5.1.2.3 Labour

The peaks and troughs of the labour demand over the year varied between the areas and differed for men and women. In Navrongo the most demanding months for men were July coinciding with the end of sowing and the main period of weeding, September when weeding was finishing and groundnuts, bambara, sweet potato and sorghum were harvested, and October coinciding with the main harvesting period. Additionally in September and October seedlings were being nursed for the dry season gardens. The least demanding months noted were post-harvesting in November and December when dry season gardening started and building maintenance was carried out. Similarly women from Navrongo agreed that July to October was busy for the same reasons of weeding and harvesting but did not refer to dry season gardening, instead noted threshing, drying and preparing crops for storage. Additionally women also reported a second busy period in February/March and May when they were carrying water and sand for men to make bricks for the houses, plastering, working in the dry season gardens, market trading and in additionally in May sowing and land preparation. Women agreed with the men that the least demanding time was November/December when they were threshing, drying and storing food crops. Women also mentioned that infestation problems occurred if crops were left to dry in the field and should preferably be harvested early and dried around the homestead. Examples of storage treatments are wood ash and some herbs e.g. cassis tree leaves, which are mixed with the food crops to reduce pest attack.

In Wiaga and Fumbisi the main labour intensive period for men was earlier than in Navrongo, occurring in April to July coinciding with the land clearing, ploughing and sowing time, then weeding and harvesting early millet. They also said that there was a peak in November/December (unlike Navrongo which noted that these months are the least demanding) particularly when they were harvesting from the bush farms, which are a distance from the homestead, but also due to the start of dry season gardening, threshing and collecting stalks for thatch. The reason for this difference between Navrongo and Wiaga/Fumbisi is that in Navrongo farmers do not generally have bush farms and therefore finish harvesting earlier. They said the least demanding months were in January/February when there was mainly only dry season gardening. Women agreed that April to August was the main busy period for similar reasons to men adding that they took manure to the compound fields, and prepared food and carried water for farm labourers. Additionally women said that October was also a busy month due to harvesting, threshing and food preserving. The least busy month was December when the final threshing and storage took place and January when they were re-plastering their houses.

In Teshie and Ankpaliga, as in Navrongo, men said that August and October due to weeding and harvesting respectively, were the most labour demanding months. This was particularly true of October, as they had to harvest the compound farm quickly so they could harvest the bush farms before roaming animals damaged them. Additionally unlike the farmers from other areas that said January was a low labour demand time, farmers from Teshie and Ankpaliga said this time was busy due to nursing and watering dry season gardens, cutting grass for thatch and weaving zama mats. The least demanding month was December when food was harvested and they were getting ready for Christmas. Conversely women noted that June/July was busy due to sowing and weeding, September due to harvesting legumes and maize and November/December due to final harvesting and cutting stalks in the bush for fuel. The least busy months were April /May when they were preparing the compound yard, plastering and waiting for the rains.

From the discussions with farmers and the labour charts they produced it became clear that there were gender specific jobs similar to those in Zimbabwe. In terms of house improvements outside the general cropping season, women plastered walls, carried water and sand to make bricks and the men constructed buildings with the bricks, did all roofing requirements and wove zama matts. Men were generally not involved in market selling, but carried out the main harvesting of sorghum and millet. Women did most if not all of the threshing and preparation of food crops for storage, in addition to all the household activities like cooking, fetching water and looking after children and all market activities. Again as in Zimbabwe the nurseries could be set up before the start of the main sowing and weeding activities, in Ghana this would be around April/May. Here too, the transplanting time would coincide with the busy sowing time and the possible constraints associated with this were constantly discussed with farmers during the trials.

5.1.2.4 Seed prices

Farmers in Ghana were also asked to give relative market prices of the sorghum, early millet and late millet over the season. Initially this was to be discussed with mixed groups however it became apparent that men were not generally involved with market activities, therefore discussions were limited to female groups. The patterns and prices varied between the different areas, however generally followed the cropping season (Figure 5.1.10 – 5.1.12).

Late millet and sorghum prices generally remained consistent at the highest price from around May to October; this was approximately 5500/6000 Cedis in Teshie and Ankpaliga, 7000 Cedis in Navrongo and 8000 Cedis in Wiaga and Fumbisi for 2.5 kg. This dropped to the lowest price of around 5000 Cedis for 2.5 kgs in November/December, coinciding with harvesting, which continued to April. Farmers from Teshie and Ankpaliga differentiated between the Bumbago (red) and Belko (white) sorghum. The price for Bumbabgo sorghum was generally slightly lower than Belko from May to July and November/December. The pattern for early millet was different to that of the late millet and sorghum and reached a much higher price at its most expensive time. The highest price for early millet was generally earlier than sorghum around April/May where the price was 10000 Cedis in Wiaga and Fumbisi, 9000 in Teshie and Ankpaliga and 8000 in Navrongo for 2.5 kg. This period is the main sowing time for early millet where demand for seed is high for this important crop. As with to the other crops the drop in price coincided with harvest, which for early millet is June/July/August. In Wiaga and Fumbisi the price fell to 6000, 5000/4000 in Teshie and Ankpaliga and 3000 in Navrongo for 2.5 kg. After this period the price either remained the same as in Wiaga and Fumbisi or increased slightly as in Navrongo before the rise in price in March/April. Farmers from Teshie and Ankpaliga however said that the crop was not available in the market from September to March.

The transplanting of the early millet and the possibility of an earlier harvest would not actually be beneficial in terms of seed price, as the highest price was actually around the time of sowing. However the price for sorghum and late millet dropped around the normal harvest time, therefore if by transplanting the harvest could be brought forward, then a much higher price could be obtained for any seed that was sold.

5.1.2.5 Food availability

Food availability charts (Figure 5.1.13) varied slightly from group to group and between male and female groups, however all showed that the months with the least food available are June/July when most of the reserves in the stores are very low. The food availability generally follows the harvest of the main crops with food being abundant in October-December when the main crops are harvested, gradually falling over the months until August when early millet is harvested. This shows that if the harvest of early millet can be brought forward by a couple of weeks this would break the hunger gap early.

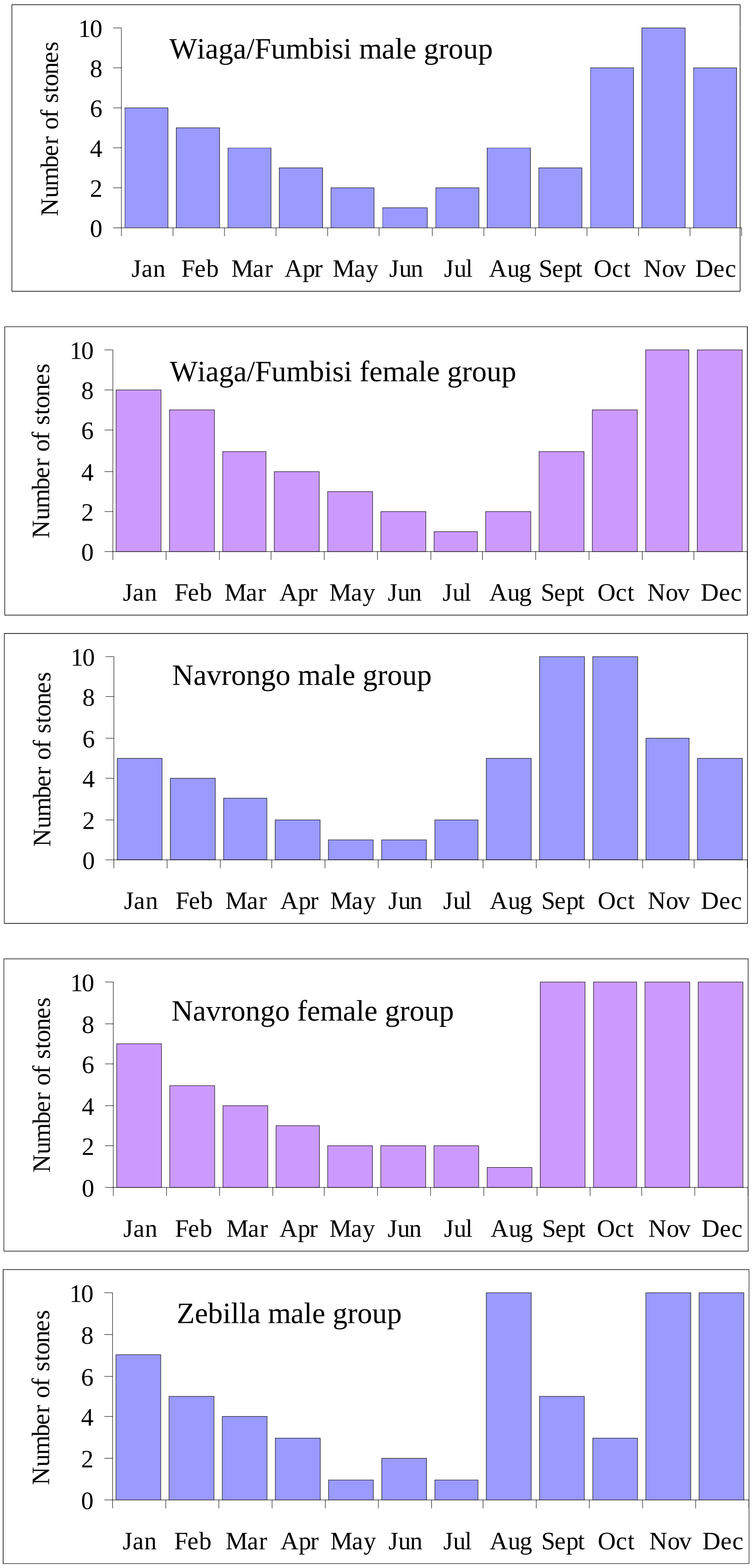


Figure 5.1.13. Food availability charts from different on-farm trials areas

5.2 On-Station Results – Zimbabwe

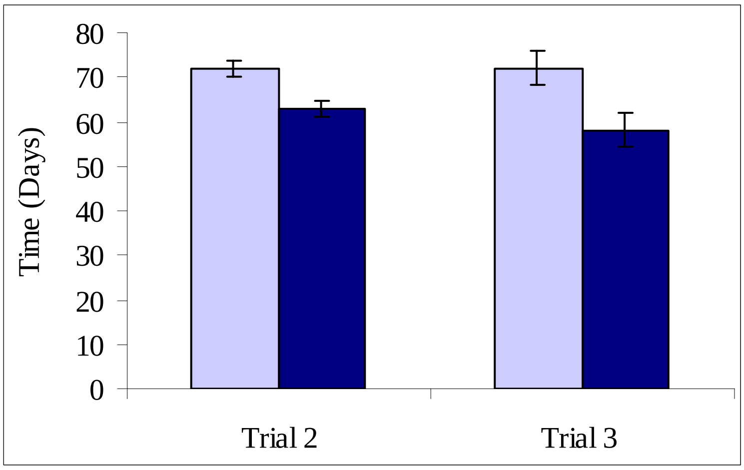
Most of the data in Zimbabwe is taken from the second and third on-station trials, due to the damage caused by cyclone Eline at the end of the first season.

5.2.1 Sorghum

5.2.1.1 Flowering and maturity

Both trials two and three confirmed varietal descriptions that Macia flowers and matures significantly earlier than Mutode ($p<0.001$) with Macia taking approximately 50 days to flower and 80 days to mature, and Mutode taking approximately 75 days to flower and 105 days to mature. Results from the two trials also showed that there were significant differences in days to flowering and maturity between the two treatments with transplanted crops flowering earlier than direct-sown. Figure 5.2.1 shows the mean flowering time across varieties (there was no significant treatment/variety interaction) for both trials. It shows that transplanted plants flowered nine and 14 days earlier than direct-sown plants in trials two and three respectively, the same difference being maintained through to maturity.

Figure 5.2.1. Time to flowering of direct-sown compared to transplanted sorghum. Values are a mean of both varieties. □Direct-sown, ■Transplanted. Treatment SED shown, differences between treatments significant at $p<0.001$.



When the growing time in the nurseries is included in the flowering and maturity periods of the transplanted plants and compared to the direct-sown, *i.e.* days from the time of sowing, the opposite is observed with transplanted plants taking longer to flower and mature than direct-sown. This result shows that the total flowering and maturity periods of the transplanted plants are longer than normal direct-sown plants, which suggest that the transplanted plants suffer from a check in plant growth or ‘transplanting shock’. This occurs when the plant is adapting to its new environment after being transplanted, causing an overall increase in time to maturity compared to a non-transplanted plant. However in real farming situations the time spent in the nursery is before the start of the rains when direct-sown seed in the field would not germinate due to lack of moisture. Therefore, although transplanted seedlings suffer a check in growth, under farming conditions the transplanted sorghum matures earlier than direct-sown.

There was no significant difference in time to flowering between the different seedling ages at transplanting. When the total time to flowering, of the difference seedling ages, including the time spent in the nurseries were compared, the results showed that the older the seedling was at transplanting the greater the transplanting shock experienced by the plant, therefore any advantage in terms of time by transplanting an older seedling was reduced by the greater shock period. There were no significant differences in terms of time to flowering between seedlings transplanted from the different nursery densities.

5.2.1.2 Yield

Yield measurements included number of heads produced and grain yield. All data recorded from trial plots has been scaled up to either per hectare values, which are expressed as t ha^{-1}, or per plant values which are expressed as g $plant^{-1}$. Most of the data is from trials two and three with additional data from trial one where it was available. Unless otherwise stated head weight is fresh at the time of harvest and grain yield is adjusted to 12% moisture content.

Table 5.2.1 displays the mean data for Macia and Mutode taken from trial three. It shows that across treatments Macia produced fewer heads per hectare than Mutode but together those heads weighed more and produced more grain. There was no significant difference between the number of plants surviving to harvest between the two varieties, and the same pattern was therefore observed when results were expressed on a per plant basis.

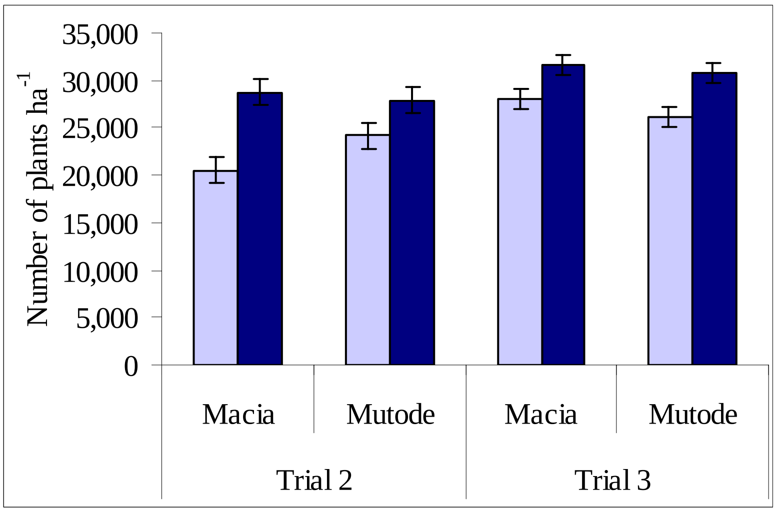
Table 5.2.1. Differences in head number and grain yield (t ha^{-1}) of Macia compared to Mutode sorghum. Values are a mean across all treatments in trial three.

Variety	Head number (ha^{-1})	Grain yield (t ha^{-1})
Macia	37,820	1.64
Mutode	43,437	1.02
SED	2764.8	*0.114*
p-value	*0.049*	*<0.001*

In trial two Mutode produced a significantly greater number of heads than in trial three where the number of heads ha^{-1} was 43,825 for Macia and 75,449 for Mutode ($p<0.001$, SED=2703.3) or when expressed per plant 1.59 heads plant^{-1} for Macia and 2.77 heads plant^{-1} for Mutode ($p<0.001$, SED=0.081). Even though Macia produces larger heads and therefore more grain per head, because in trial two Mutode produced such a large number of heads the effect was balanced out and there were no significant differences in grain yield between the two varieties.

In both trials significant differences were found in yield between the treatments of direct sowing and transplanting. When the plant survival to harvest was compared significantly more ($p<0.001$) transplanted Macia and Mutode sorghum plants survived to harvest when compared to direct-sown (Figure 5.2.2) (there was no significant interaction between variety and treatment).

