

SEED MAIZE (*Zea mays* L.) QUALITY FACTORS FROM FIVE AGROECOLOGICAL ZONES IN GHANA AND THEIR IMPACT ON GROWTH AND GRAIN YIELD

Abstract Maize (*Zea mays* L.) is an important food crop in Ghana and is produced in all agro-ecological zones in the country. However, its productivity is constrained by a number of problems out of which unimproved and low-quality seeds is the most important one next to moisture deficiency. About 90 % of Ghanaian farmers are used farmer-saved seeds of obatanpa maize variety. Therefore, an experiment was conducted in field and Laboratory to evaluate seed quality parameters and their impacts on germination, growth, and grain yields in crop and soil science department at the pathology lab and field yields trial test at plantation section at KNUST respectively. Results from tests in the laboratory showed that seeds under certified seed systems seed qualities (in terms of germination, vigour, and moisture content) were better under certified seed systems to farmer-saved seeds. And also, on field evaluation of seed yield trial tests, seed from certified seed system has given better yield than the farmer-saved seed systems across all zones by far. Despite that, the maximum mean value of yield was certified seed from Guinea savanna zone (664kg/ha) and the minimum value was observed in farmer-saved seed from Transitional zone (390.5kg/ha) respectively. And also by this study we realized that the seed quality parameters have an impact on emergence, growth, and grain yields of maize.

Keywords: Impact of seed quality on germination, emergence, growth, and grain yield.

1. Introduction

Maize (*Zea mays* L.) is the most important cereal food crop for peoples in Africa [1]. It has represented the largest source of calories, followed by cassava and accounted for 22 to 25 % of starchy diet consumption in the region [2]. Maize grain has greater nutritional value as it contains approximately 72 % starch, 10 % protein, 4 % fat, 3 % sugar, and 4 % ash, supplying an energy density of 365kcal/100g [3]. In Africa, almost half of the population is being considered for food insurance. To achieve food security, African must be able to grow sufficient food crops. Since most developing countries rely on their agricultural production for their food security, it follows that insecurity is mainly due to deficient agricultural production and low productivity. The main reason for this situation is that using low-quality seed and improved technology. Most African countries still mainly depend on farmer-saved seeds in which about 80-90 % of seeds come from these sectors, even though improved, superior varieties have been developed in most of those countries. Maize production in sub-Saharan Africa (SSA) is dominated by small-scale farmers who have land holdings from 0.5 to 0.3 ha [4]. Maize is used for the main staple food and has represented the second largest commodity crop for Ghana after cocoa. The crop is cultivated in five Agro-ecological zones; these are Transitional, Guinea savanna, Coastal savanna, Semi-deciduous, and Rainforest zones [5]. An estimate of 85-90 % of the total maize seeds used by farmers in Ghana is produced by farmers themselves on- their on-farm of obatanpa open pollinated variety, which is low in yield when to compare to improved hybrid seeds. However, this system of seed production does not follow seed production procedures that which reduce the quality of the seeds, like isolation distance, varietal purity, appropriate fertilization, disease management, Moisture content of the seeds, and appropriate storage conditions [6]. And as a result produce low-quality seeds finally, which affect the next yields when using planting material of these seeds [7] and [8]. Even if more than 95 % of maize producers in Ghana were aware of the certified seed, only 27 % of them used certified seeds to produce maize [9]. Seeds of the newly developed varieties are not usually available in adequate

quantities: due to the limitation of certified seed producers, basic seeds and some of them are not affordable for those poor resource farmers [10]. However, the productivity of maize is still low, in average approximately 1.5 t/ha compared to the potential of 5.5 t/ha. Because of the large area under maize production is covered by farmer-saved seeds. Despite that low seed quality and use of farmer-saved seeds are the major reason for this yield gap. Good quality of seed is also one of the important means to increase the productivity of any crop [11]. Seed vigour and germination ability directly affect yield and seed quality also affect seedling emergence[12]. The germination, viability and vigour are considered as the most important quality characteristics of the seed [13]. However, rapid and synchronized seed germination and seedling emergence are crucial for achieving an optimal crop stand and high productivity[14].

