates of fertilisation, seedlings may be more favourable than direct seeding with low fertiliser rates as commonly used by smallholder farmers. Monitoring studies in the study area indicated that poor weed control was one of the major factors limiting productivity of maize (Fanadzo, 2007).

In this study, weed control was generally not a big problem probably because of the smaller areas planted to the crop. Although not measured in this study, the rapid development of transplanted maize relative to direct seeded maize is expected to result in better weed control and better water use efficiency by shortening the time the maize has to be irrigated. This was also cited by farmers as one of the advantages of transplanting over direct seeding. Scheffer (1992) reported that with transplanting, the need for herbicides could be reduced since the rapid growth of the maize seedling transplants is more competitive with weeds than the slow establishment phase of direct seeded maize. Being a vegetable crop, green maize has a short life span and has to be marketed as soon as possible after it reaches maturity. The critical period for harvesting green maize is only about four days (National Department of Agriculture, 1998). In this regard, the results of this study demonstrate that, regardless of establishment method, readily available transport is a pre-requisite for marketing of green cobs. Availability of transport allows farmers not only to sell the produce on time, but also to sell on competitive markets. This was demonstrated by one farmer who competitively marketed her produce in a town about 20 km away from her farm as she was able to deliver using her vehicle. Marketing cobs at the field to hawkers resulted in far lower prices being obtained (80% less in some instances) than by selling at markets. Since the maize was produced at the same time by the six farmers, it matured at approximately the same time, resulting in competition among the farmers. One solution to this problem would be to stagger plantings so that maize from different fields (or farmers) matures at different times and this would reduce competition and maximise sales. This is one of the strategies used by farmers in the scheme for cabbage production. It is apparent from the study that, just as for direct seeded maize, good management of weeds, soil fertility, and pests among other factors, is important for transplanted maize. Stalk borer control in transplants is crucial in order to reduce plant losses and time of transplanting must be taken into account by the farmers. By the time the seedlings are transplanted, they are already at a physiologically advanced stage of growth, meaning that stalk borer control has to be carried out earlier compared with direct seeded maize. Poor weed and fertility management were among the causes of poor performance. Early timing of top-dress fertilisation is also critical in transplanted maize for the same reasons as cited for stalk borer control.

Economic analysis showed that even though the total costs that varied were higher for transplanted maize, the net benefits were still higher than for direct-seeded maize at three of the six farms. However, the results also indicate that with improper management, farmers incurred more losses when transplanting was used rather than direct seeding, mainly because of the higher costs that varied with transplanting. Establishment method did not significantly affect number of cobs produced due to the interaction of many factors. The negative net benefits incurred at some farms regardless of establishment method were as a result of many factors such as: (i) failure to control weeds which resulted in unmarketable cobs; (ii) stand reduction due to bird damage forced some farmers to abandon their fields as they did not have additional resources for crop re-establishment; (iii) lack of transport to take produce to market, and (iv) failure to apply fertiliser or application at lower rates resulted in few or no marketable cobs.

Conclusion

Results of this study suggested that transplanting promotes achievement of a good plant stand, which would translate into a higher number of green cobs and higher returns in areas where bird damage is a problem. Since transplanted maize produced longer cobs than direct seeded maize at similar N rates, transplanting might a better alternative to smallholder farmers who generally apply low fertiliser rates to their maize. Despite the popularity of transplanting during the execution of the trials, active evaluation indicated that only one farmer adopted the technology the following season, meaning that the technology might not be suitable in situation where labour is in short supply as was the case in the study area. In this case, transplanting is unlikely to succeed unless the labour intensiveness of manual transplanting can be solved.

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