Figure 5.2.2. Numbers of plants surviving to harvest for direct-sown compared to transplanted Macia and Mutode sorghum. Maximum 33,333 plants ha^{-1}.
□ Direct-sown, ■ Transplanted. Treatment SED shown, $p<0.001$ for treatment effect. No significant difference between varieties or treatment/variety interactions.



In the second trial there was a significant interaction between variety and treatment for the total number of heads produced and grain yield (t ha^{-1} and g $plant^{-1}$) (Table 5.2.2). Transplanted Macia sorghum produced more heads and a higher grain yield when measured per area and individual plant (t ha^{-1} and g $plant^{-1}$) than direct-sown. For Mutode there was no significant difference between the treatments when expressed as t ha^{-1} but when compared at plant level direct-sown plants produced significantly more heads and grain yield than transplanted (g $plant^{-1}$).

Table 5.2.2. Mean number of heads and grain weight (t ha^{-1} and g $plant^{-1}$) produced by direct-sown compared to transplanted Macia and Mutode sorghum - trial two.

Variety	Treatment	Head number (ha^{-1})	Grain yield (t ha^{-1})	Head number ($plant^{-1}$)	Grain yield (g $plant^{-1}$)	*n*
Macia	Direct sown	27,137	0.84	1.31	38.6	*4*
	Transplanted	45,679	1.57	1.61	55.3	*36*
Mutode	Direct sown	78,633	1.65	3.34	74.1	*4*
	Transplanted	75,095	1.55	2.71	56.5	*36*
	SED max-min	*6371.7*	*0.2221*	*0.191*	*8.32*	
	SED max	*2849.5*	*0.0993*	*0.085*	*3.72*	
	p-value	*0.017*	*0.01*	*<0.001*	*0.005*	

As noted in Figure 5.2.2 more transplanted Macia and Mutode sorghum plants survived to harvest than direct-sown. For Macia sorghum the increase in yield in transplanted plants is therefore attributed to a slight increase in the productivity per plant but mainly due to an improvement in stand establishment. For Mutode sorghum the productivity per plant was actually reduced in transplanted plants, however the improvement in stand establishment in transplanted plants increased the productivity in terms of area, and negated any significant difference between the treatments.

In trial three there was no significant interaction between variety and treatment for number of heads produced, but there was a significant main effect of treatment *i.e.* consistent for both varieties, with transplanted plants producing more heads than direct-sown when expressed as both area and individual plant numbers (Table 5.2.3).

Table 5.2.3. Mean number of heads produced (ha^{-1} and $plant^{-1}$) of transplanted compared to direct-sown sorghum. Values are a mean of both varieties – trial three.

Treatment	Head number (ha^{-1})	Head number ($plant^{-1}$)	*n*
Direct-sown	29,273	1.076	*4*
Transplanted	42,521	1.366	*24*
SED	*3950.5*	*0.1175*	
p-value	*0.002*	*0.018*	

When grain yields were compared there was a significant variety-treatment interaction, however unlike trial two there was no significant difference between the treatments for grain yield of Macia sorghum, but transplanted Mutode yielded more grain (t ha^{-1} and g $plant^{-1}$) than direct-sown (Table 5.2.4).

Table 5.2.4. Mean grain yield (t ha^{-1} and g $plant^{-1}$) of direct-sown compared to transplanted Macia and Mutode sorghum - trial three.

Variety	Treatment	Grain yield (t ha^{-1})	Grain yield (g $plant^{-1}$)	*n*
Macia	Direct sown	1.67	58.6	*4*
	Transplanted	1.64	51.7	*24*
Mutode	Direct sown	0.34	13.4	*4*
	Transplanted	1.13	37.2	*24*
	SED max-min	*0.229*	*6.75*	
	SED max	*0.123*	*3.61*	
	p-value	*0.014*	*0.003*	

Therefore in trial three, as with Macia in trial two, transplanted Mutode produced more grain than direct-sown due to an increase in the number of heads per plant but mainly due to an improved stand establishment. However, although compared to direct-sown more transplanted Macia plants survived to harvest and produced more heads, both in terms of area and individual plants, there was no difference in the yield. It was observed during the trials that birds attacked the Macia sorghum more than the Mutode, due to it having large bulbous heads and large white grain. Bird scaring was conducted throughout the trial period, however it was impossible stop all the damage due to the large number of plots. Additionally the transplanted sorghum matured earlier than all crops in surrounding areas and were therefore constantly under attack by groups of birds. It is therefore suggested that as the transplanted plants produced more heads than the direct-sown, the non-significant difference between yields is due to the birds eating the seed whilst still in the field.

When the different aged seedlings at transplanting were compared in terms of yield there was a significant interaction between variety and seedling age at transplanting for number of heads produced and grain yield. Table 5.2.5 shows the results for number of heads and grain yield both in terms of area (t ha^{-1}) and individual plants (g $plant^{-1}$) for trial two. The results show that there was no significant difference between the seedling ages at transplanting for Mutode either for number of heads produced or grain yield. However 38-day-old Macia seedlings produced more heads (ha^{-1} and $plant^{-1}$) than the other two ages. In terms of grain yield (g $plant^{-1}$) 38-day-old and 29-day-old seedlings yielded more than 20-day-old, but when compared in terms of area only the 29-day-old seedlings yielded more than 20-day-old.

Table 5.2.5. Mean head number and grain yield (t ha^{-1} and g $plant^{-1}$) of different aged seedlings at transplanting of Macia and Mutode sorghum - trial two.

Variety	Age at transplanting	Head number (ha^{-1})	Head number ($plant^{-1}$)	Grain yield (t ha^{-1})	Grain yield (g $plant^{-1}$)
Macia	38-days-old	60,043	2.23	1.58	58.6
	29-days-old	41,595	1.45	1.83	64.1
	20-days-old	35,399	1.16	1.30	43.3
Mutode	38-days-old	73,219	2.87	1.52	60.4
	29-days-old	77,493	2.72	1.50	52.7
	20-days-old	74,573	2.53	1.64	56.5
	SED	*4935.5*	*0.148*	*0.1721*	*6.44*
	p-value	*<0.001*	*0.001*	*0.028*	*0.031*

In trial three there was no significant interaction between variety and seedling age for number of heads produced but there was a significant main effect of treatment *i.e.* for both varieties with 37- and 27-day-old seedlings producing significantly more heads ha^{-1} than 17-day-old seedlings (37-day-old seedlings 48,396 heads ha^{-1}, 27-day-old seedlings 44,444 heads ha^{-1} and 17-day-old seedlings 34,722 heads ha-1, p=0.002, SED =4479.4). This pattern was consistent when number of heads was expressed at individual plant level. For grain yield there was a significant variety-seedling age interaction. Unlike trial two there was no significant difference between the ages of transplanted Macia, but for Mutode there was a significant difference with 37-day-old seedlings produced a higher grain yield (t ha^{-1} and g $plant^{-1}$) than 17-day-old (Table 5.2.6).

Table 5.2.6. Mean grain yield (t ha^{-1} and g $plant^{-1}$) of different aged seedlings at transplanting of Macia and Mutode sorghum - trial three.

Variety	Age at transplanting	Grain weight (t ha^{-1})	Grain yield (g $plant^{-1}$)
Macia	37-days-old	1.55	48.8
	27-days-old	1.59	49.9
	17-days-old	1.77	56.3
Mutode	37-days-old	1.41	46.9
	27-days-old	1.12	35.8
	17-days-old	0.88	28.7
	S.e.d	*0.212*	*6.25*
	p-value	*0.05*	*0.002*

In trial two there were no significant differences in yields between seedlings transplanted from different nursery densities. However in trial three plants transplanted from the 200 plants m^2 produced significantly more heads (1.457 heads $plant^{-1}$) than direct-sown (1.275 heads $plant^{-1}$) ($p=0.048$, SED=0.088). In terms of grain yield there was a significant interaction between variety and nursery density where transplanted Mutode from the nursery with the fewest plants produced a greater grain yield than the most-dense nursery. There was no significant difference between the nursery densities for Macia.

Table 5.2.7. Mean grain yield (t ha^{-1}) of plants transplanted from different nursery densities. Results from trial three.

Variety	Nursery density plants m^{-2}	Grain weight (t ha^{-1})	Grain yield (g $plant^{-1}$)
Macia	200	1.48	46.7
	1000	1.79	56.7
Mutode	200	1.30	42.7
	1000	0.97	31.6
	S.e.d	*0.173*	*5.11*
	p-value	*0.014*	*0.006*

5.2.1.3 Stover

In trial two there was a significant difference in stover produced between the two varieties, with Mutode producing significantly more stover (dry weight) (2.65 t ha^{-1}), due to it begin much taller than Mutode (0.626 t ha^{-1}) ($p=<0.001$, SED=1.246). Similarly direct-sown plants produced significantly more stover (dry weight) (2.14 t ha^{-1}) than transplanted (1.58 t ha^{-1}) ($p=0.009$, SED=0.208)

5.2.1.4 Summary

- Transplanted sorghum sorghum flowered 9-14 days earlier than direct-sown plants, but there were no significant differences in flowering times between the different aged seedlings at transplanting or seedlings transplanted from the different nursery densities.
- Transplanted plants established much better than direct-sown with more plants surviving to harvest, and in terms of grain yield transplanted plants either produced the same or more yield (approximately 1 t ha^{-1} more) than direct-sown.
- Where yields were not different this is probably due to birds eating the earlier maturing seed of transplanted plants in the field. This is a constraint that farmers are aware of and are more able to deal with than station staff.
- Trials showed that the seedlings closest to 40 and 30-days-old at transplanting produced a significantly greater yield than those around 20-days-old it is therefore recommended that Macia and Mutode sorghum seedlings should be 20-days-old at transplanting.
- Nurseries can be sown up to a density of 1000 plants m^{-2} without any detrimental effect on yields or flowering. Some benefits were associated with lower density nurseries but were not sufficiently large to counteract the need for more area for seedling production.

5.2.2 Pearl Millet

5.2.2.1 Flowering/Maturity

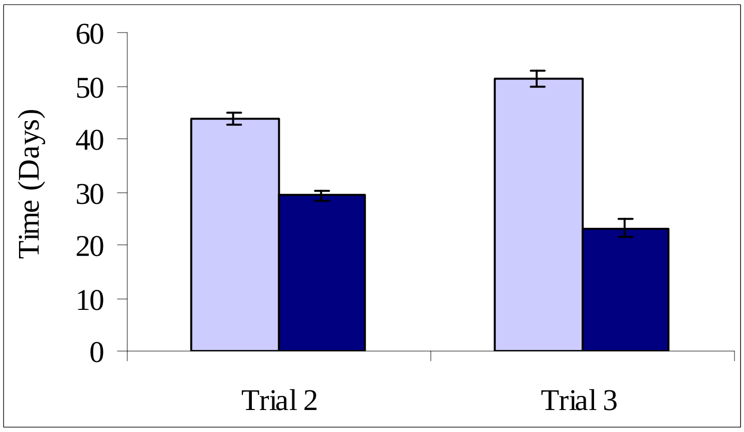
PMV3 flowered and matured significantly earlier than PMV2, as predicted by varietal descriptions, but only by approximately 3 days (Table 5.2.8).

Table 5.2.8. PMV2 and PMV3 pearl millet, time to flowering. Values are a mean across treatments and are the days recorded from the time the direct-sown plants were sown and transplanted plants transplanted.

Variety	Trial 2	Trial 3
PMV2	32.1	28.4
PMV3	29.3	26.1
SED	*0.63*	*1.09*
p-value	*<0.001*	*0.039*

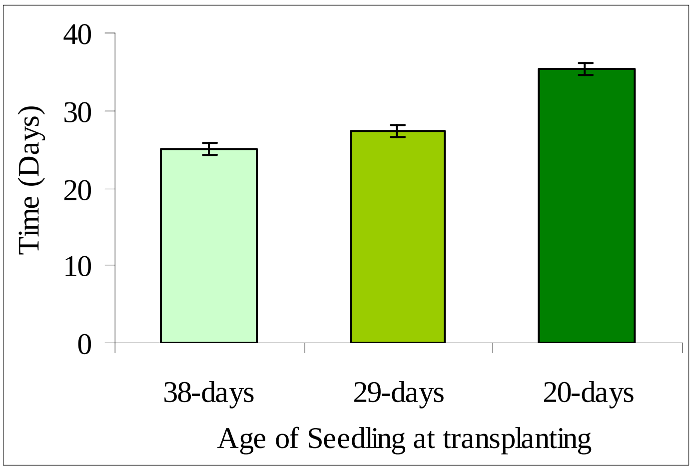
As with sorghum, transplanted pearl millet flowered and matured significantly earlier (14 days trial two, 28 days trial three, p=<0.001) than direct-sown (Figure 5.2.3). Similar to results for sorghum, the plants experience a transplanting shock causing the total flowering and maturity periods, *i.e.* from the time of sowing, to be longer than direct-sown. This is not a problem because under normal farming conditions the time spent in the nursery is before the start of the rains when direct-sown seed in the field would not germinate due to lack of moisture. Therefore, although transplanted seedlings suffer a check in plant growth, under normal farming conditions the transplanted sorghum matures earlier than direct-sown.

Figure 5.2.3. Time to flowering of direct-sown compared to transplanted pearl millet. Values are a mean of both varieties. □Direct-sown, ■Transplanted. Treatment SED shown, differences between treatments significant at p<0.001.



Looking more closely at the transplanted plants there were significant differences in time to flowering and maturity (p=<0.001) between the ages of seedlings at the time of transplanting. Figure 5.2.4 shows that in trial two 38-day-old seedlings flowered earlier than 29-day-old, and 29-day-old seedlings flowered earlier than 20-day-old. In trial three there was a significant variety-treatment interaction (p=0.013) where 37-day-old PMV2 seedlings flowered significantly earlier than 27- and 17-day-old seedlings (no significant difference between the two youngest ages) but 37-day-old PMV3 seedlings only flowered significantly earlier than 17-day-old.

Figure 5.2.4. Time to flowering of different aged pearl millet seedlings at transplanting – trial two. Values are a mean of both varieties. SED shown, p<0.001.



When comparing flowering period of seedlings transplanted from different nursery densities the only significant difference observed was in trial two where seedlings transplanted from the 200 and 500 plants m^2 nurseries flowered earlier than seedlings transplanted from the 1000 plants m^2 (200 plants m^2=28.75, 500 plants m^2=28.46, 200 plants m^2=30.58, p=0.022, SED=0.809).

5.2.2.2 Yield

Yield results for trial two showed that PMV3 produced significantly more heads and a higher grain yield than PMV2 (t ha^{-1}) due to individual plants producing more grain (Table 5.2.9). This was reflected in trial one where PMV3 produced 118.3 g $plant^{-1}$ compared to PMV2, which produced 77.1 g $plant^{-1}$ (p=0.012, SED=14.99). In trial three individual PMV3 plants yielded more heads (4.49 heads $plant^{-1}$) than PMV2

(3.99 heads plant^{-1}) (p=0.036, SED=0.231*)* however this difference was significant difference at hectare level.

Table 5.2.9. Differences in head number and grain yield (t ha^{-1} and g plant^{-1}) of PMV2 compared to PMV3 pearl millet. Values are a mean across all treatments in trial 2.

Variety	Head number (ha^{-1})	Grain yield (t ha^{-1})	Grain yield (g plant^{-1})
PMV2	92,137	1.63	35.1
PMV3	101,218	2.02	64.4
S.e.d	*4,380.5*	*0.140*	*4.59*
p-value	*0.042*	*0.007*	*0.025*

When treatments were compared in trial two there was a significant difference between direct-sown and transplanted crops (Table 5.2.10), with transplanted crops producing more heads and greater grain yield per hectare and per plant. The number of plants surviving the harvest in trial two was slightly higher for direct-sown (31,624 plants ha^{-1}) than transplanted (29,701 plants ha^{-1}) (p=0.043, SED=559.6), however this did not affect yield results because the individual plant yield of transplanted plants was so high. Similarly in trial one, transplanted plants out-yielded direct-sown with grain yields of 4.57 t ha^{-1} and 2.62 t ha^{-1} respectively (p=0.032, SED=2.62).

Table 5.2.10. Head number and grain yield (t ha^{-1} and g plant^{-1}) of direct-sown compared to transplanted pearl millet. Values are a mean across both varieties – trial two.

