Effects of farmers' seed source on maize seed quality and crop productivity

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ABSTRACT

Although farmer-saved seeds constitute about 90 per cent of maize seeds planted annually, their effects on crop performance are not well known. This study determined the seed quality and field performance of farmer-saved seeds of the most popular quality protein maize (QPM) variety, *Obatanpa*, compared to the certified seed of the same variety. Seed samples collected from four locations (Kwadaso, Ejura, Nkoranzah and Wenchi) showed higher percentage complete vital staining of embryos using 2, 3, 5 triphenyl tetrazolium chloride (TTC) and higher 1000-seed weight in certified seeds, indicating high vigour and complete seed development. Whereas germinating seedlings of the certified seeds did not show any fungal growth, farmer-saved seeds showed profuse fungal development and stunting. Seedling counts showed 9 and 21 per cent reduction in certified and farmer-saved seeds, respectively; but plant counts before harvest showed 12 and 23 per cent reduction. Plants originating from certified seeds flowered at the predetermined date of 55 days, but the farmer-saved seeds flowered about a day or two later owing to reduced vigour. Lodging was less in plants originating from certified seeds, particularly in the trial planted at Ejura (transition zone) compared to Kwadaso (forest zone). The advantages of certified seeds reflected on increased grain yield, which was about 1.2 t ha^{-1}, equal to ¢1,100,000.00 ($110) ha^{-1} or 47 per cent increases over the farmer-saved seeds. The study, therefore, showed the importance of certified seeds in increasing maize productivity and farmers' incomes.

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RÉSUMÉ

ASIEDU, E. A., ASANTE, R., SALLAH, P. Y. K., BADUON, A. & AVAH, E.: *Les effets de la source de semence d'agriculteurs sur la qualité de la graine de maïs et la productivité de culture*. Bien que la semence gardée par l'agriculteur constitue environ 90 pour cent de graines de maïs semées annuellement, ses effets sur le rendement de culture ne sont pas bien connus. Une étude était entreprise pour déterminer la qualité de graine et le rendement sur le terrain de semence gardé par l'agriculteur de la variété la plus populaire du maïs protéique de qualité (MPQ), *Obatanpa*, comparé à la graine certifiée de la même variété. Les échantillons de graine recueillis de quatre emplacements (Wenchi, Nkoranzah, Ejura et Kwadaso) montraient un pourcentage plus élevé de tâches embryonnaires vitales et complétes, appliquant 2,3,5 chlorure triphényl tétrazolium (CTT), ainsi qu'un poids de 1000 graines plus élevées en semence certifiée, indiquant une vigueur élevée et un développement complet de graine. Tandis que les semis germant de semences certifiées n'ont pas montré aucune croissance fongique, les semences gardés par les agriculteurs montraient un développement fongique abondant et retardé. Les comptes de semis montraient 9 et 21 pour cent de réduction respectivement en semence certifiée et en semence gardée par l'agriculteur, tandis que les comptes de plante avant la moisson montraient 12 et 23 pour cent de réduction. Les plantes poussant de semences certifiées fleurissaient à la date déterminée de 55 jours, tandis que les semences gardées par l'agriculteur fleurissaient environ un ou deux jours plus tard à cause de vigueur réduite. Moins de la verse se produisaient chez les plantes poussant de semences certifiées, surtout dans les cultures d'essai plantées à Ejura (zone de transition) comparé à l'essai de Kwadaso (zone de forêt). Les avantages de semences certifiées se traduisaient dans l'augmentation de rendement de graine, qui étaient environ 1.2 t/ha, un équivalent de ¢1,100,000.00 ($110)/ha ou 47 pour cent d'augmentation par rapport aux semences gardées par l'agriculteur. L'étude, par conséquent, démontraient l'importance de semences certifiées à l'augmentation de la productivité de maïs et les revenus d'agriculteurs.