Several reports indicated that the farmers saved seed are not achieve seed quality parameters [15, 16]. However, limited research work has been done on maize seed quality and its effect on grain yield. Therefore, using good quality seeds can increased the yield potential of a crop and thus, it is the most an essential input to develop an agricultural product for a country like Ghana [17]. Thus, to achieve this objective good and uniform on field seedling establishment is necessary, which needs having high-quality seeds [18, 19].

OBJECTIVE OF THE STUDY

The main objective was to study the impact of seed quality on germination, emergence, growth and yield of maize.

The specific objectives are to:-

- I. determine maize seed quality difference between farmer and commercial seed production.
- II. determine maize seed quality differences among the various ecological zone in Ghana.

- III. evaluate seed quality difference and their impact on germination and seedling emergence of maize.
- IV. evaluate seed quality differences on growth and seed grain yield of maize.

2. Materials and Methods

The research had two parts; laboratory and field trial yield test. Seed purity analysis and pathogenicity tests were conducted at the Plant pathology lab in Crop and Soil Sciences Department during 2015 minor season KNUST.

2.1 Laboratory stage

This investigation evaluated physical and physiological seed quality components of 30 seed lots of obatanpa maize variety collected from different farm saved and certified seed systems from five agro-ecological zones of Ghana, where seeds were collected from 12th-30th June 2015. The five ecological zones were; Transitional, Guinea Savanna, Semi-Deciduous, Costal Savanna, and Rain Forest zones. From each ecological zone, 3 locations (village) known for the production of maize were covered and from each location three to six farmers were selected and the seed was collected from each. The seed samples were collected after the seeds had harvested and processed in the same season of certified seed and farmer-saved seeds. At each zone 3 samples, one kilogram of each had taken from both seed growers. Each of the seed samples was labeled as follows, Name of the farmer, Ecological zone, Location, Seed type, and date of collection.

2.1.1 Parameters for Analysis

2.1.1.1 Seed Moisture Content:

The moisture content of collected samples was determined using Joundrn automatic moisture tester at insect laboratory. Three reading were taken and the mean computed and recorded.

2.1.1.2 Purity Analysis:

A sub-sample of the 1000g seed of each sample was stored in the pure seed, broken seed, shriveled seed, discolored seed, and pest damaged seeds components and their percentage by weight determined. 100 seeds were picked at random from the pure seed and weighed using an electric weighing balance.

2.1.1.3 Mycological tests:

A hundred seeds were selected at random under each system and disinfected with ten percent commercial bleach to get rid of all superficial organisms and used 250mg chloramphenicol to supers bacteria when prepared PDA. Seeds were then set on Petri dishes half –filled with PDA medium; 10 seeds per Petri dish. This was done in the lamina flow to prevent any contamination. Petri dishes were then set on a clean working table sterilized with ethanol. After 7 days fungal growth on maize samples was examined and identified under an electronic microscope and help of the disease identification manual.

2.1.1.4 Embryo, Cotyledon, and Endosperm disease identification:

Randomly 20 seeds were selected from pure seeds and soaked in water for 24 hours and separated embryos, endosperms, and cotyledons from each sample seeds. It were disinfected with ten percent commercial bleach and then set on Petri dishes half –filled with PDA medium 10 seeds per Petri dish. After 7 days fungal growth on each part of maize seed samples was examined and identified under an electronic microscope and help of the disease identification manual.

2.1.1.5 Germination Test:

Four hundred seeds were counted at random from the well-mixed pure seed under each system. Seed trays were used filled with the same type of sterilized river sand, wetted and then seeds sown in them 100 in four replications. Sown seeds were then left at plant house for a period of 7 days after which seeds were stored out into Normal seedlings, abnormal seedlings, and dead seeds.