Treatment	Head number (ha^{-1})	Grain yield (t ha^{-1})	Head number (plant^{-1})	Grain yield (g plant^{-1})	n
Direct-sown	74,573	1.112	2.38	35.1	8
Transplanted	99,133	1.905	3.36	64.4	72
S.e.d	*7,300.8*	*0.2338*	*0.232*	*7.65*	
p-value	*0.001*	*0.001*	*<0.001*	*<0.001*	

In trial three, however, when expressed in individual plant terms direct-sown plants produced a higher grain yield (117.3 g plant^{-1}) than transplanted plants (78.6 g plant^{-1}) (p<0.001, SED=8.77) although there was no difference in the number of heads produced. However when the results were expressed in terms of area, transplanted plants produced more heads (130,698 heads ha^{-1}) than direct-sown (92,308 heads ha^{-1}) (p=0.003, SED=11,990.8) due to an increase in the number of plants surviving to harvest (21,474 ha^{-1} direct-sown plants surviving compared to 31,214 plants ha^{-1} transplanted plants ($p<0.001$, SED=925.6)) but there was no significant difference in grain yield as direct-sown plants produced more grain per plant.

There was no significant difference in yield between the different seedling ages at transplanting in trial two either when expressed on area or individual plant terms. This was despite there being significant differences in head numbers, where 38- and 29-day-old seedlings produced significantly more heads than 20-day-old (Table 5.2.11). However plant survival results showed that both the 20- and 29-day-old seedlings at transplanting survived better (30,271 and 30,306 plants ha^{-1} respectively) than the 38 day-old seedlings (28,526 plant ha^{-1}) ($p=0.024$, SED=722.5). Therefore the younger seedlings survive better than the older ones, but the older seedlings produce a higher yield per plant therefore overall there is no difference between the seedling ages.

Table 5.2.11. Head number (t ha^{-1} and $plant^{-1}$) produced by the different seedling ages at transplanting. Values are a mean across both varieties – trial two.

Age at transplanting	Head number (ha^{-1})	Head number ($plant^{-1}$)
38-days-old	108,048	3.77
29-days-old	105,449	3.51
20-days-old	83,903	2.79
SED	*<0.001*	*<0.001*
p-value	*5,655.2*	*0.1792*

These head number results were reflected in trial three where again 37- and 27-day-old seedlings produced significantly more heads than 17-day-old (Table 5.2.12). Additionally in trial three 27- and 17-day-old seedlings at transplanting produced a greater grain yield than 37-day-old seedlings due to increased plant survival. Therefore in this case the increased survival of the younger seedling was enough to increase the yield on terms of area.

Table 5.2.12. Mean head number and grain yield (t ha^{-1}) of different aged seedlings at transplanting - trial three.

Age at transplanting	Head number (ha^{-1})	Grain yield (t ha^{-1})
37-days-old	152,831	2.12
27-days-old	133,974	2.67
17-days-old	105,289	2.58
S.e.d†	11,101.3	*0.228*
p-value	<0.001	*0.042*

No significant differences in terms of area were observed in yields of seedlings transplanted from different nursery densities.

5.2.2.3 Stover

There were no significant differences between the stover yield of the two pearl millet varieties, nor were there any differences between the two treatments of transplanted and direct-sown from trial two. However in trial three PMV2 produced more stover (305 g plant^{-1}) across treatments than PMV3 (256 g plant^{-1}) ($p=0.033$, SED=22.4). When comparing treatments direct-sown plants produced more stover (521 g plant^{-1}) than transplanted (240 g plant^{-1}) ($p<0.001$, SED=31.9). There was also a significant effect of seedling age on stover production with the 17-day-old seedlings producing more stover (355 g plant^{-1}) than 27-day-old (206 g plant^{-1}) and 37-day-old seedlings (159 g plant^{-1}) ($p<0.001$, SED=29.6).

5.2.2.4 Summary

- Transplanted PMV2 and PMV3 flowered earlier (14-28 days) than direct-sown crops.
- The seedlings closest to 40 and 30-days-old also flowered significantly earlier than the seedlings close to 20-day-old by approximately 10 days.
- Transplanted plants either yielded the same or more when compared to direct-sown, where there were differences the increase in yield was approximately 1 t ha^{-1}.
- The yield produced by the different seedling ages at transplanting varied depending on how well the transplants established, if the seedlings close to 40-

and 30-days-old established well they produced a higher yield, however if they did not, the younger seedling produced a higher yield due to improved seedling establishment.

- It is therefore recommended that seedlings around 30-day-old are transplanted for these two types of pearl millet.
- Nursery density again had no significant effect on flowering or yields it is therefore safe to establish nurseries up to 1000 plant m^{-2}.

5.3 On-station results – Ghana

5.3.1 Early millet

5.3.1.1 Flowering and maturity

Results for early millet (Figure 5.3.1) show that when flowering was measured from the time of transplanting, transplanted seedlings flowered significantly earlier ($p<0.001$) than direct-sown by approximately 20 days in both trials. As found in Zimbabwe transplanted plants suffered a transplanting shock, for early millet this was approximately three days in trial one.

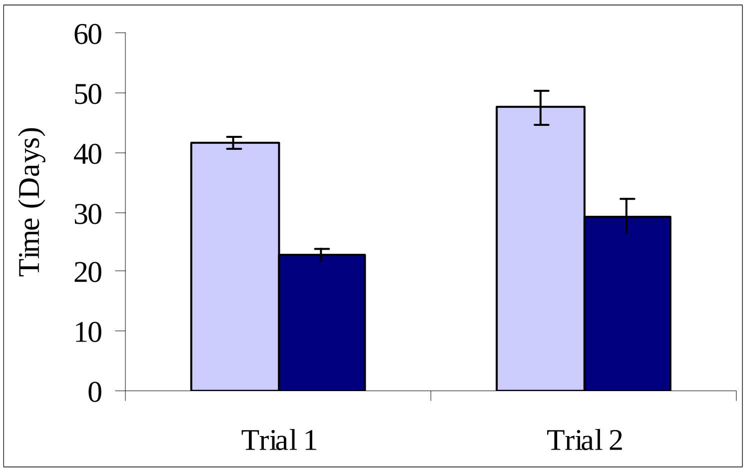


Figure 5.3.1. Days to flowering of transplanted (■)compared to direct-sown (□)early millet, measured from the time of transplanting for trial one and two.

There was a significant difference in flowering time, when measured from the time of transplanting, for the different aged seedlings at transplanting. Table 5.3.1 shows that the 33- and 23-day-old seedlings at transplanting flower significantly earlier than the 8-day-old seedlings by approximately 23 and 21 days respectively in trial one, and the 35- and 25-day-old-seedlings 13 and 14 days earlier than 15-day-old seedlings in trial two. Thirty-three-day-old seedlings at transplanting also flowered significantly earlier than 23-day-old in trial one, however this difference was only approximately 2 days.

Table 5.3.1. Days to flowering from the time of transplanting for the different aged seedlings at transplanting. 33-, 23- and 8-days-old in trial one, 25-, 15-, and 5 days old in trial two.

Age at transplanting	Trial 1	Trial 2	*n*
Direct	41.50	47.50	*4*
33/35-days-old	16.25	25.37	*8*
23/25-days-old	18.37	24.25	*8*
8/15-days-old	39.50	38.25	*8*
SED max-min	*0.952*	*3.156*	
SED max	*0.777*	*2.577*	
p-value	*<0.001*	*<0.001*	

5.3.1.2 Yield

In trial one the number of heads produced and grain yield was higher for transplanted plants compared to direct-sown. However in trial two there were no significant differences between the treatments for number of heads produced or grain yield (Table 5.3.2).

Table 5.3.2. Head number and grain yield (t ha^{-1}) of transplanted compared to direct-sown plants in trial one.

Treatment	Head number (ha^{-1})	Grain yield (t ha^{-1})	*n*
Direct	36,296	0.49	*4*
Transplanted	52,469	0.67	*24*
SED	*4,186*	*0.091*	
p-value	*0.001*	*0.039*	

In addition to the treatment differences there were significant differences between the different ages of seedlings at transplanting. In trial one the 33-day-old seedlings produced more heads than the 8-day-old seedlings at transplanting. The 23-day-old seedlings however produced more heads and a greater yield (ha^{-1}) than both the 33-day-old and the 8-day-old seedlings. In trial 2 there was no significant difference between the 25- and 15-day-old seedlings at transplanting for number of heads produced or grain yield but both produced more heads and a higher grain yield than the 35-day-old (Table 5.3.3).

Table 5.3.3. Head number and grain yield of seedlings transplanted at different ages in trial one and two. Seedling ages 33-, 23-, and 8-days-old in trial one and 25-, 15-, and 5-days-old in trial two.

	Trial 1		Trial 2		
Age at transplanting	Head number (ha^{-1})	Grain yield ($t\ ha^{-1}$)	Head number (ha^{-1})	Grain yield ($t\ ha^{-1}$)	*n*
Direct	36,296	0.49	68,301	0.67	*4*
33/35-days-old	54,691	0.59	42,974	0.27	*8*
23/25-days-old	70,864	0.98	78,431	0.75	*8*
8/15-days-old	31,852	0.52	68,954	0.78	*8*
SED max-min	*4746.6*	*0.103*	*13,826*	*0.169*	
SED max	*3875.6*	*0.084*	*11,289*	*0.138*	
p-value	*<0.001*	*<0.001*	*0.016*	*0.003*	

5.3.1.3 Stover

When stover weights were compared in both trials the weight of stover produced was less for transplanted plants compared to direct-sown (Table 5.3.4).

Table 5.3.4. Stover weight ($t\ ha^{-1}$) of transplanted compared to direct-sown plants in both trials.

Treatment	Trial 1	Trial 2	*n*
Direct	13.33	9.74	*4*
Transplanted	9.85	3.92	*24*
SED	*1.140*	*1.09*	
p-value	*0.007*	*<0.001*	

Leaf cutting had no effect on yield results from either of the two trials.

5.3.1.4 Summary

- Transplanted early millet flowered approximately 20 days earlier than direct-sown, which is particularly important as early millet breaks the hunger gap when food reserves are very low. Thirty- and 20-day-old seedlings also flowered approximately 10-20 days earlier than the 10-day-old seedlings. By transplanting farmers can break the hunger gap two weeks earlier.
- As in Zimbabwe yields were either similar to direct-sown or higher, in this case approximately 0.2 $t\ ha^{-1}$ higher from transplanted plants.

- The seedlings closest to 10 and 20-days-old yielded more than the older seedlings in the case of early millet.
- The flowering and yield results for the different aged seedlings at transplanting showed that seedlings around 20-days-old are best to transplant for early millet.
- Results showed that there is no benefit of cutting the leaves of transplanted plants at transplanting.

5.3.2 Early sorghum

5.3.2.1 Flowering

The flowering results for early sorghum (Figure 5.3.2) are similar to those of early millet and show that when flowering was measured from the time of transplanting, transplanted seedlings flowered significantly earlier ($p<0.001$ in trial 1, $p=0.006$ in trial 2) than direct-sown by approximately 8 to 10 days.

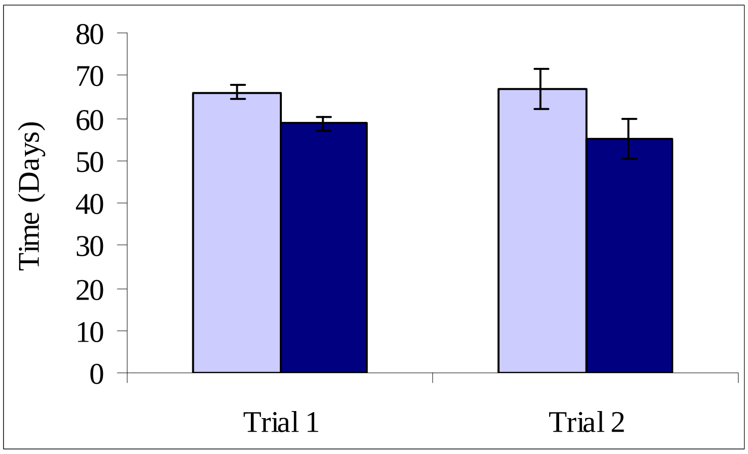


Figure 5.3.2. Days to flowering for transplanted compared to direct-sown early sorghum, measured from the time of transplanting.

In trial one there was a significant difference in flowering time for the different aged seedlings at transplanting. Table 5.3.5 shows that the 63-day-old seedlings at transplanting flowered approximately 8 days earlier than 53-day-old seedlings and both flowered significantly earlier than 43-day-old seedlings (approximately 15 and 7 days respectively). In trial two the 45-, 35- and 25-day old seedlings at transplanting flowered significantly earlier ($p<0.001$) than the 15-day old seedlings and the 45- and 35-day old seedlings at transplanting flowered earlier than the 25-day-old seedlings.

Table 5.3.5. Days to flowering from the time of transplanting for the different aged seedlings at transplanting in both trials.

Age at transplanting	Trial 1	Trial 2	*n*
Direct-sown	66.0	66.7	*4*
63-days-old	51.0	-	*8*
53-days-old	59.3	-	*8*
43/45-days-old	66.0	47.0	*8*
35-days-old	-	48.7	*8*
25-days-old	-	55.7	*8*
15-days-old	-	69.5	*8*
S.e.d max-min	*1.866*	*4.44*	
S.e.d max	*1.523*	*3.62*	
p-value	*<0.001*	*<0.001*	

5.3.2.2 Yields

Unlike early millet in trial one the grain yield was significantly lower for transplanted plants (1.69 t ha^{-1}) when compared to direct-sown (2.31 t ha^{-1}) (p=0.008, SED=0.206), however there was no significant difference in the number of heads produced. In trial two transplanted plants produced more heads (36,699 ha^{-1}) than direct-sown (26,603 ha^{-1}) (p=0.012, SED=3719.4) but there was no significant difference in grain yield between the two treatments.

There was a significant difference in the number of heads produced and grain yield of the different ages of seedling at the time of transplanting (Table 5.3.6). In trial one, the 43- and 53-day-old seedlings produced a greater grain yield than the 63-day-old seedlings. The 63- and 53-day old seedlings at transplanting produced significantly more heads than the 43-day-old seedlings at transplanting. In trial two 45-day-old seedlings at transplanting produced significantly more heads than 35-day-old seedlings, both ages produced significantly more heads than 25-day-old seedlings and all more than 15-day-old seedlings. However when grain yields were compared both 35- and 25-day-old seedlings produced a significantly higher yield than 15- and 45-day-old. Significantly fewer 15-day-old seedlings survived to harvest compared to the other ages.

Table 5.3.6. Head number, grain yield of the different aged seedlings at transplanting compared to direct-sown in trials one and two.

	Trial 1		Trial 2		
Age at transplanting	Head No (t ha^{-1})	Grain wt (t ha^{-1})	Head No (t ha^{-1})	Grain wt (t ha^{-1})	*n*
Direct-sown	32,071	2.31	26,603	2.51	*4*
63-days-old	34,596	1.28	-	-	*8*
53-days-old	31,692	1.94	-	-	*8*
43/45-days-old	24,460	1.85	55,288	1.5	*8*
35-days-old	-	-	44,071	2.63	*8*
25-days-old	-	-	29,808	2.6	*8*
15-days-old	-	-	17,628	1.49	*8*
S.e.d max-min	*2126*	*0.233*	*4294.8*	*0.400*	
S.e.d max	*1736*	*0.190*	*3506.7*	*0.326*	
p-value	*<0.001*	*0.006*	*<0.001*	*<0.001*	

Leaf cutting had no effect on yield results from either of the two trials.

5.3.2.3 Stover

When stover weights were compared there were no significant differences in trial one, however in trial two direct-sown plants produced more stover (20.32 t ha^{-1}) than transplanted (15.77 t ha^{-1}) (p=0.058, SED=2.28). There was also a significant difference between the different aged seedlings at transplanting in trial two with 35- and 25-day-old seedlings producing more (18.15 t ha^{-1} and 18.12 t ha^{-1} respectively) than 45- and 15-day-old seedlings (14.31 t ha^{-1} and 12.51 t ha^{-1} respectively) (p=0.032, SED=2.15).

5.3.2.4 Summary

- Transplanted early sorghum flowered approximately 10 days earlier than direct-sown, and the older the seedling up to 50-days-old the earlier it flowers. In terms of yield.
- There was either no difference in yield between the treatments or the direct-sown produced a higher grain yield than the transplanted. This result was due to significant bird damage to the transplanted Kaapala sorghum and additional animal damage by sheep and goats that managed to get into the trial area. The

damage was much worse on the transplanted sorghum because it matured earlier when no other crops in surrounding fields had matured.