Introduction

In Ghana, maize is produced on a total land area of 665,000 ha and yields 1,008,000 metric tones (SRID-MOFA, 2005). This gives an average yield of 1.5 t ha^{-1} compared to the yield potentials of 5.0 and 7.3 t ha^{-1} of the most popular open-pollinated quality protein maize (QPM) variety, *Obatanpa*, and the QPM hybrid, *Mamaba*, respectively. Factors contributing to reduced yields include low plant population, low soil fertility, poor weed control, late harvesting, post-harvest losses, and the use of poor quality farmer-saved seeds.

The total certified seeds produced annually are low. In 2003, for example, a total of 1,300 tons of seed maize was produced, which could plant only 65,000 ha (10% of total land area planted to maize) in 2004 at a planting rate of 20 kg ha^{-1}. Thus, 90 per cent of maize seeds planted annually originate from farmer-saved seeds, which may be of poor quality due to the poor conditions under which they are produced and stored. However, the effect of this seed on crop performance and productivity is not fully known.

The objective of this study was, therefore, to determine the quality, field performance, and yield of farmer-saved seed compared to certified seed of the QPM variety, *Obatanpa*.

Materials and methods

Samples of certified and farmer-saved seeds meant for planting during the major season of 2003 were collected from four important maize-growing districts: Wenchi and Nkoranza in the transition zone of the Brong Ahafo Region, and Ejura in the transition and Kwadaso in the forest zones of the Ashanti Region. Four seed samples per district were collected, comprising two farmer-saved and two certified seeds of *Obatanpa*, an open-pollinated maize variety. Five hundred grams per sample were taken and seed quality determined in the laboratory followed by a field trial. Thousand-seed weight per sample was determined by counting 1000 individual seeds and weighing in four replicates. Germination was tested by setting four replicates of 50 seeds in moist sand (sterilized by heating at 105 ºC for 24 h) in 30-cm diameter trays kept in polyethylene bags at 27-32 ºC. The first count was on the 4th day and the second on the 7th day after seeds had been set for germination. Seeds were considered germinated if the seedlings were normal as described by AOSA (2002).

The living tissues of the seed's embryo were stained using 2, 3, 5 triphenyl tetrazolium chloride (TTC). Twenty seeds per replica were soaked in water for 2 h at room temperature (27 ºC) and each dissected through the embryo. One hundred millilitres of 1 per cent (w/v) TTC solution in distilled water was added to each set of 25 seeds in a Petri dish. The seeds were then held in the dark for 3 h at room temperature (27 ºC). In living tissues, the TTC reacts with the dehydrogenase enzymes in the cotyledons to produce a red stain called fromazan (Cottrell, 1948; Roberts, 1951; Powell & Mathews,1979; Asiedu *et al.,* 2000). Dead tissues of the cotyledons remained unstained. The cotyledons were then categorized as (1) × = 100 per cent, (2) 100 per cent > × >50 per cent, (3) 50 per cent > × >1 per cent, or (4) 0 per cent stained, where × stands for the extent of staining of each embryo. The percentage of each category was then calculated for each replica.

After the laboratory evaluation of seed quality, a field trial was used to determine the effect of seed source on agronomic performances of such traits as days to flowering, percentage lodging and grain yield. The trial comprised 16 entries, with four from each district consisting of two farmer-saved and two certified seeds. An experimental plot consisted of four rows, each 5 m long. Row width was 75 cm, hill spacing was 40 cm and two seedlings per hill maintained, giving a target plant population of 62,500 plants ha^{-1}.

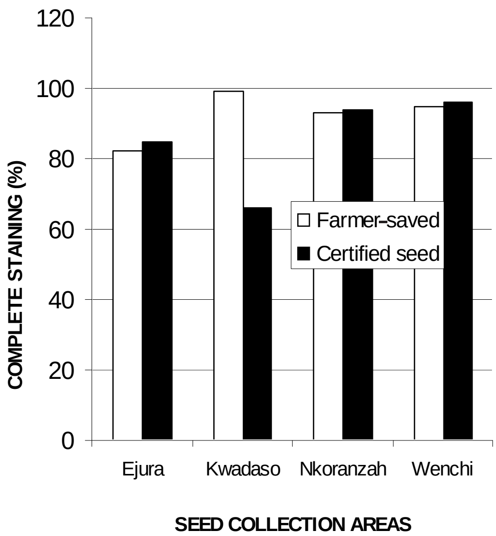
Three seeds were planted per hill and thinned to two after seedling establishment 2 weeks after planting. Fertilizer rate was 90:60:30 N:P:K per hectare and was split-applied at 2 and 4 weeks after planting, and standard weed control measures were adopted. The trial was planted at Ejura in the forest-savanna transition zone and Kwadaso in the forest zone, where seeds were planted in the middle of April. The experimental design was randomized complete block with four replications, and T-test was used to determine differences between treatments.