2.1.1.6 Seedling Growth Rate Test:

From each sample of pure seeds 25 seeds were selected and placed over filter paper moistened with 4ml distilled water inside a Petri dish. After 5-10 days counted and removed the germinated seed every 12h. Germination was considered when the radical protrudes by 2-4mm and calculated germination index used the equation $\sum (t*n)/\sum n$, where n was the number of germinated seed and t was the number of hours from the beginning of the germination test.

2.2 Field tests

Field evaluation of all seed types from each location was done at Department of crop and soil sciences plantation section during 2015 minor season at KNUST. The land was plowed, harrowed and the experiment was 2x5 factorial with treatment arranged in a randomized complete block design. The experimental plot was planted on September, 20th at the spacing of 80cmx 40cm with two seeds per hill. NPK fertilizer was applied at two weeks after emergence and top-dressed with urea at 6 weeks after emergence. Weeds were controlled with manual weeding.

2.2.1 Data collected

Soil Sampling and Analysis

Before planting the trial, a representative soil sample was taken in different parts of the field. The soil auger was used to sample soil at a randomly selected site on each treatment combination plot. The samples were taken at a depth of 0-15cm. They were then mixed thoroughly, air-dried and made to pass through a 2mm, and 0.5mm sieves for soil texture and chemical analysis. The analysis was done at Department of crop and soil sciences laboratory, KNUST.

Seedling emergence: Seedling emergence at 2 weeks after planted was recorded and calculated in percentage plants emerged from each plot.

Growth analysis: Growth analysis at 20,40,60,80 and 100 days after planting was recorded by measuring six plants from each plot randomly.

Days to tasselling: Days to tassel was taken when 50% of the plant in a plot was tassels.

Days to silking: Days to silking was taken when 50% of the plant in a plot was silk emerged.

Plant height (cm): plant height was measured as the height from the soil surface to the base of the tassel of six randomly taken plants from the net plot area at physiological maturity.

Days to physiological maturity (DPM): physiological maturity date was recorded as the number of days after sowing to the formation of a black layer at the point of attachment of the kernel with the cob.

A number of kernels per ear: kernels per ear was computed as the average number of kernels of six randomly taken ears from the central net plot areas.

The number of grains per cob: Number of grains per cob was conducted randomly from six cobs from each plot of central rows.

Thousand kernels weight (g): It was determined from 1000 grain was weighed randomly taken from each plot and weighed using sensitive balance.

Grain yield (kg/ha): Grain yield per plot was measured using electronic balance and then adjusted to 12.5% moisture and converted to hectare basis.

2.2.2 Data Analysis

Data were analyzed by Gen stat statistical package software means were compared by LSD in a level of 5%. The conducted experiment treatments were subjected to a computer and compare each other the result was calculated ANOVA of parameters seed quality and to determine the treatment effects at the level of significance ($P \leq 0.05$). Correlation coefficients were done between seed quality parameters.

4. Results and Discussion

4.1 Laboratory Results

4.1.1 Seed Moisture Content of the seeds (MC):

The mean moisture content of seed samples from farmer-saved seed grower system has significantly ($p < 0.05$) higher than seed samples from certified seed system across the ecological zones. However, there was a non-significant difference within farmer-saved seed and commercial seed grower systems through zones. The highest moisture content value was registered in farmer-saved seeds of Semi-deciduous (14.6 %), Transitional zone (14.37 %) and Rainforest zone (14.33 %) and the lower was recorded in Costal Savanna and Guinea savanna zone (14.13 %) the result presented in (Table 1).