- Seedling ages of 25-50 days old produced a significantly greater yield than younger and older seedlings; it is therefore recommended that these seedling ages be transplanted for Kaapala sorghum.
- Results showed that there is no benefit of cutting the leaves of transplanted plants at transplanting.

5.3.3 Late millet

5.3.3.1 Flowering/maturity

There were no significant differences in time to flowering between transplanting and direct sowing or of the different seedling ages at transplanting of late millet as the variety is photoperiod sensitive.

5.3.3.2 Yields

Harvest data from trial one for late millet showed that the number of heads produced and grain yield were significantly higher in transplanted compared to direct-sown plants (Table 5.3.7). However there were no significant differences between treatments for trial two, neither were there any significant differences between the different ages at transplanting for either of the two trials.

Table 5.3.7. Head number and grain yield of transplanted compared to direct-sown plants – trial one.

Treatment	Head number (ha^{-1})	Grain wt ($t\ ha^{-1}$)	*n*
Direct	36,869	0.66	*4*
Transplanted	50,842	0.98	*24*
SED	*5008*	*0.131*	
p-value	*0.012*	*0.027*	

There was a significant effect of cutting the leaves of late millet in trial one with seedlings that had their leaves cut at transplanting producing more heads and a higher grain yield than those left intact (Table 5.3.8), in trial two however there was no significant effect of leaf cutting on yields.

Table 5.3.8. Head number and grain yield of transplanted plants with intact and cut leaves – trial one.

Treatment	Grain wt (t ha^{-1})	Head No (ha^{-1})
Leaves uncut	*0.86*	46,128
Leaves cut	*1.10*	55,556
S.e.d max	*0.099*	*3785.8*
p-value	*0.027*	*0.023*

5.3.3.3 Stover

In trial one, transplanted late millet produced more stover (21.39 t ha^{-1}) than direct-sown (26.74 t ha^{-1}) (p=0.025, SED=2.183). However no significant differences were observed in trial two.

5.3.3.4 Summary

- Transplanted late millet does not flower earlier than direct-sown as the plants are photoperiod sensitive.
- Yields are either similar or higher from transplanted crops.
- Seedling ages from 15-45-days-old did not vary in terms of yield, but it is recommended 20-40-day-old seedlings should be transplanted.
- There is some benefit in cutting the leaves of transplanted late millet in terms of increasing yield.

5.3.4 Late sorghum

5.3.4.1 Flowering/maturity

As with late millet there were no significant differences in time to flowering between the treatments of transplanting and direct sowing or of the different seedling ages at transplanting of late sorghum, as to the variety is photoperiod sensitive.

5.3.4.2 Yield

There was no significant yield difference between the treatments in trial one. However in trial two direct-sown plants produced significantly more heads and grain yield than direct-sown due to more direct-sown plants (32,692 ha-1) surviving to harvest than transplanted plants (29,287 ha-1) (p=0.025, SED=1428.9) (Table 5.3.9)

Table 5.3.9. Head number and grain yield of transplanted compared to direct-sown plants – trial two.

Treatment	Head number (ha^{-1})	Grain wt ($t\ ha^{-1}$)	*n*
Direct	61,538	1.33	*4*
Transplanted	45,192	1.00	*32*
SED	*5574.0*	*0.1178*	
p-value	*0.007*	*0.01*	

There were also significant differences between the seedlings of different ages at transplanting in trial two (Table 5.3.10). Fifteen-day-old seedlings produced significantly less heads than the other seedling ages due to less plants surviving to harvest. Only 45-day-old seedlings produced a significantly higher yield than the 15-day-old seedlings.

Table 5.3.10. Days to flowering from the time of transplanting for the different aged seedlings at transplanting in both trials.

Age at transplanting	Head number (ha^{-1})	Grain wt ($t\ ha^{-1}$)	Number of surviving plants (ha^{-1})	*n*
Direct-sown	61,538	1.33	32,692	*4*
45-days-old	46,314	1.15	30,769	*8*
35-days-old	54,006	1.03	32,051	*8*
25-days-old	51,122	0.99	30,288	*8*
15-days-old	29,327	0.83	24,038	*8*
S.e.d max-min	*6436.3*	*0.1361*	*1649.9*	
S.e.d max	*5255.2*	*0.1111*	*1347.2*	
p-value	*<0.001*	*0.058*	*<0.001*	

Leaf cutting at transplanting increased the number of plants surviving to harvest but not enough to have a significant effect on yields (transplanted=30,529 plants ha^{-1}, direct-sown=28,045 plants ha^{-1} p=0.015, SED=952.6).

5.3.4.3 Stover

There was no significant difference in stover yield between the treatments of direct sowing and transplanting, however there were differences between the different aged seedlings at transplanting with 45-day-old seedlings producing more stover (values are for sun-dried stover) (21.14 t ha^{-1}) than all other ages, 35- (20.37 t ha^{-1}) and 25-day-old seedlings (16.59 t ha^{-1}) producing more than 15-day-old seedlings (11.62 t ha^{-1}) ($p<0.001$, SED=2.102).

5.3.4.4 Summary

- Transplanted late sorghum does not flower earlier than direct-sown as the plants are photoperiod sensitive.
- Yields were similar or lower on-station than direct-sown crops. This is attributed to on-station procedure being less flexible than on farmers fields.
- Seedling ages of 45-days-old yielded more than the other ages, it is therefore recommended that plants of 30-50-days-old be transplanted for late sorghum.
- Leaf cutting may increase plant survival.

5.4 On-farm results

5.4.1 Zimbabwe-specific results

Of the 18 farmers who completed the questionnaires at the post-harvest discussion workshop following the first year of trials, all of them had nurseries consisting of one to three beds which varied in size from two to four m^2. Various watering amounts and regimes were used for the nurseries: 44% of farmers applied 20 litres of water at each watering, 11% applied 40 litres and 22% applied 60 or 80 litres. These amounts were applied two or three times a week. All farmers applied manure and mulch and 83% had shade over the nurseries. In the second year of trials 74% applied manure, and 22% applied mulch, fertiliser or compost or a mixture of them.

One problem expressed by 39% of farmers in the first year of trials was that the distance from the nursery to the field was too long, a point also noted was that 56% of farmers had nurseries 15 minutes walk from the fields, the rest had nurseries right next to the fields. Therefore 70% of the farmers who had fields 15 minutes walk from the nurseries considered it to be too far. In the second trials all farmers situated their nurseries within 10 minutes walk of the water source.

During the second year of trials farmers were asked to record the number of hours per week spent on nursery activities, mainly watering. Results showed that 29% of farmers spent half to one to hour per week on the nursery activities, 37% of farmers spent one to two hours, 19% spent two to four hours and the other 15% spent more than four hours, with 81% of the farmers expressing the view that this did not cause problems for other work duties.

A majority (67%) of farmers transplanted their crops on a rainy day and 67% also transplanted after one day's rain (Figure 5.4.1). In the second year of trials all farmers transplanted on a cloudy or rainy day and 76% following a day of rain.

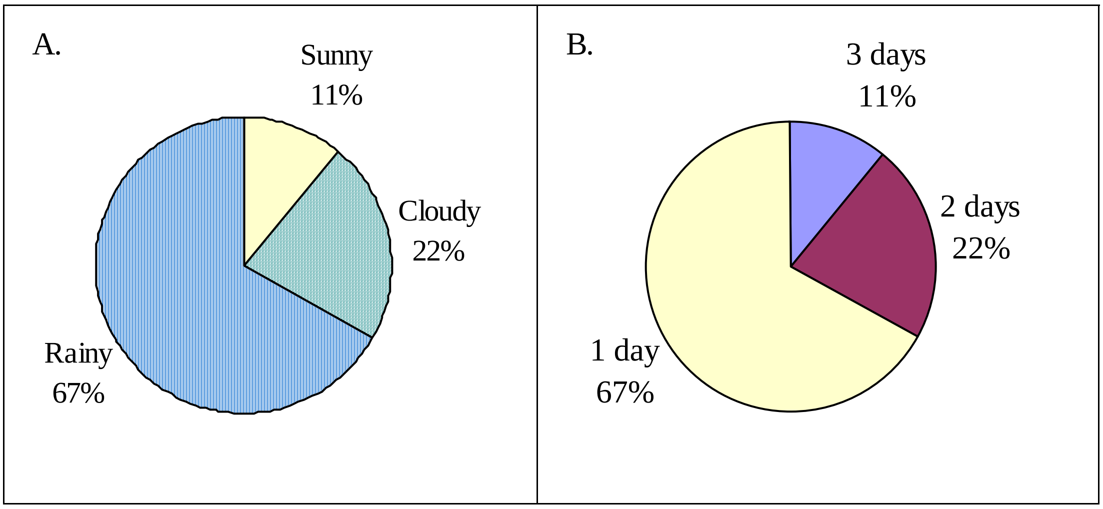


Figure 5.4.1. a. Weather on day of transplanting. b. Days rained before transplanting.

Generally in the second year of trials when transplant survival was compared to number of days without rain after transplanting, if it rained within three days more than 75% of plants survived, however if the period without rain extended to more than three days 50% or fewer of the transplanted plants survived.

In the first year of trials all farmers harvested their transplanted crop before the normal direct-sown. Thirty-three percent of the farmers harvested the transplanted seed three weeks earlier than the 'normal' crop and 77% a month earlier. Eighty-nine percent of farmers also experienced higher yields when compared to their normal direct-sown in the first year of trials and 80% in the second year of trials (Plate 5.4.1).

Of the farmers taking part in the on-farm trials who attended the workshop all said they would transplant again and 83% would consider transplanting other crops *e.g.* finger millet, pearl millet, rapoko and paprika and five farmers suggested transplanting maize.

Plate 5.4.1. Mrs Maunganidze with her on-farm trial (Chivi District, Zimbabwe). Transplanted sorghum (left) is a better stand and is maturing much earlier than the direct sown (right).

Although it was not possible to obtain detailed records from on-farm trials in the third year due to political unrest in Zimbabwe information was gathered from farmers during a final workshop conducted by RUDO staff. Thirty of the 32 farmers/stakeholders attending the workshop, through an anonymous ballot, agreed that they thought transplanting was so much better than broadcasting sorghum that they would persuade other farmers in their area or village to try it.

Results from the role-playing to establish the main costs, benefits, difficulties and improvements in using the technique were as follows:

a. The extra requirements of transplanting compared to broadcasting are:

- Labour for preparing and caring for the nursery and transplanting the seedlings.
- Fencing materials: poles and wire.
- Water sources for the nurseries.

b. The main benefits:

- Bigger healthier grains.
- Larger harvest due to increased tillering.
- Earlier harvest.
- Reduced risk of crops losses due to drought as the maturity period in the field is reduced.

- Easy management; reduced weeding frequency, easy application of fertilizer.

c. Specific issues related to transplanting that new farmers should be aware of:
   - Extra labour is required for transplanting from the nursery to the field.
   - Correct between-row spacing should be maintained to reap benefits.
   - Transplanting during the morning/afternoon when it is hot and sunny should be avoided.
   - Farmers should produce lots of smaller seedbeds and transplant the entire seedbed on same day to avoid wilting of seedlings that remain.

d. Based on farmers' experiences of using the technique improvements suggested were:
   - Some female farmers suggested that they were restricted to poor quality, unproductive fields by their husbands who were the decision makers in the household, so the technique should be targeted towards the male decision makers who would then allocate better land.
   - In addition to the land issue, the decision makers of the household skewed the distribution of time and material resources in favour of the traditional cultivation, making it more difficult to spend time on transplanting activities at the required time.
   - Nurseries should be sown well before the start of the rains and a series of nurseries should be established so seedlings of the right age were ready when the rains started.

Other points noted by farmers during the discussions included the following:

- The earlier harvests from the transplanted crops relieved the starvation period.
- Farmers were encouraged by the new opportunity to expand their knowledge concerning agricultural practices, and were happy to be involved in a project that promoted sorghum, ‘a multi-purpose crop which can be used for bread, sadza, beer’.

5.4.2 Ghana-specific results

In Ghana on-farm trials were conducted with the aid of extension agents, so it was therefore possible to obtain more detailed records from the trials.

5.4.2.1 Early millet

Farmers in Wiaga and Fumbisi were convinced that it was not possible to transplant early millet based on a taboo passed down through generations. In the first year of trials therefore no farmers from these areas transplanted early sorghum. In Zebilla this taboo was not recognised and farmers were happy to try transplanting early millet. In the first year of trials 19 farmers in Zebilla conducted early millet transplanting trials and of those, 16 farmers received higher yields from the transplanted crops compared to the direct-sown, some of whom almost doubled their yields by transplanting (Figure 5.4.2).

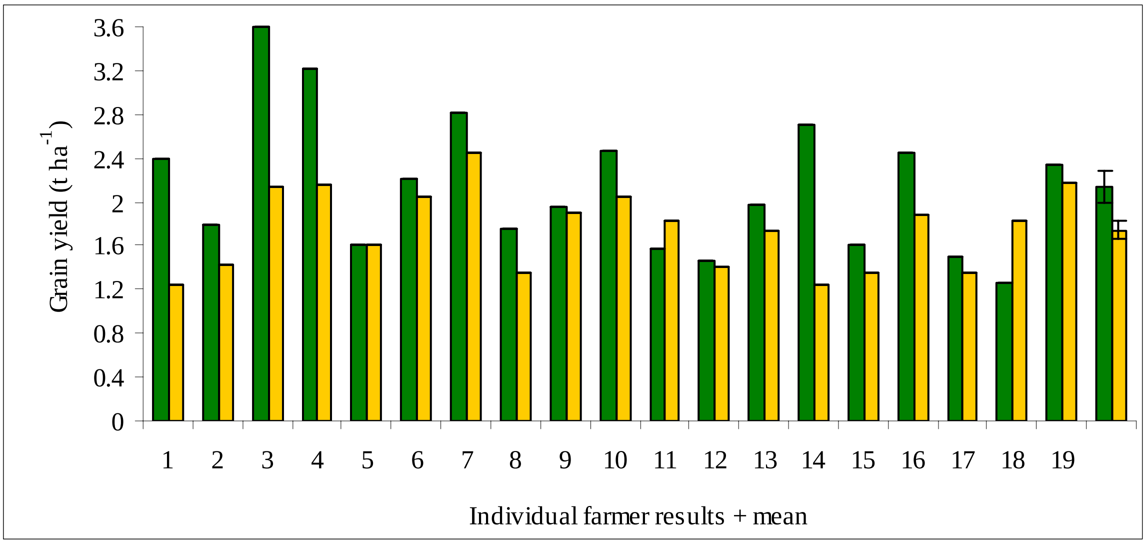


Figure 5.4.2. Grain yield of direct-sown (□) and transplanted (■) early millet (t ha^{-1}) for 19 farmers from Zebilla in the first year of trials. Mean and standard error of results shown.

During the second year of trials in Zebilla 25 farmers transplanted early millet and 23 received higher grain yields from transplanted crops compared to direct-sown (Figure 5.4.3. In the second year stover weights were also recorded and the same 23 farmers received higher stover yields (Figure 5.4.4).

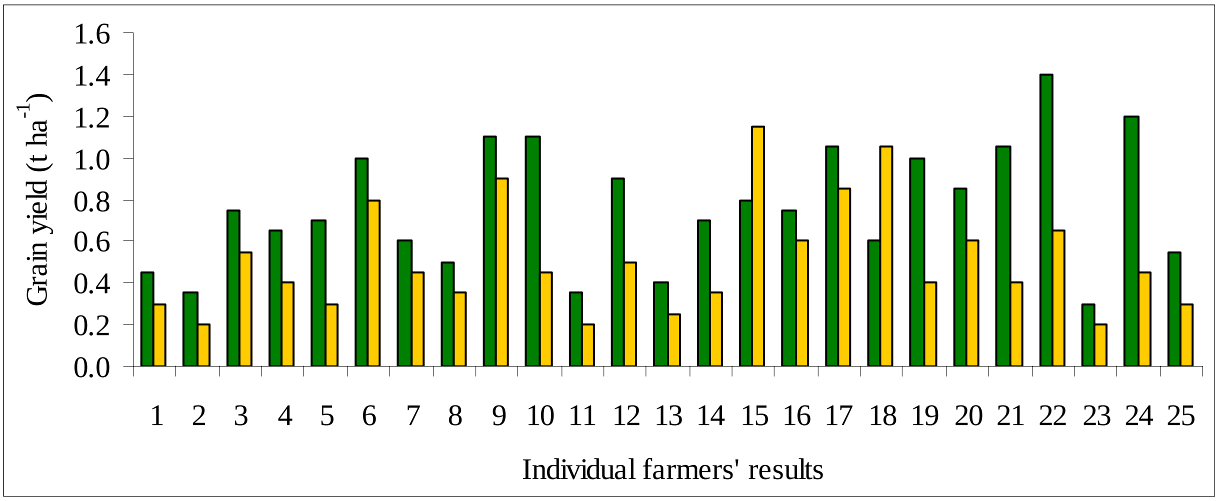


Figure 5.4.3. Grain yield of direct-sown (■) and transplanted (■) early millet (t ha^{-1}) for 25 farmers from Zebilla in the second year of trials.