Results and discussion

In the laboratory, slight increases in complete staining of the embryonic tissues were observed in the certified seeds over the farmer-saved seeds (Fig. 1a and 1b). Visual observation during germination showed that healthy seedlings had developed in the certified seeds, whereas the farmer-saved seeds showed fungal development and stunting (Fig. 2). The certified seeds had higher 1000-seed weight ranging between 330 and 350 g (Fig. 3), which is comparable to the characteristic 1000-seed weight (350 g) for the variety *Obatanpa* determined earlier by Asiedu, Powell & Stuchbury (2000).

The farmer-saved seeds were lower in seed weight, ranging between 206 and 310 g, possibly due to sub-optimum field conditions, including drought stress, low level of soil fertility and poor weed control. Farmers' seeds were also stored under unfavourable natural conditions (26-33 ºC/ 38-98% relative humidity [Asiedu, Powell & Stuchbury, 2000]), resulting in enhanced physiological aging, fungal development and respiration and, consequently, reduced seed weight. Such seeds would normally show low nutrient content to support seedling emergence and development, resulting in low seedling vigour.

The number of seedlings counted 2 weeks after planting at the two locations ranged between 56,000 and 57,000 plants ha^{-1} for the certified seeds, and from 47,500 to 51,000 plants ha^{-1} for farmer-saved seeds (Fig. 4a). Plant count before harvest ranged from 52,500 to 57,000 plants ha^{-1} for certified seeds, and from 46,000 to 50,000 plants ha^{-1} for farmer-saved seeds (Fig. 4b). The low seedling count for farmer-saved seed might be



Percent vital staining of embryos with complete vital staining using TTC

(a) Certified seed showing good level of vital staining

(b) Farmer-saved seed showing poor level of vital staining

Fig. 1. Percentage seeds with complete vital staining of embryos of farmer-saved and certified seeds sampled from four major maize-producing areas of Ghana.

(a) Farmer-saved seed of maize showing profuse fungal development and stunted seedling growth.

(b) Certified seed of maize showing healthy and vigorous seedling growth.

Fig. 2. Germinating (a) farmer-saved and (b) certified seeds showing differences in fungal infection and seedling vigour.