4.1.2 Pure seeds percentage (PS):

The results of true seeds per 1000 grams of working sample seed measured in terms of percentage. Certified

seed samples have significantly ($p < 0.05$) recorded the maximum value than farmer saved seed growers across the study zones. The highest value was observed in Coastal savanna zone and the lowest was from Rainforest zone. Despite that, there was a non-significant difference within certified seed systems across ecological zones and the same within farmer saved seeds but the seed from rainforest zone was significantly different from them. Under certified seed system, the Costal Savanna (95.10 %), Semi-deciduous (94.57 %), Transitional (94.53 %), Guinea savannah (94.13 %), and Rainforest zone (93.73 %) respectively. In Farmer- saved seeds costal savannah (80.53 %), Transitional (79.93 %), Guinea savannah (79.80 %), semi-deciduous (77.43 %) and Costal savannah zone (74.4 %) in decreasing order (Figure 1)

4.1.3 Broken seeds percentage (BS):

The maximum broken seed value was recorded under the farmer- saved seeds across ecological zones. Though, certified seed system has significantly ($p < 0.05$) lower figure than farmer-saved seed across all zones but there was non-significant variation within certified seed system across the zones. However, under farmer saved seed, seed from Transitional zone was significantly different from Rainforest zone but similar to Costal savanna, Semi-deciduous, and Guinea savanna zones (Table 1)

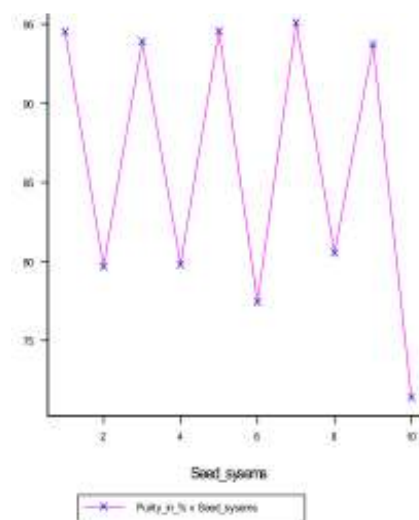


Figure 1 mean seed purity in % of certified and farmer saved seed systems. Where, even and odd numbers represents certified and farmer-saved seeds

4.1.4 Discolored seeds percentage (DS):

The highest mean value of discoloured seed was observed from farmer-saved seed across all the study zones and also there was significant variation between certified and farmer-saved seed across ecological zones. However, farmer saved seed in Rainforest zone has significantly different from other zones and that of all certified seeds from five agro-ecological zones (Table 1)

4.1.5 Pest damage seeds percentage (PDS):

There is also no significance difference observed in pest damaged seeds under the certified seed grower systems the of study zones. But has significantly different across zones within the farmer- saved seeds and Rainforest zone has

recorded the highest value in pest damage seeds (6.0 %) and between the rest, there was no significance difference across a region. The result showed in (Table 1).

4.1.6 Shriveled seeds percentage (SS):

The mean shriveled seed percent from certified grower system in Rainforest zone was significantly different from Transitional, Guinea savannah and Semi-deciduous zones but similar with Costal savannah, and Transitional zone that of Farmer saved seed. But there was significance difference between Certified and Farmer-saved seeds across ecological zones (Table 1)



Figure 2 (a) pure seeds



Figure2 (b) Shriveled seeds



Figure 2(c) discoloured seeds



Figure 2 (d) Broken seeds



Figure 2 (e) Pest damaged seeds

Table 1 Mean percent of purity analysis of certified and farmer-saved seed Grower from five

Agro-ecological zones of Ghana.

		Seed quality parameters					
Ecological Zones	Types	MC (%)	PS (%)	BS (%)	DS (%)	PDS (%)	SS (%)
Transitional	CS	12.93b	94.53a	0.38d	0.43c	0.54c	4.08bc
	FS	14.37a	79.93b	3.13c	3.4b	3.43b	10.0a
Guinea savanna	CS	13.13b	94.13a	0.36d	0.68c	0.61c	4.2bc
	FS	14.13a	79.80b	3.8bc	4.11b	3.87b	8.3a
Semi-deciduous	CS	12.6b	94.57a	0.69d	0.8bc	0.21c	3.67c
	FS	14.6a	77.43b	4.7b	4.07b	4.8ab	8.37a
Costal savanna	CS	12.8b	95.10a	0.30d	0.43d	0.42c	0.43d
	FS	14.13a	80.53b	4.0bc	3.9b	3.88b	4.1bc
Rain Forest	CS	12.9b	93.33a	0.6d	0.66c	0.8c	0.66d
	FS	14.33a	74.4c	6.7a	6.23a	6.0a	5.97b
mean		14	86	2	3	2	5
L.s.d(0.05)		0.55	4.6	1	1.25	1.32	1.8
Cv		2.4	3	23.8	29	31.5	4.2