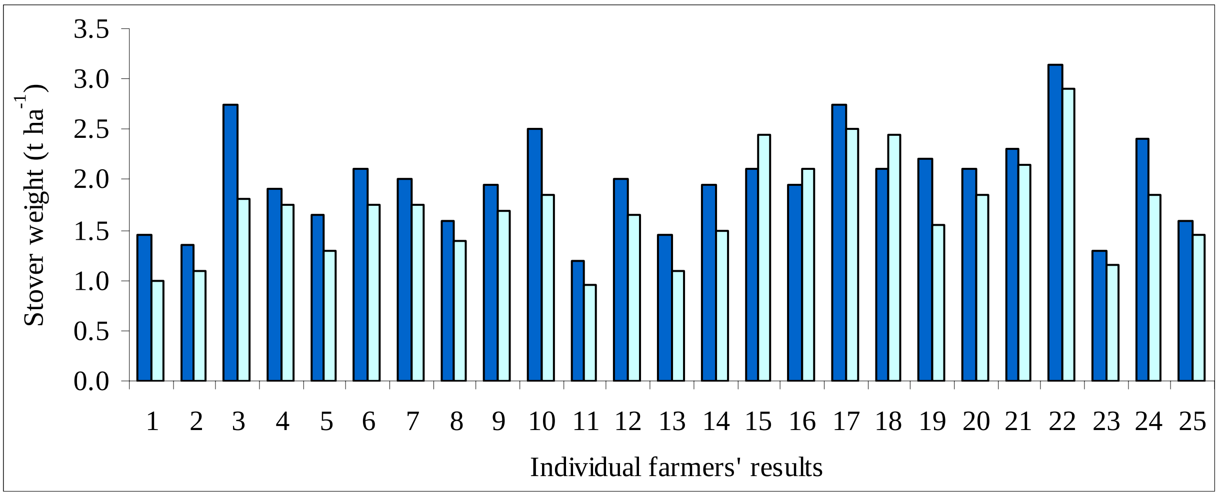


Figure 5.4.4. Stover weight of direct-sown (□) and transplanted (■) early millet (t ha^{-1}) for 25 farmers from Zebilla in the second year of trials.

Plate 5.4.2 shows the Mrs Apangbum early millet results in the field in Zebilla.

Plate 3a. Mrs Apangbun standing in her direct sown early millet field, Ankipaliga, Zebilla. .

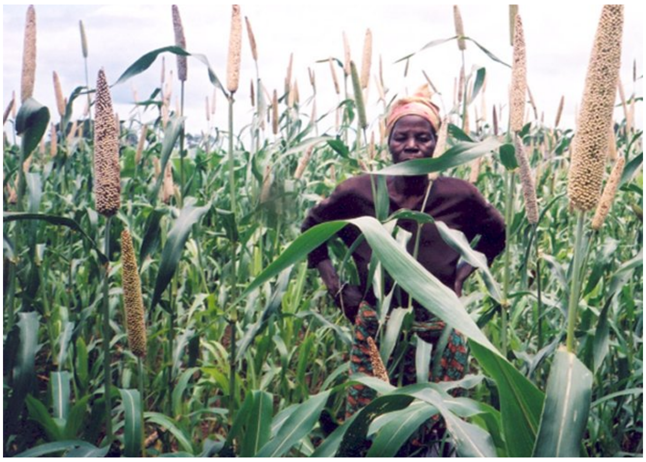


Plate 3b. Mrs Apangbun standing in her transplanted early millet field. The stand is improved and plants are producing larger heads.

During the first year of trials farmers from Wiega and Fumbisi were taken to Zebilla to see the transplanted early millet crops in the farmers' fields there. After seeing that it was possible to transplant early millet 21 farmers from Wiaga decided to ignore the taboo and try transplanting early millet during the second year of trials in Ghana. Of those farmers 19 received higher yields from the early millet compared to their direct-sown crops (Figure 5.4.5). The same two farmers that received lower yields from the transplanted compared to the direct-sown crops, also received lower stover yields (Figure 5.4.6), three other farmers received lower stover yields from transplanted crops, although 16 of the 21 farmers harvested more stover from their transplanted crops.

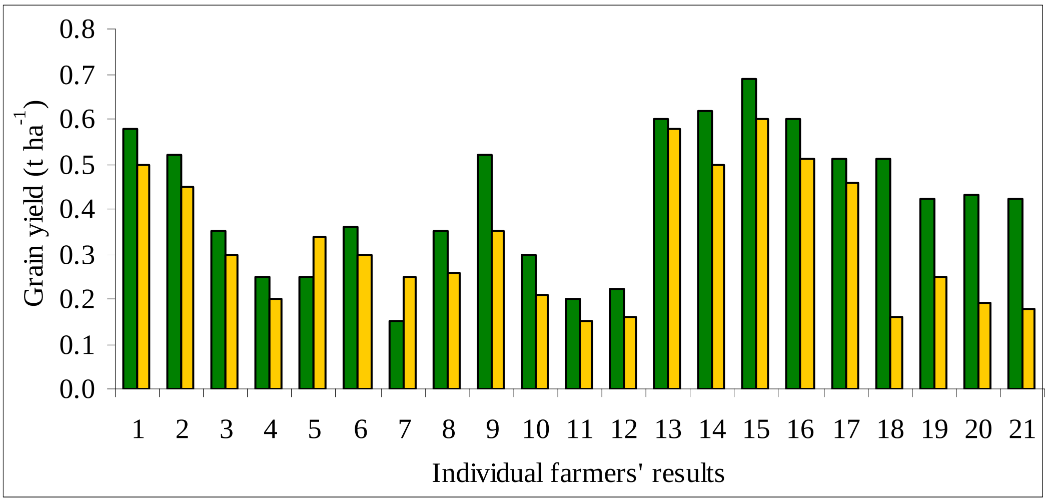


Figure 5.4.5. Grain yield of direct-sown (■) and transplanted (■) early millet (t ha^{-1}) for 21 farmers from Wiaga in the second year of trials.

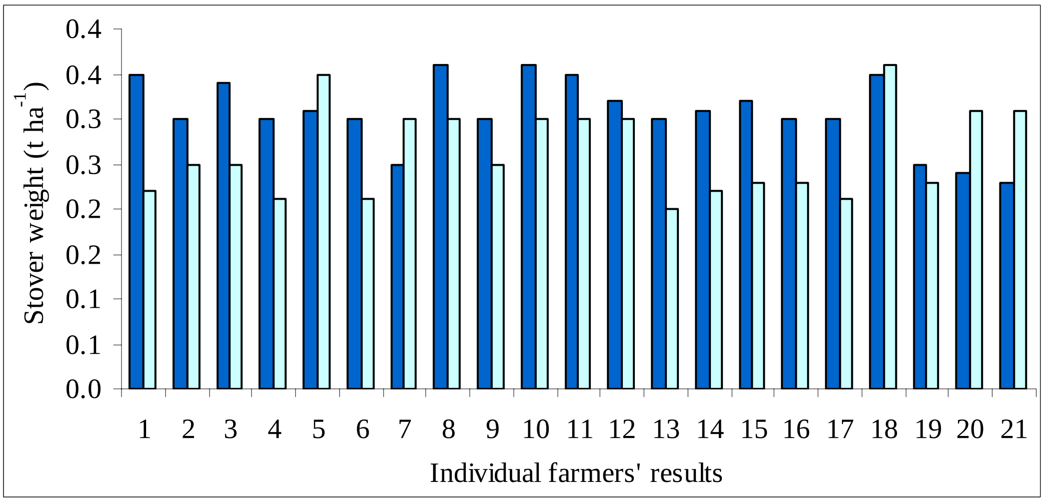


Figure 5.4.6. Stover weight of direct-sown (□) and transplanted (■) early millet ($t\ ha^{-1}$) for 21 farmers from Wiaga in the second year of trials.

In Navrongo, a new district included in the second year of trials, 20 of the 25 farmers who conducted early millet trials for the first time received higher grain yields from their transplanted crops compared to their direct-sown, and 21 received higher stover yields from transplanted crops (Figures 5.4.7 and 5.4.8).

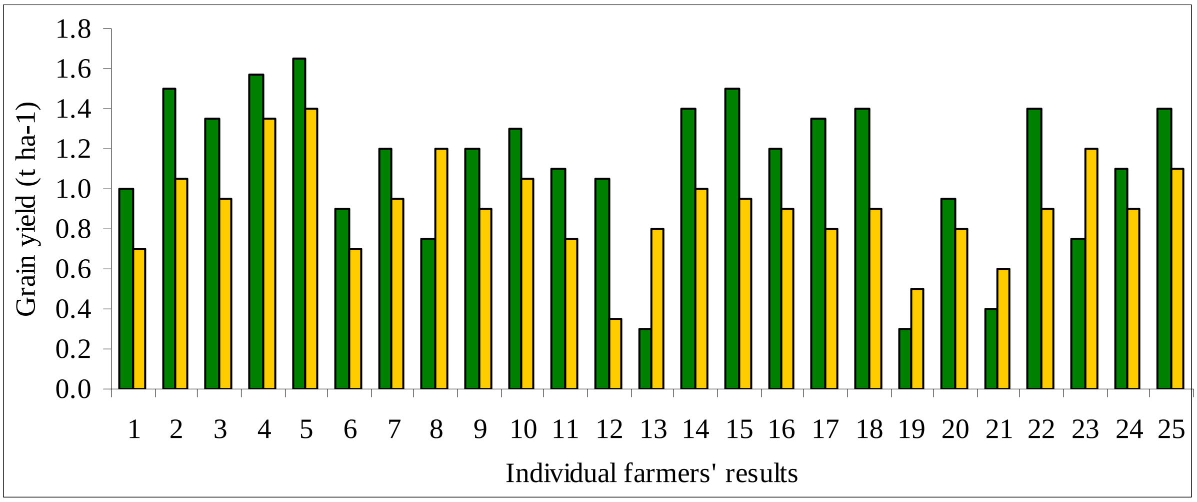


Figure 5.4.7. Grain yield of direct-sown (□) and transplanted (■) early millet ($t\ ha^{-1}$) for 25 farmers from Navrongo in the second year of trials.

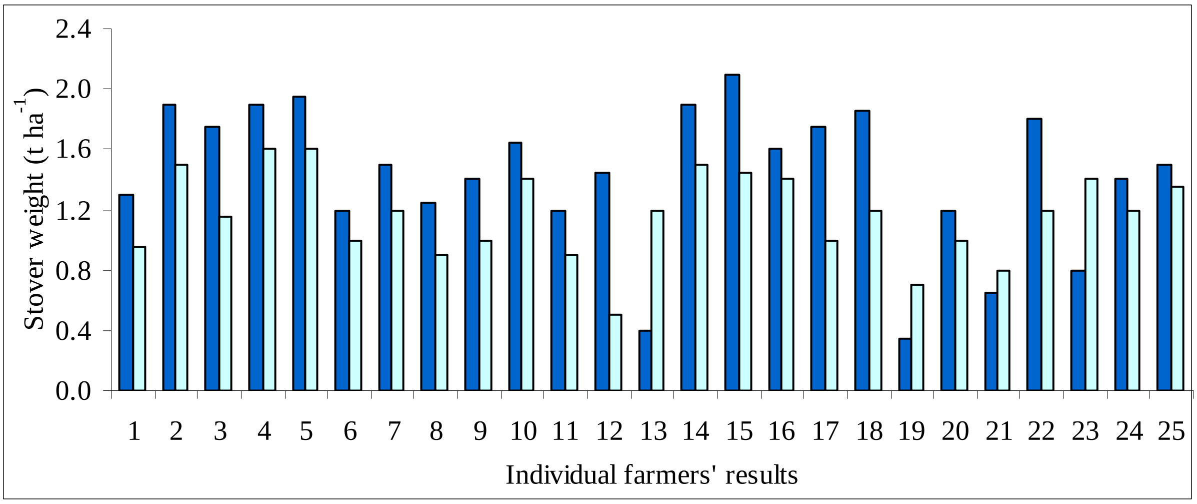


Figure 5.4.8. Stover weight of direct-sown (□) and transplanted (■) early millet (t ha^{-1}) for 25 farmers from Navrongo in the second year of trials.

5.4.2.2 Late millet

During the first year of trials all five farmers from Fumbisi received higher grain and stover yields from their transplanted late millet crops compared to their direct-sown (Figure 5.4.9). Two of the five farmers received approximately double the yield from transplanted crops.

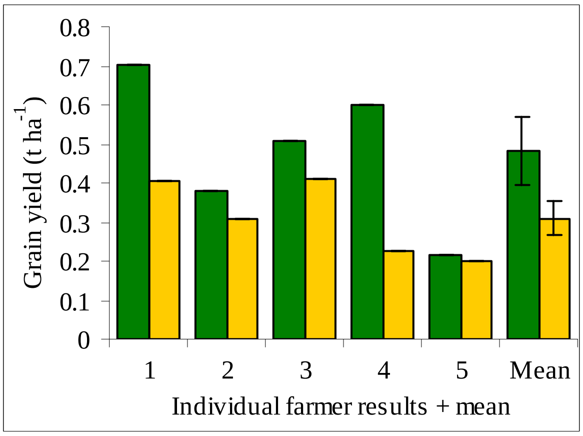


Figure 5.4.9 (a). Grain yield of direct-sown (■) and transplanted (■) late millet for five farmers from Fumbisi. Mean of farmers results and standard errors shown.

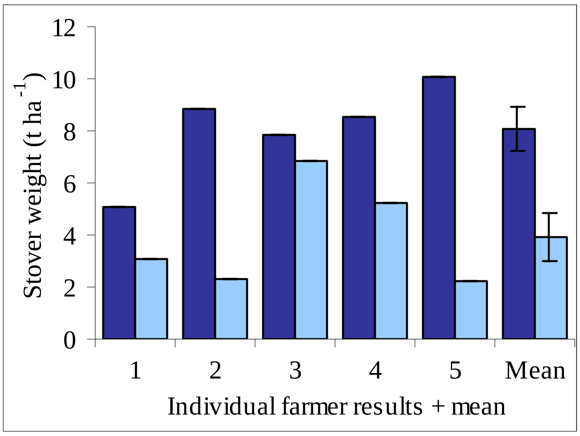


Figure 5.4.9 (b). Stover yield of direct-sown (□) and transplanted (■) late millet for five farmers from Fumbisi. Mean of farmers results and standard errors shown.

In Wiaga during the first year of trials (Figure 5.4.10) 15 of the 19 farmers involved received higher yields from transplanted late millet crops, and in the second year 19 of 20 farmers received higher yields from transplanted crops (Figure 5.4.11). Results for stover weights in the second year also show that the same 19 farmers received higher stover yields (Figure 5.4.12).