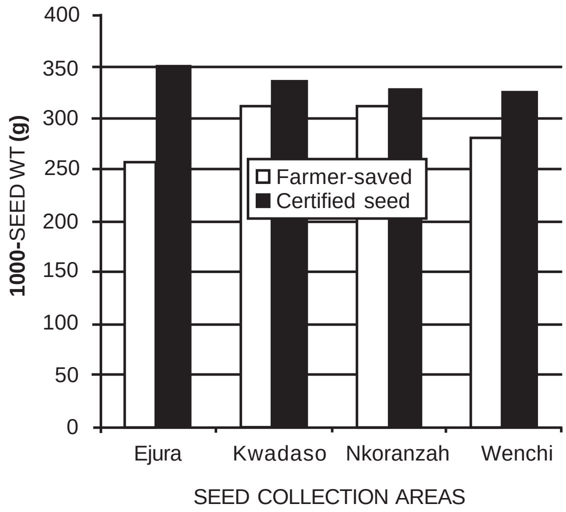
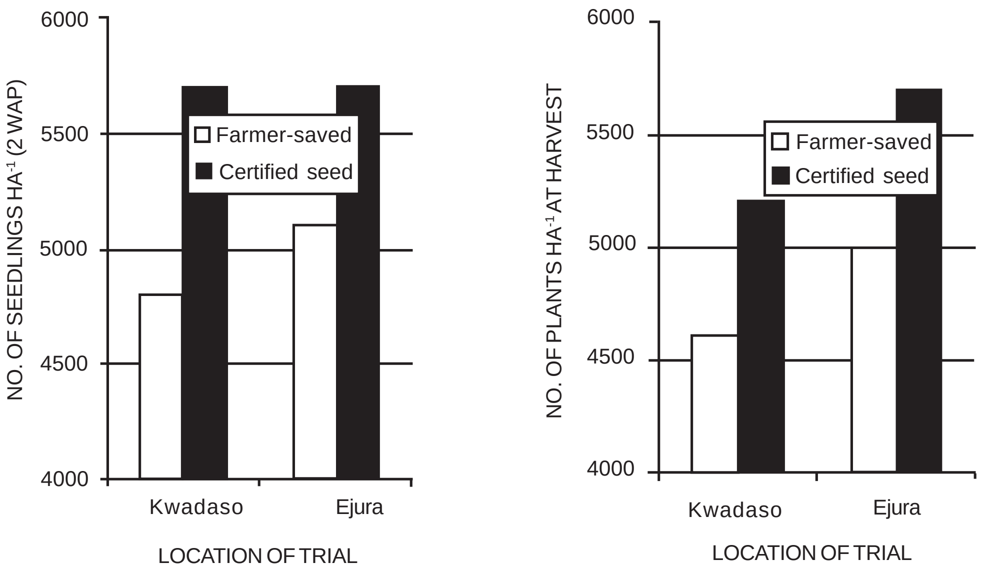


Fig. 3. Thousand-seed weight of farmer-saved and certified seeds collected from four major maize-producing areas in Ghana.



(a) Seedling count (b) Plant count before harvest

Fig. 4. (a) Seedling count 2 weeks after planting and (b) plant count before harvest of farmer-saved and certified seeds.

due to its initial poor seed quality. In both seeds planted at Kwadaso, a significant decrease was recorded from seedling to harvest, but in Ejura such a decrease was not observed. The decrease in seedling counts against the target 62,500 plants ha^{-1} might have been the result of the adverse effects of field conditions, including soil properties, pathogens and pests; but the subsequent decrease before harvest, particularly at Kwadaso, might have been the result of premature lodging.

The certified and farmer-saved seeds flowered around 55 days (Fig. 5), which is the characteristic flowering date for the variety (Asiedu *et al.*, 2000). This indicated that the seeds collected from both sources were of the same maturity. This is so, because conscious effort was made to collect the seeds of the variety *Obatanpa* from the farmer and certified sources. Farmer-saved seed was slightly late for the seed samples collected at Ejura, Nkoranza and Wenchi; which may be the result of slow rate of growth due to reduced seed vigour as observed with poor TTC staining (Fig. 1), low germination test (Fig. 2), and low 1000-seed weight (Fig. 3).

More lodging was observed in the trial at Kwadaso compared to that at Ejura (Table 1). At both locations, plants originating from farmer-saved seeds lodged more, possibly because of the effect of fungal infection that was observed on these seeds and reduced resistance to stresses due to low vigour. The most predominant fungus observed was suspected to be *Fusarium moniliforme*, a seed-borne pathogen which develops as the seed germinates. It infects the seed and seedling and continues to develop in the stem tissues, and later appears in the developed cobs. The fungus, therefore, causes severe lodging and ear rot in maize. Percentage total lodging was very high at Kwadaso, possibly due to higher relative humidity, which was ideal for fungi, such as *F. moniliforme*, to develop.