MC=seed moisture, PS= pure seeds, BS= broken seeds, DS=discoloured seeds, PDS= pest damaged seeds, SS= shrivelled seeds, CS=certified seeds, FS= Farmer-saved seedsLSD=least significant difference, CV= coefficient of variation, Means followed bythe same letters in column do not differ by Tukey test at 5% probability.

4.1.7 Normal seedlings in percentage (NS):

The mean viability per four hundred (400) seeds measured in terms of percentage samples from five agro-ecological zones of Ghana showed that the highest normal seedling percentage was recorded under the certified seed grower system across the zones. Moreover, the Rainforest zone (85.2 %), Guinea savannah zone (84.9 %), Transitional zone (84.2 %), Costal savannah zone (83 %) and Semi-deciduous zone (79.8 %) in descending order respectively. For the Farmer-saved seed grower system, the Costal savannah produced the highest mean normal seedling followed by Guinea savannah zone, Transitional zone, Semi-deciduous zone, and Rain Forest zone. There was no significant difference within certified seed growers across the zones. However, there was a significant variation between Certified and Farmer-saved seeds across ecological zones (Table 2).

4.1.8 Abnormal seedlings in percentage (AS):

The laboratory germination analysis result showed that the farmer-saved seed system produced more abnormal seedling than the certified seed system in all samples conducted from five agro-ecological zones. Even though, there is no significance difference have seen within

certified seed grower system across agro-ecological zones and also same under farmer-saved seed grower across agro-ecological zones. However, there was a significant difference between certified and farmer saved seed grower across various zones. The higher values were recorded in Semi-deciduous zone (20.2 %) followed by Transitional (19.5 %), Rain Forest (19.4 %), Guinea savannah (18.9 %) and Costal savannah zone (17.9 %). Under certified seed system Semi-deciduous (13.4), Costal savannah (10.8 %), Guinea savannah (10.3 %), Transitional (9.7 %) and Rain Forest zone (9.6) respectively (Table 2).

4.1.9 Dead Seeds in percentage (DS):

The result in (Table 2) indicated that the Farmer-saved seed system produced dead seeds than the certified seed system across the study zones. The value recorded in Guinea savannah zone was less than Rainforest zone but similar with Semi-deciduous zone and there was no significance variation across zones within Farmer-saved seed system. However, they have significance difference within certified seeds across ecological zones and there was also no significance difference under certified seed system across various agro-ecological zones.

4.1.10 Ingeminated seeds in percentage (UGS):

The highest percentage value of ingeminated seeds is recorded under Farmer-saved seed system than certified seed system. There was no significance difference under certified seed systems across various zones and also same to Farmer-saved seeds. But there was a significant difference between certified and Farmer-saved seeds across zones. The result has indicated in (Table 2).



Figure 3 (a) Normal seedlings



Figure 3 (b) Abnormal seedlings



Figure 3 (c) dead seeds

4.1.11 seed grain weight (GWT) 100seeds:

The mean result under certified and farmers seed was indicate that, there was significance difference between the two seed grower systems across ecological zones. However, the farmer saved seeds from Transitional zone weigh the higher figure and followed by certified seeds from the same zone and the lowermost value was recorded in semi-deciduous farmer-saved seeds but there was significant difference between the two systems within and across the zones (Table 2)

Table 2 Mean Germination test of certified and Farmer seed growers from five Agro-ecological zones of Ghana.