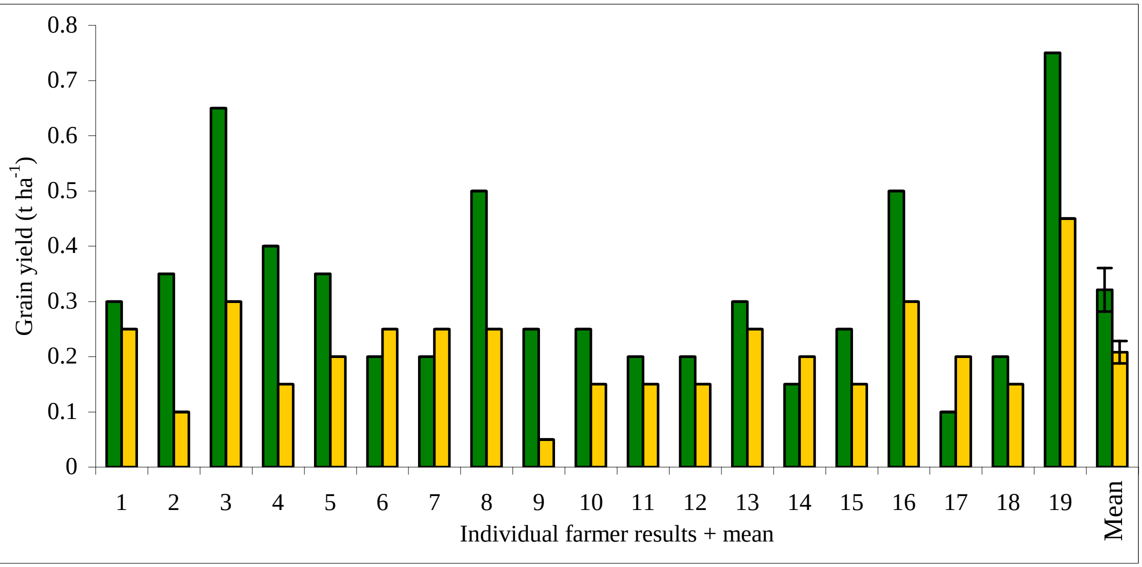


Figure 5.4.10. Grain yield of direct-sown (□) and transplanted (■) late millet (t ha^{-1}) for 19 farmers from Wiaga in the first year of trials . Mean of farmers results and standard errors shown.

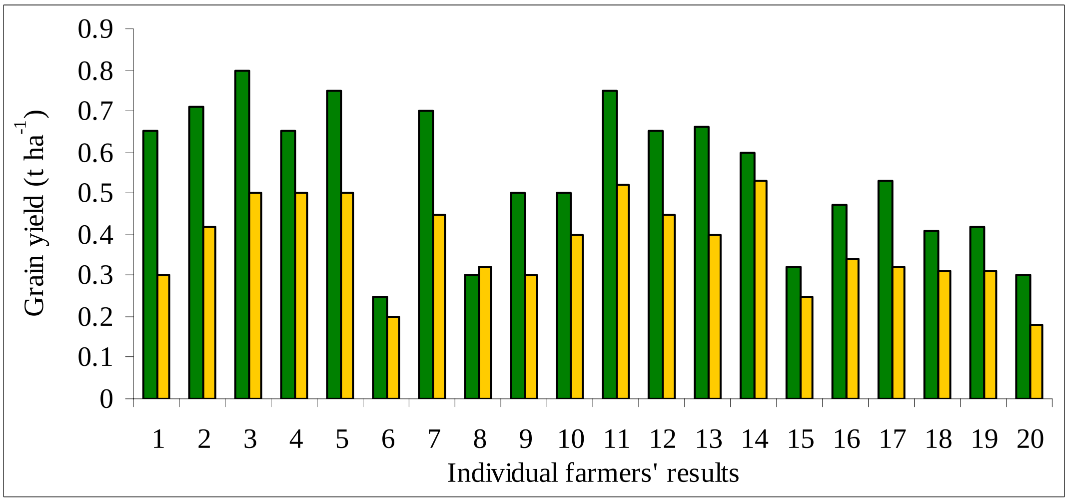


Figure 5.4.11. Grain yield of direct-sown (□) and transplanted (■) late millet (t ha^{-1}) for 20 farmers from Wiaga in the second year of trials.

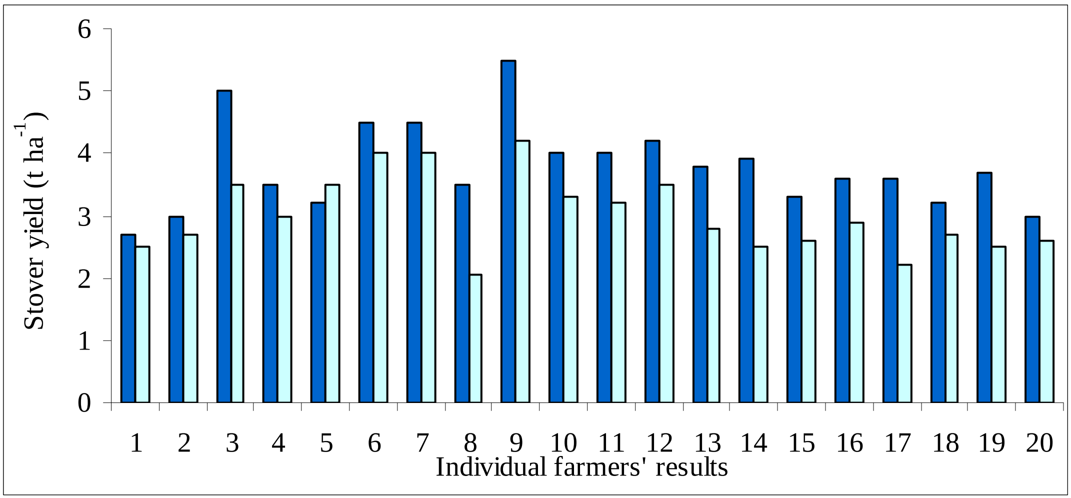


Figure 5.4.12. Stover weight of direct-sown (□) and transplanted (■) late millet ($t\ ha^{-1}$) for 20 farmers from Wiaga in the second year of trials.

During the first year of trials in Zebilla only two farmers conducted late millet trials as farmers consider sorghum to be more important, both farmers received higher grain and stover yields from the transplanted crops. In the second year six farmers conducted late millet trials and all farmers received higher yields and more stover from transplanted late millet compared to direct-sown (Figure 5.4.13).

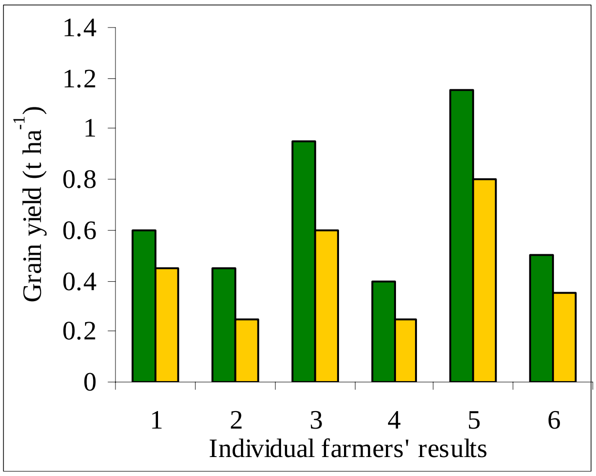


Figure 5.4.13 (a). Grain yield of direct-sown (□) and transplanted (■) late millet for six farmers from Zebilla in second year of trials.

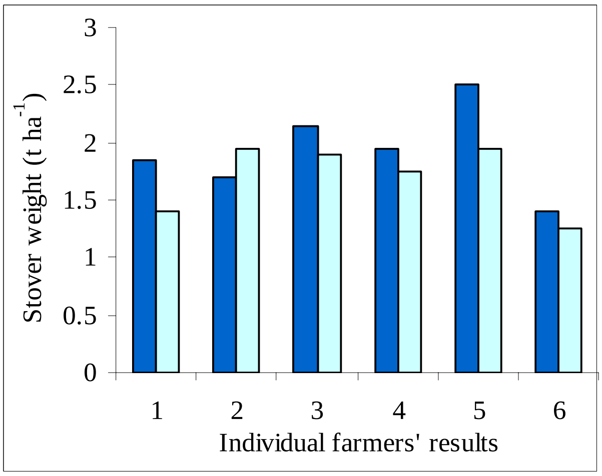


Figure 5.4.13 (b). Stover yield of direct-sown (□) and transplanted (■) late millet for six farmers from Zebilla in second year of trials.

In Navrongo 17 of the 19 farmers received higher yields and all received more stover from their transplanted crops (Figures 5.4.14 and 5.4.15).

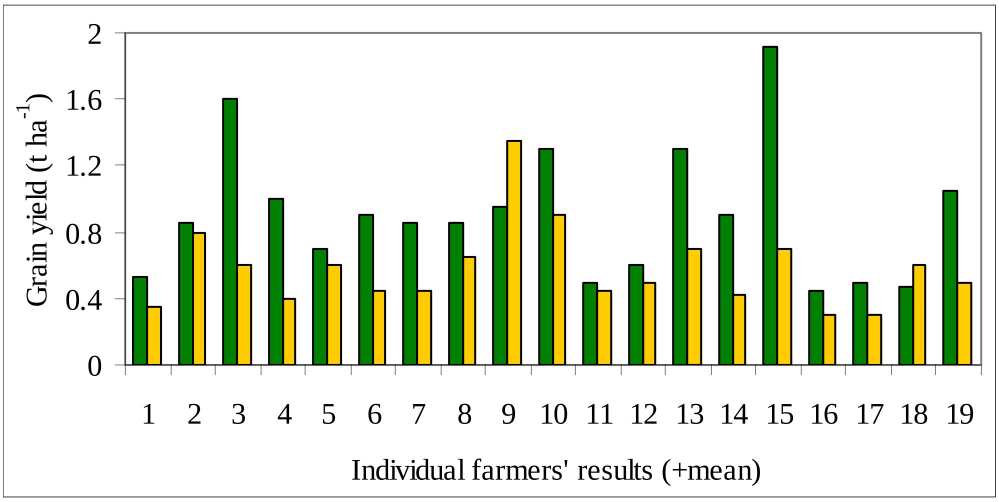


Figure 5.4.14. Grain yield of direct-sown (▢) and transplanted (■) late millet (t ha^{-1}) for 19 farmers from Navrongo in the second year of trials.

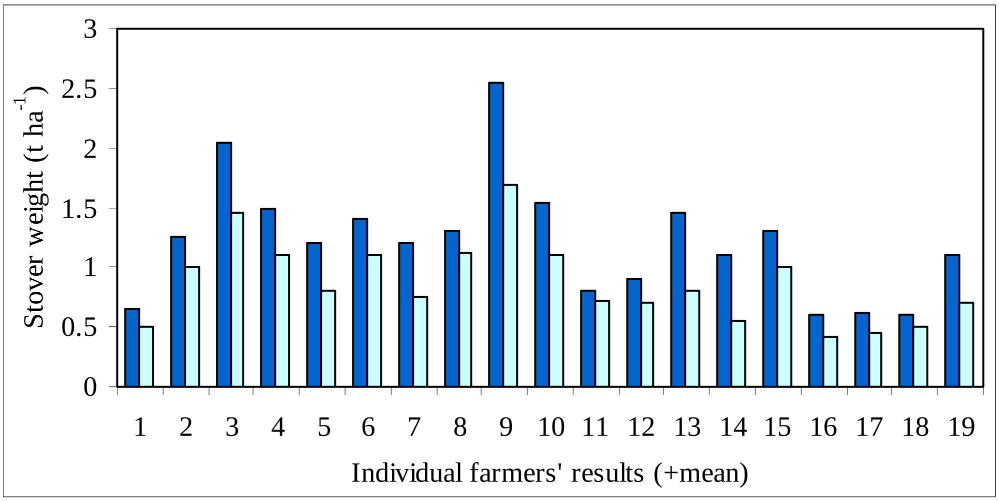


Figure 5.4.15. Stover weight of direct-sown (▢) and transplanted (■) late millet (t ha^{-1}) for 19 farmers from Navrongo in the second year of trials.

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5.4.2.3 Sorghum

Results for sorghum yields were similar to those of late millet where most farmers' transplanted crops yielded more than direct-sown. In Fumbisi all of the farmers' transplanted sorghum produced a higher grain and stover yield than direct-sown in the first year of trials (Figure 5.4.16), and all received higher grain yields from transplanted crops in the second year of trials although one farmer received less stover (Figure 5.4.17 and 5.4.18)

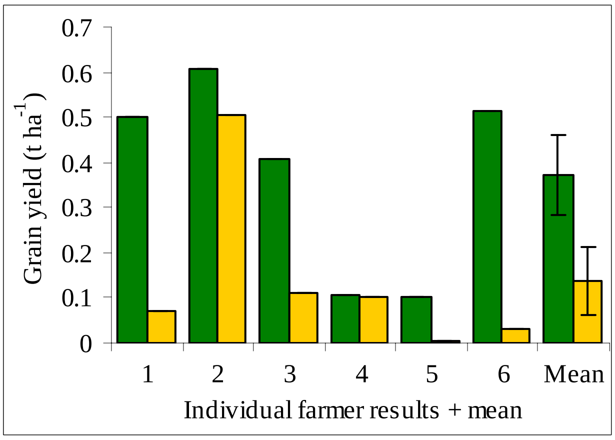


Figure 5.4.16 (a). Grain yield of direct-sown (■) and transplanted (■) sorghum for six farmers from Fumbisi. Mean of farmers results and standard errors shown.

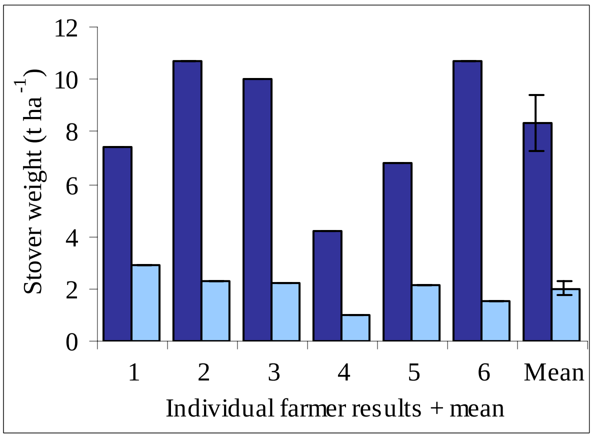


Figure 5.4.16 (b). Stover yield of direct-sown (□) and transplanted (■) sorghum for six farmers from Fumbisi. Mean of farmers results and standard errors shown.

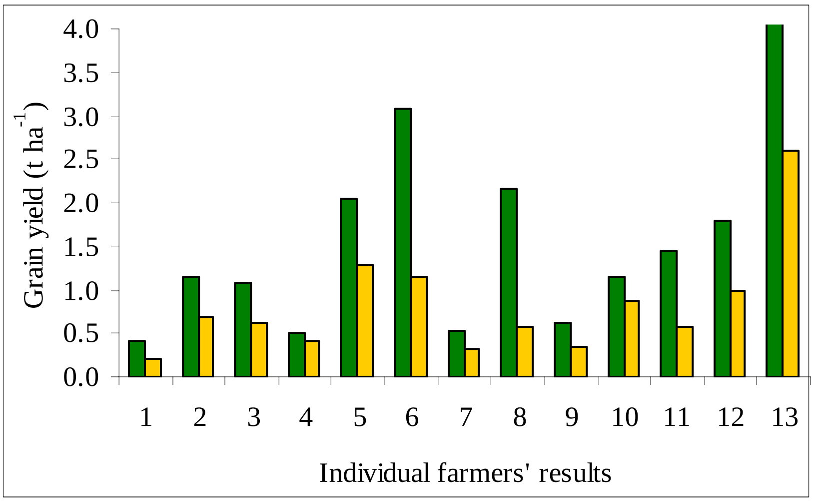


Figure 5.4.17. Grain yield of direct-sown (■) and transplanted (■) sorghum (t ha^{-1}) for 13 farmers from Fumbisi in the second year of trials.

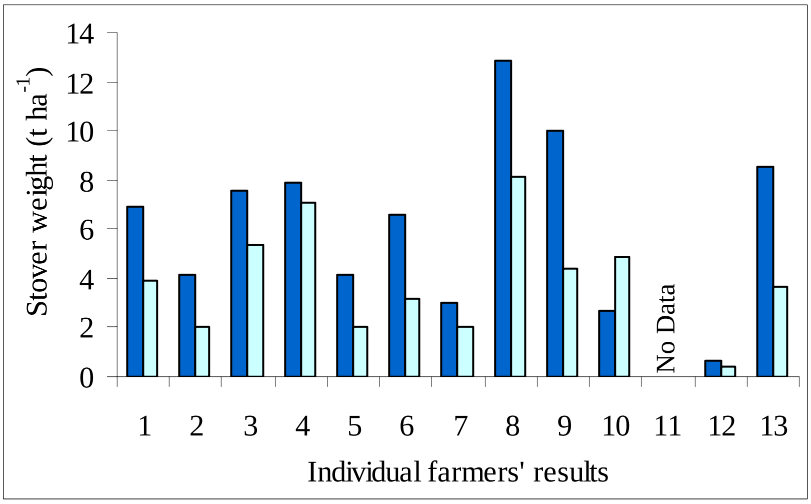


Figure 5.4.18. Stover weight of direct-sown (□) and transplanted (■) sorghum (t ha^{-1}) for 13 farmers from Fumbisi in the second year of trials.