The mean grain yields were 5.9 and 3.8 t ha^{-1} for certified and farmer-saved seeds, respectively, tested at Kwadaso. At Ejura, the mean grain yields were 4.2 and 2.9 t ha^{-1} for certified and farmer-saved seeds. Thus, at both locations, the mean yield increased by about 1.2 t ha^{-1}, or 47 per cent could be recorded if certified seed replaces farmer-saved seed with the same field management. With the present seed price of ¢5,000.00 (about \$0.6) per kg, a farmer would need ¢100,000.00 (about \$11) to purchase 20-kg seed to plant 1 ha. Because this could increase the grain production level by 1.2 t, even at a minimum farm gate price of ¢100,000.00 (\$11), farmers could increase their income by ¢1,100,000.00 (\$110) per

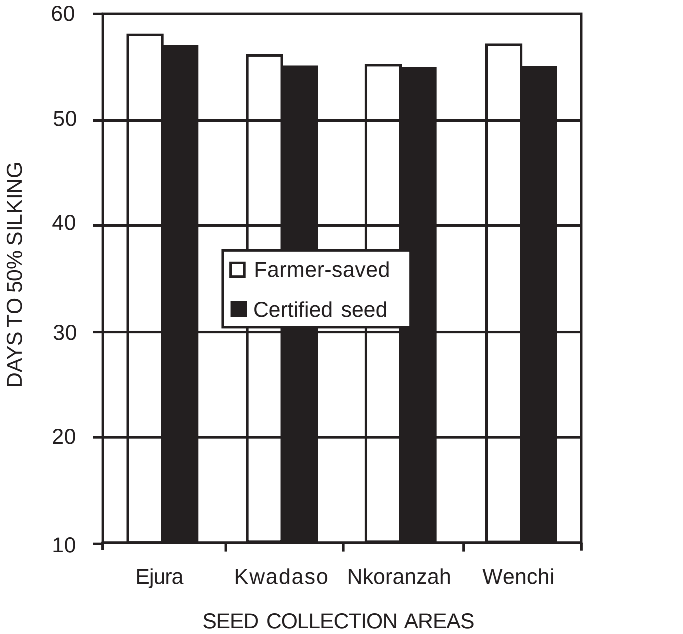


Fig. 5. Mean days to 50% silking of farmer-saved and certified seeds collected from four locations and tested at Kwadaso and Ejura.

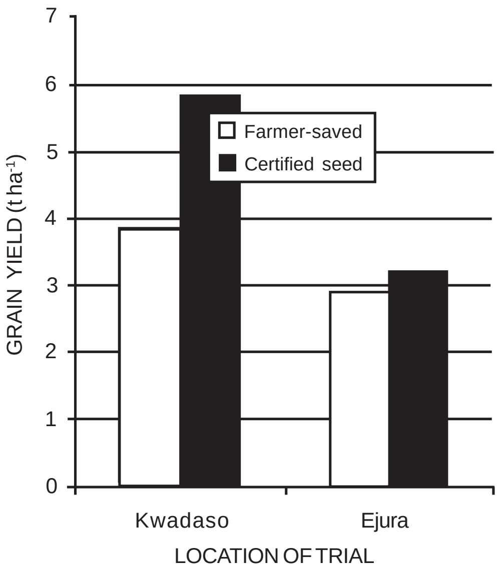


Fig. 6. Mean grain yield (t ha^{-1}) of farmer-saved and certified seeds collected at four locations and tested at Kwadaso and Ejura.

TABLE 1

Percentage Total Lodging of Farmer-saved and Certified Seeds Collected from Four Locations and Tested at Kwadaso and Ejura

Location	*Seed source*	*Total lodging (%)*	
		Kwadaso	*Ejura*
Wenchi	Certified	3,2000	400
	Farmer	5,867	667
Nkoranzah	Certified	2,667	0.0
	Farmer	4,800	667
Ejura	Certified	2,800	133
	Farmer	3,733	667
Kwadaso	Certified	2,000	0.0
	Farmer	5,200	800
Mean	3,783	3,783	292
LSD (0.05)	493	493	133

hectare. It is, thus, more economical for farmers to invest in certified seed maize.

Therefore, the need is for the relevant governmental and non-governmental agencies to vigorously promote the use of improved certified seeds in maize-growing communities of Ghana to realize the national objectives of achieving food security and increasing rural incomes.

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