In Wiaga 15 of 19 farmers in trial one, and 19 of 21 farmers in trial two received higher yields from transplanted sorghum (Figures 5.4.19 and 5.4.20). During the second year all farmers received higher stover yields from transplanted sorghum (Figure 5.4.21)

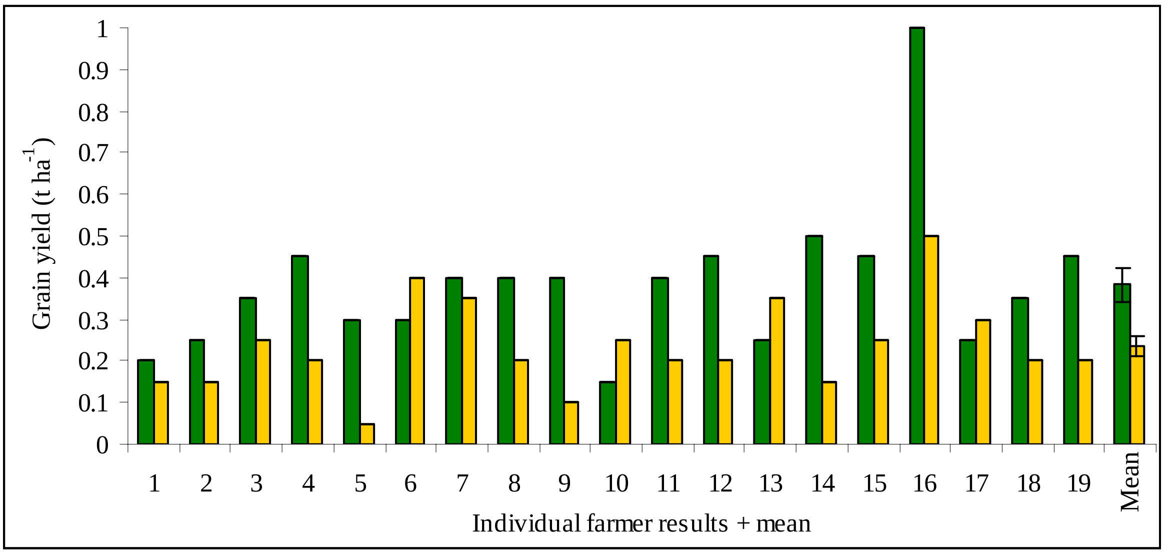


Figure 5.4.19. Grain yield of direct-sown (■) and transplanted (■) sorghum (t ha^{-1}) for 19 farmers from Wiaga in trial one. Mean of farmers results and standard errors shown.

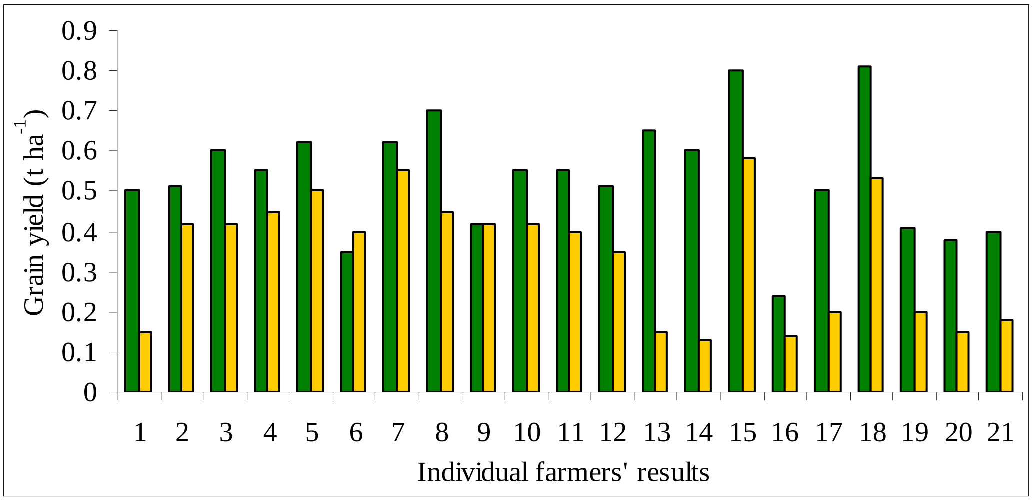


Figure 5.4.20. Grain yield of direct-sown (■) and transplanted (■) sorghum (t ha^{-1}) for 21 farmers from Wiaga in trial two.

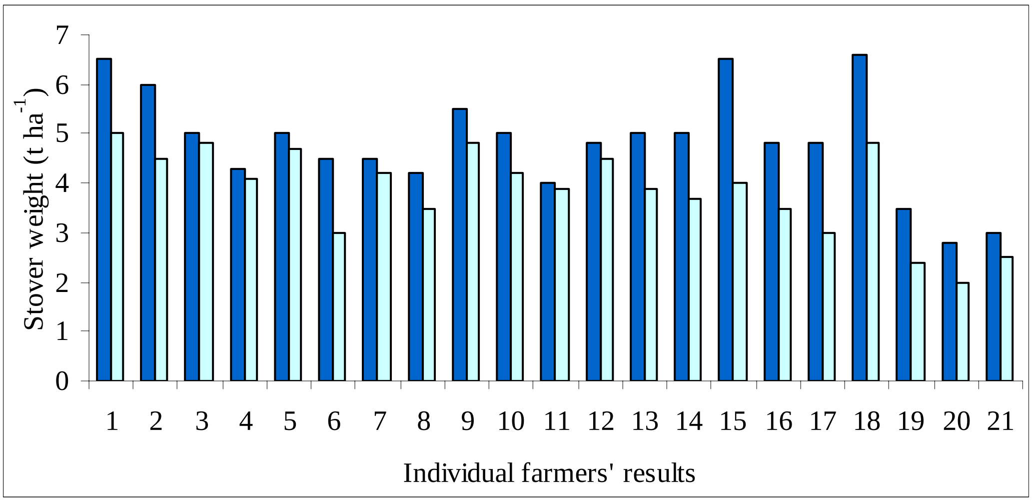


Figure 5.4.21. Stover weight of direct-sown (□) and transplanted (■) sorghum (t ha^{-1}) for 21 farmers from Wiaga in the second year of trials.

Figure 5.4.22 and 5.4.23 show that in Zebilla during the second year of trials 17 of 19 farmers received higher yields and the same farmers received more stover from transplanted crops compared to direct-sown.

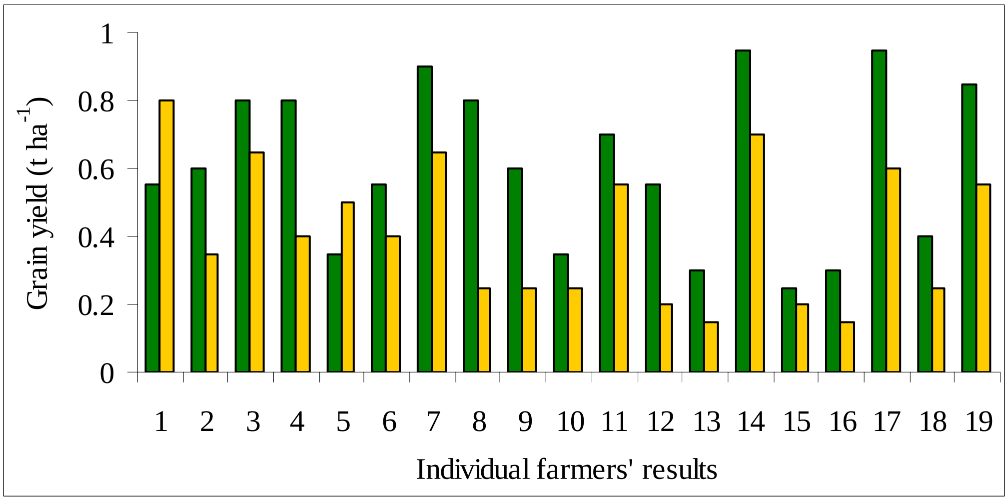


Figure 5.4.22. Grain yield of direct-sown (□) and transplanted (■) sorghum (t ha^{-1}) for 19 farmers from Zebilla in trial two.

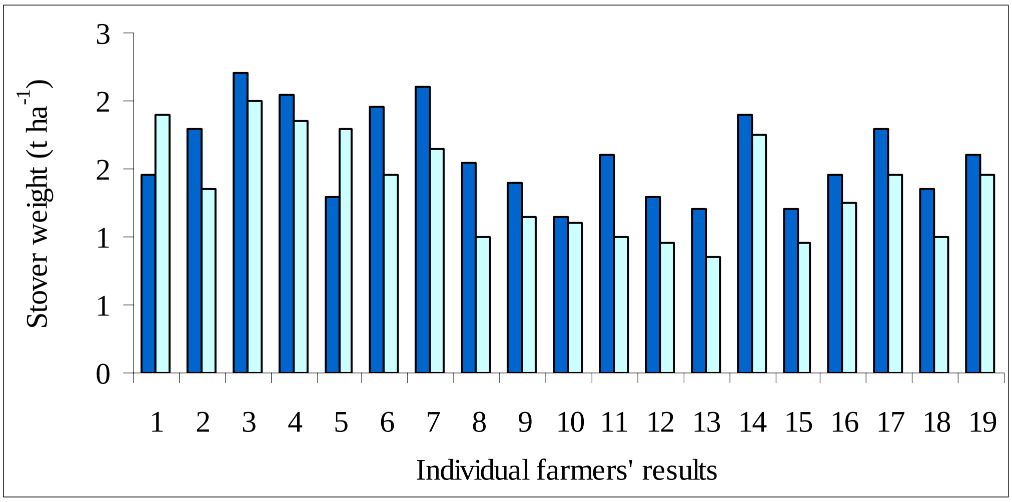


Figure 5.4.23. Stover weight of direct-sown (□) and transplanted (■) sorghum (t ha^{-1}) for 19 farmers from Zebilla in the second year of trials.

In Navrongo all farmers received higher grain and stover yields from the transplanted sorghum compared to their direct-sown (Figure 5.4.24 and 5.4.25).

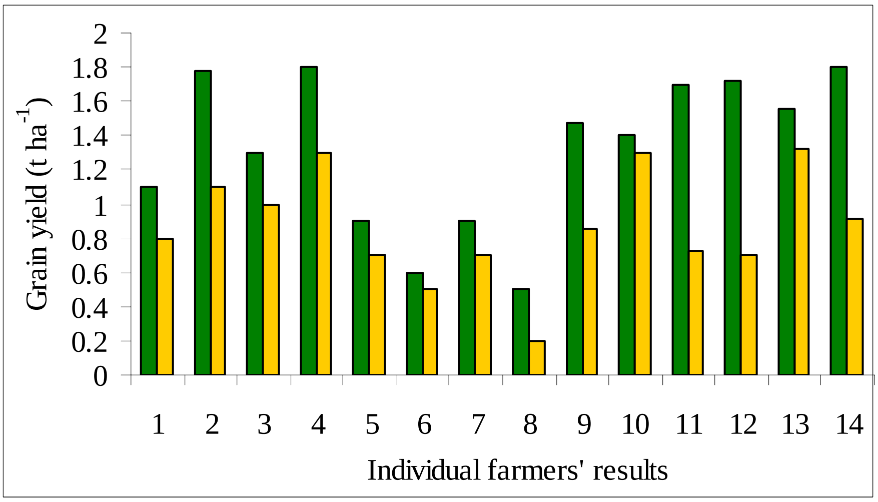


Figure 5.4.24. Grain yield of direct-sown (□) and transplanted (■) sorghum (t ha^{-1}) for 14 farmers from Navrongo in trial two.

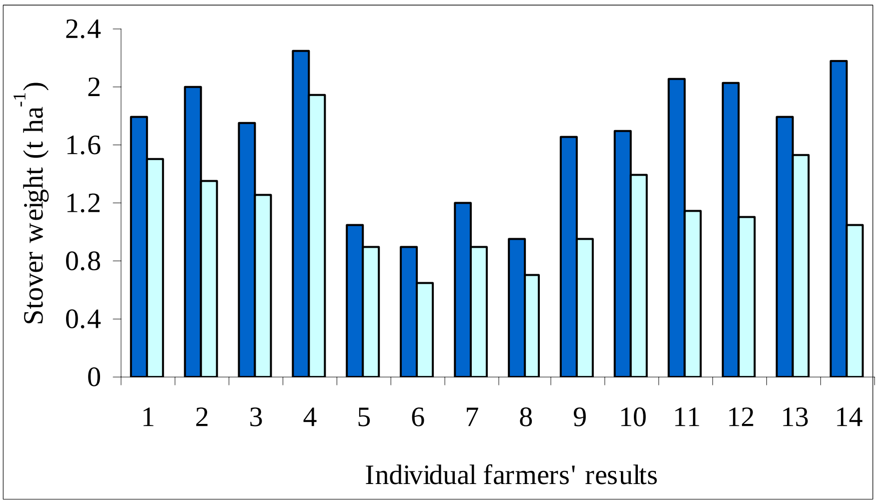


Figure 5.4.25. Stover weight of direct-sown (□) and transplanted (■) sorghum (t ha^{-1}) for 14 farmers from Navrongo in the second year of trials.

All the on-farm trials from Ghana show that for early millet, late millet and sorghum between 79-90% of farmers who conducted the trials in each of the different areas received a higher yield from their transplanted crops compared to their normal direct-sown, and in some cases this increase was double the normal harvest. When the results were discussed with the farmers in report-back sessions during the final workshops, they said that the transplanted crops were much stronger and healthier than direct-sown crops as only one or two seedlings were transplanted per position. The direct-sown plants were much more weedy and thin due to the high seed-rate required because of poor germination, and resulting overcrowding. They attributed the increased yield to increased plant vigour where plants produced more heads, and to improved stand establishment. Farmers who had *Striga* infested fields also noted that transplanted crops produced a much higher yield compared to direct-sown crops as the effect of *Striga* was greatly reduced due to transplanting a seedling, and the plant having a head start over the germinating *Striga* seed.

No specific correlations between particular practices and higher/lower transplanted yields were found from the exercise that was conducted with farmers in Ghana. However through discussions with farmers in the few cases where farmers received higher yields from their direct-sown crops they attributed this to overgrown nurseries or a drought period after transplanting. During the discussions at the end of the second year of trials many of the farmers admitted that they had not established all the nurseries that were suggested, *i.e.* at least three 15 days apart, but that after trying the technique for one or two seasons they now understood the importance of establishing a series of nurseries so seedlings of the right age are ready when the rains start, and that in future they would do this and expected improved yields. Of all the farmers involved in the trials in the second year in Ghana every one said that they would continue with transplanting even though the project could not support them, and many reported that their neighbours were going to try the technique by themselves next year.

In addition to the data from the trials the strengths and weaknesses of the technique were highlighted through SWOT analyses conducted with groups of farmers involved in the trials, the results of these exercises are shown in Table 5.4.1.

Table 5.4.1. Summary of the SWOT analysis carried out at the end of season workshop (Feb 2002) with farmers in Ghana.

Strengths *Nurseries* 1. Nurseries are easily managed due to their small size. 2. Germination improved compared to seed directly sown in the field. 3. Early sowing in the nursery prevents seed being eaten as food. 4. Seedlings grow quickly and are strong and vigorous. *Transplanted* 5. Seedling survival after transplanting is good. 6. No need to re-sow/gap fill. 7. Leaves are green and plants strong and healthy. 8. Plants produce more tillers and stover, bigger heads, higher yields and better quality grain. 9. Plants harvested earlier (approx. 10 days) when market price is higher and food in short supply. 10. Labour is not required to scare birds from the field as seed is not sown directly. 11. Striga infestations reduced. 12. New knowledge/sense of happiness.	**Weaknesses** *Nurseries* 1. First nursery may overgrow if rains are late. 2. Fencing required to prevent attack from ground birds and animals. 3. Insect damage including ants. 4. Some water sources dried before the start of the rains. *Transplanting* 5. Labour requirement at transplanting. *Transplanted* 6. Transplanted seedlings attacked by roaming animals due to being the only green matter at the start of the season. 7. Transplanted plants suffered lodging more than direct sown plants due to a storm that hit when transplanted plants were larger.
Opportunities *Nurseries* 1. Better fencing to restrict animal damage to nurseries. 2. Situate nurseries close to compounds to allow further protection from animals. 3. Covering seeds well by sowing at 3cm depth, avoiding previously ant-infested areas and applying ash in a ring around nurseries to reduce ant attack. 4. Water nurseries before sowing so as to charge the soil and reduce ant damage. 5. Trim leaves of seedlings to slow growth in the nursery if rains are delayed. *Transplanting* 6. Reduce water before transplanting to harden seedlings. 7. Cut leaves at transplanting to aid survival. 8. Reduce labour problem by ploughing with bullocks, hire and use family labour and possibly set up community nurseries. *Transplanted* 9. Talk to land custodians/heads to apply restrictions on roaming animals earlier to reduce damage after transplanting.	**Threats** *Nurseries* 1. No source of water for nurseries or source to far away. *Transplanting* 2. Not enough labour to carry out the transplanting process. *Transplanted* 3. Long dry period within the growing season causing plants to die. 4. Termites destroying all seedlings. 5. For women in Sandema, difficult to expand transplanting area due to men owning the land.

5.4.3 Results common to Zimbabwe and Ghana

In addition to highlighting the strengths and weaknesses, farmers from both Ghana and Zimbabwe, at various discussion-group meetings throughout the project were asked to list the main benefits and problems of the transplanting technique. A summary of all the main points highlighted are presented:

5.4.3.1 Benefits of transplanting

- **Earlier harvest**: this is particularly important as the end of the dry season/beginning of the wet season is the lean period for farmers when food reserves are low and grain prices are high. It is also important for those areas that experience short rainfall duration, or where there is an increasing trend for rains too finish early.
- **Higher yields**: bigger panicles and more heads per plant.
- **Reduces the effect of *Striga***: higher yields in *Striga* infested fields as the transplanted seedling has a head start over the germinating striga.
- **Conserves seed**: when comparing a transplanted plot with a normal direct-sown plot of the same area, less seed is required in the nursery to provide enough seedlings compared to broadcasting.
- **Labour is reduced at other times**: although transplanting from nurseries to the field is time-consuming labour requirement is reduced at other times, for example the need for weeding is reduced. Seedlings have a head start over weeds and the transplanted crop does not have to be thinned and gap-filled during the first weeding, which is time-consuming and damages the crop.
- **If nurseries are secured they are easy to supervise**: nurseries are small so pests can easily be spotted and manure can be applied directly to the seedlings.
- **Improved germination in the nursery**: compared to a direct sown field germination is improved, possibly due to more frequent watering and better supervision as described above.
- **Flexibility in time of transplanting**: seedlings do not have to be transplanted at the first rains, which are often unreliable. They can be left in the nursery while a farmer is busy with other activities until a more convenient time, as long as seedlings do not become too old to transplant (<30 days for early

millet, <40 days for sorghum and late millet). This may be of greatest benefit for farmers who do not own an ox and plough as generally the start of the rains is the busiest time when land must be prepared as soon as possible to provide a long enough season for the crop to mature. Farmers who do not have an ox and plough often have to wait until other farmers have finished ploughing their own land, which may result in late sowing and increase the risk of the crop failing to reach maturity if the season is short. Such resource-poor farmers can allow their seedlings to grow in the nurseries until the demand for ploughs is reduced and the transplanted crop should still mature. Similarly if the rains are late seedlings may be left in the nursery until the rains start and should still mature if the season is short.

- **Surplus nursery seedlings can be sold to other farmers**.

5.4.3.2 Problems associated with transplanting

- **Birds eating germinating seeds**: this is a particular problem in the nurseries as they are the only green material at this time of the season. Some farmers reduced the bird damage by mulching, also high density sowing ensures there are adequate numbers of plants for transplanting.
- **Animal damage to unsecured nurseries**: this is a particular problem because at this time early in the season animals are roaming freely and owners are not compelled to tether animals until the main cropping season begins.
- **Source of water too far from the nursery**: some farmers' nurseries were situated more than 30 minutes walk from a water source, which made frequent watering problematic.
- **Termites eating seedlings**: termites are a constant problem for many of the farmers involved in the trials and attack most crops. To reduce damage in nurseries one farmer suggested that when nurseries were watered daily *i.e.* when they were constantly wet, termites were not such a problem. Others suggested a ring of ash around the nursery boundaries.
- **Overgrown seedlings**: If a series of nurseries are not established seedlings may overgrow in the nurseries whilst waiting for the rains, and become too old to transplant.
- Transplanting from the nursery to the field is **laborious and time consuming**.

5.4.3.3 Checklist of elements critical to the success of transplanting

Through a combination of discussions with farmers and local institutions participating in the trials, and the on-station results a checklist of elements critical to the success of transplanting has been compiled:

1. A reliable perennial source of water must be available for nurseries and it must be conveniently situated for watering nurseries.
2. Farmers should normally grow either sorghum millet, or both. This is a technique to be used by sorghum and millet farmers, not a package for introducing sorghum and millet into new areas.
3. Rainfall should be low and the distribution erratic. There is not much to be gained by this type of low-input transplanting in high-potential areas unless double cropping is the main aim.
4. Labour must be available for transplanting seedlings from nurseries to the field.
5. A series of nurseries should be established so that a supply of seedlings at the 'right' age is available when rains are sufficient for transplanting. Seedlings should be transplanted at 10-20 days old (optimum 20 days) for early millet and 20-40 days old (optimum 30-40 days) for late crops.

5.4.3.4 Guidelines for transplanting

A set of guidelines for transplanting has been compiled:

Nursery Management

The optimum transplanting age of seedlings is 10-40 days. Nurseries should therefore be sown approximately 10-40 days before the expected start of the rainy season. A series of nurseries may be sown to provide a bank of seedlings of various ages to accommodate variability in the season start-date.

Nursery beds construction can vary but suggested guidelines are:

- Nurseries should be located as near as possible to a water source and to the field into which seedlings will be transplanted.
- Nurseries should be fenced to protect seedlings from animal damage.
- Ideally the nurseries should be provided with some shade particularly at the hottest time of the day to reduce heat damage to the seedlings.

- Beds should be bunded to reduce water runoff.
- Sowing densities of nurseries should be approximately 1000 plants per m^2, and should be sown in rows. The size of beds depends on the size of the area to be transplanted, however it is estimated that a 5m x 6m nursery at a plant density of 1000 plants m^{-2}, should provide sufficient plants for approximately 1ha at 30,000 plants ha^{-1}.
- Mulch may be used on the nurseries to reduce bird damage to the seeds and seedlings, although termites may be attracted to the mulch if they are a problem in the areas concerned.
- Manure or fertiliser should be added to the seedbed in low fertility soils depending on what is available according to the normal practice. Transplanting does not require any additional inputs outside farmers' normal practice.
- Nurseries should be watered when required. For the first few days, up to and after emergence, nurseries may need watering twice a day until seedlings have established a root system below the soil surface, which may form a dry to a crust in high temperatures.

Transplanting

- Transplanting should be carried out after the beginning of the rainy season. There should be at least one day's rain (preferably two or more) prior to the day of transplanting, which should be conducted in late afternoon or evening on a cloudy or rainy day to reduce evapotranspiration.
- When seedlings are removed from the nursery the root damage should be kept to a minimum and dug up from at least 15cm depth.
- Root exposure in the period between removal from the nursery and transplanting in the field should be kept to a minimum; the more wilted the seedlings are at transplanting the less and slower the chance of recovery. The damage to exposed roots can be minimised by protecting with moist leaves or sacking.
- Seedlings should be transplanted at 10-20 days for early millet, and 20-40 days for late crops.

6 Contribution of Outputs

As a result of this project:

- The constraints on the adoption of transplanting as a technique for improving crop establishment as a means of increasing food security in selected areas have been characterised.
- We know that in general locally available varieties and landraces of sorghum and pearl millet are suitable for transplanting. Early varieties will mature significantly earlier and yield more than direct-sown crops when transplanted and late (photoperiod sensitive) varieties will also show a yield advantage.
- Areas for application of transplanting techniques have been identified
- Optimal methodological strategies for transplanting have been developed.

6.1 Contribution to DFID's developmental goals

The Department for International Development (DFID)[15] is the UK Government department responsible for promoting sustainable development and reducing poverty. The central focus of the Government's policy, based on the 1997 and 2000 White Papers on International Development, is a commitment to the internationally agreed Millennium Development Goals[16], to be achieved by 2015. The goals specifically addressed by this project are as follows:

➢ Eradicate extreme poverty and hunger	We have shown that transplanting can reduce the "hunger gap" at the end of the dry season
➢ Promote gender equality and empower women	We have shown that women are particularly interested in transplanting of sorghum and pearl millet as it is mostly their responsibility to ensure that the household is fed. In their opinion being able to harvest even two days earlier would make a difference, being able to do so two to three weeks earlier is a major breakthrough in their uncertain environment.
➢ Reduce child mortality	Ensuring an earlier harvest and increasing yields will contribute towards improving child nutrition and survival.
➢ Improve maternal health	Ensuring an earlier harvest and increasing yields will contribute towards improving maternal health.

15 http://www.dfid.gov.uk/

16 http://www.developmentgoals.org/

➢ Ensure environmental sustainability	Although not exclusively for the poorest of the poor, this technique has been developed with resource poor farmers who live in extremely marginal areas. Any improvement in their livelihood will contribute towards environmental sustainability

DFID's assistance is concentrated in the poorest countries of sub-Saharan Africa of which Zimbabwe and Ghana are two.

6.2 Identified promotion pathways to target institutions and beneficiaries

Market studies carried out for project outputs:

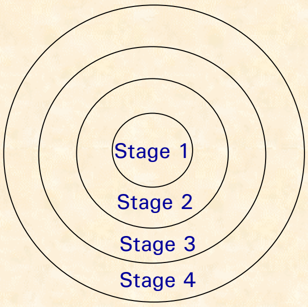
Earlier participatory research on crop establishment in Zimbabwe (R6395) highlighted failed crops, patchy stands and costs of replanting during years when the rain is late as a major problem. Seed priming has proved to be effective in raising yields of some crops, but we have found that transplanted plants mature earlier and yield even more than crops that have been seed primed, and can increase food security. Our recommendation is that farmers adopt a "basket of choices" approach with a combination of transplanted, primed and direct-sown areas.

How will outputs be made available to intended users?

The on-farm participatory research was carried out in collaboration with the Save Valley Research Station and RUDO in Zimbabwe and with SARI, MOFA and Action Aid in Ghana. Local farmers in the study areas are the immediate beneficiaries. A final workshop was held at the end of the project and the main local actors in the field of semi-arid agriculture were invited to discuss the findings and strategise for the future. In our opinion it is too early for widespread uptake to happen spontaneously in Ghana and we believe that a "ripple" methodology (Figure 6.1) would be the most effective promotion pathway.

Fig 6.1 A 'ripple' methodology for dissemination of the transplanting technique

Stage 1
Trial phase in two operational areas in each of two districts in a region to ascertain whether the technique is a viable option for farmers in that region.



Stage 2
Consolidate results found in stage 1 and expand technique through trial phase to all operational areas within the same two districts in the region.

Stage 3
Consolidate results found in stage 2 and expand technique through trial phase to more districts in the same region. Incorporate the technique into the first two district extension activities.

Trial Phase
- 30 farmers – 10x10 m plots
- Field days/workshops
- AEAs from other areas attend training days

Stage 4
Consolidate results found in stage 3 and expand technique to all operational areas in all districts within the region. Incorporate the technique into the regional extension service.

Our NGO partners RUDO (in Zimbabwe) and Action Aid (Ghana) are prepared to support further dissemination of the recommendations as improved crop production, particularly those crops impacting directly and positively on food insecurity, is part of their remit. In Zimbabwe, despite lack of further outside funding sorghum transplanting has been promoted on a small scale by RUDO through:

- Continued dialogue and sharing of information between UK partners
- Preparation of seed banks for sorghum or seed bulk and sharing of seed.
- Encouraging other farmers to engage in sorghum transplanting.
- Working in groups to minimise costs and share activities.
- Field days.

The ministry of Food and Agriculture in Ghana and Zimbabwe and the Research institutions (SARI and DR&SS) are also focussed on crop improvement.

During the life of the project reports and occasional papers have been sent to institutions such as ICRISAT for wider dissemination. Close links have been maintained with the RNRRS Plant Sciences Programme who were funding a project on 'Participatory promotion of on farm seed priming' These contacts have promoted cross-linkages and exchange of ideas.

Further stages needed to develop outputs:

The outputs of this project have established that transplanting alone or in combination with seed priming is a viable proposition in semi-arid areas. More importantly perhaps it has concluded from the opinions of participating farmers that the new technique is ergonomically viable and can be successfully adapted into the farming system without creating unrealistic demands on labour and increasing the work-load, especially of women. If it is successful and to be expanded further then the best varieties and optimum transplanting times for those areas will need to be investigated and disseminated as suggested earlier (Figure 6.1)

How will further stages be carried out and paid for?

A further stage or stages – in whatever form – pure research, adaptive research or wider dissemination will utilise the networks established by the research team during this project and existing links to national extension systems. The methodology will be disseminated through the full range of target institutions, and collaborators will ensure that dialogue is maintained at grass roots level. Unsuccessful efforts have been made to target funding bodies, which can move the research results further into the 'development' arena.

Dissemination mechanisms:

Dissemination to the identified target institutions, NGOs and other interested parties have occurred regularly during the life of the project through meetings with key personnel. At the end of the project a workshop was held in which key people from relevant institutions and groups participated. Dissemination has also occurred through project reports and will soon lead to articles in internationally recognised refereed journals. Reports and occasional papers have also been sent to CGIAR research centres such as ICRISAT. These reports are also available on the CAZS internet site.

6.3 Follow up action needed for promotion of transplanting to achieve development benefits.

A systematic approach is required if transplanting is to be disseminated successfully. To this end a detailed proposal for dissemination of transplanting in the north of Ghana was prepared. This "ripple" methodology is generic and can be transferred to any location.

6.4 List of publications

Young E & Mottram A (2001) "Transplanting sorghum and pearl millet as a means of increasing food security in semi-arid, low-income countries". Tropical Agriculture Newsletter, December 2001.

6.5 Plans for further dissemination

We have devised a farmer-focussed "ripple" method of disseminating transplanting based on the experiences of adapting the generic technology to local situation gained in this project. Clearly it is important that this type of activity, which directly impacts on the poorest farmers (between 79-90% of farmers who conducted the trials in each of the three districts in Ghana received higher yields from their transplanted crop and in many cases the yield was doubled) and has enormous potential for further demonstrable benefits, remains a priority intervention despite changes in DFID focus.

We were advised to contact CIDA who have a food security programme in the north of Ghana and who agree that this project fits in with their remit. However, all funds have been transferred to the region to be dissected between the stakeholders and it is very unlikely that this money will be spent on external technical support. We believe the dissemination method proposed by us, which is designed to transfer knowledge of transplanting throughout the relevant parts of northern Ghana within four years (including two years of intensive UK partner involvement with an exit strategy over the following two years) would have ensured successful uptake of the methodology and capacity building in systematic dissemination techniques. The call for proposals for CIDA money within Ghana has only recently been issued and the relevant evaluation committee will not be convened until May, which is too late for dispersal of funds for the 2003 growing season.

Following discussions at the end of project workshop in Bolgatanga, Upper East Region of Ghana on 21st February 2003 the three participating District Directors of Agriculture will introduce transplanting to the agricultural extension agents in their districts. Training booklets for this purpose have been prepared by Andrea Mottram. The SARI collaborators would ideally like to support this activity but are limited by funds.

Regrettably, in our opinion there is insufficient local capacity for much progress to be made - especially as our SARI collaborators have no access to further funding to enable them to travel regularly to Upper East Region to offer invaluable support to the Ministry of Agriculture staff and ultimately to farmers.

RUDO and Agritex continue with the transplanting project on a small scale in Zimbabwe. Contact has been made with Mr Owen Hughes, FAO, Harare who is interested in including transplanting in the 'Farmer Schools' manual. Other possibilities regarding FAO-funded Technical Assistance in the greater SADC region will be pursued with him.

A Concept Note will be submitted to the CGIAR Challenge Programme on Water and Food in collaboration with the African Centre for Crop Improvement, University of Natal, the Limpopo Province Department of Agriculture, South Africa and the Mozambique Department of Agriculture by 14th April 2003. Transplanting fits very well within themes 1 & 2 of the Challenge Program on Crop Water Productivity Improvement and Multiple Uses of Upper Catchments. It is expected that the research will have wider long-term (15-20 years) global application in developing coping strategies for the uncertainties associated with global climate variation and change.

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