Ecological zones	Types	NS (%)	AS (%)	DS (%)	UG (%)	HSWT(g)	GI
Transitional	CS	84.2a	9.7b	3.3c	2.6b	31.5ab	103
	FS	63.8b	19.5a	9.3a	7.0a	34.4a	99.4
Guinea savanna	CS	84.9a	10.3b	3.0c	1.7b	27.1bc	92.9
	FS	64.3b	18.9a	9.7a	7.2a	28.6bc	103.7
Semi-deciduous	CS	79.8a	13.4b	4.7bc	2.3b	29.5ab	97.2
	FS	61.6b	20.2a	9.7a	8.3a	23.7c	100.4
Costal savanna	CS	83.0a	10.8b	4.1c	2.2b	27.5bc	97.6
	FS	65.3b	17.9a	8.7ab	8.1a	29.9ab	95.8
Rain Forest	CS	85.2a	9.6b	2.9c	2.5b	30.4ab	103.1
	FS	61.5b	19.4a	10.3a	8.8a	28.2bc	93
Mean		73	15	7	5	29	99
L.S.D (0.05)		6.44	4.23	4.3	2.45	4.93	NS
CV (%)		5.2	16.6	38	28	11.9	7.2

NS=Normal seedlings, AS=abnormal seedlings, DS= Dead seeds, UG= Un germinated seeds, HSWT= Hundred seeds weight, GI= Germination index, CS=certified seeds, FS= Farmer-saved seeds LSD=least significant difference, CV= coefficient of variation, Means followed by the same letters in column do not differ by Tukey test at 5% probability

4.1.12 Pathogenicity test on seed parts:

4.12.1 Aspergillus Flavus

The disease incidence was indicated in percentage. It was recorded in all zones and in both seeds growing systems. Aspergillus flavus infection was higher in the farmer-saved seed system. The total value for the various zones, when computed (Table 3) gave Guinea savannah zone has the highest value (67 %) and followed by Coastal savannah zone (60 %), Semi-deciduous zone (57 %), Transitional zone (53 %) and Rainforest zone (30 %) in the decreasing order.

4.12.2 Aspergillus Niger:

As the result conducted in both seed, growers indicate in (Table 3) that *Aspergillus Niger* has recorded in a higher value under certified seeds. The Rainforest zone (43 %), Coastal savannah (33 %), Semi-deciduous (20 %), Guinea savannah (17 %) and Transitional zone (10 %) in decreasing order.

4.12.3 *Colletotrichum* spices:

This spice was also recorded in all zones and in both seed grower systems, but the higher infection value was registered in Farmer saved- seed grower system. Rainforest zone has the highest value (23 %), followed by Guinea savanna zone (17 %), Semi- deciduous, Costal savannah and Transitional zone were showed the same value (13 %) as indicated in (Table 3)

4.12.4 *Penicillium* spices:

This disease species was also recorded in both Farmer seed grower and certified seed systems from all sampled zones, but the higher value was seen in Farmer seed-saved system. Semi- deciduous (32 %) followed by Costal savannah and Transitional zones (10 %), Rain Forest zone (7 %) and Guinea savannah zone has (3 %). The result has computed in (Table 3).

4.12.5 *Curvelaria* spices:

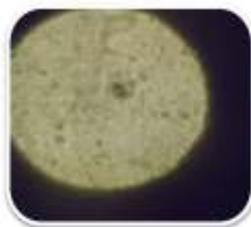
Curvelaria spices were recorded in Transitional zone in both seed systems. In certified seed system (7 %) and Farmer saved- seeds (3 %), in Semi-deciduous, Guinea savannah and Coastal savannah zones found only on certified seed growers. According to the test result has indicated in (Table 3) Semi-deciduous (6 %), Guinea savannah and Costal savannah (3 %) respectively.



Plate 1 (A) Fungal growth on media



Plate 2 (A) *Curvelaria* spp.



(B) *Colletotrichum* spp.

Table 3 Mean Frequency of infection of seed Maize by Fungal pathogens in certified and Farmer saved seeds from five Agro-ecological zones of Ghana.

Ecological zones	Types	AF (%)	AN (%)	CT (%)	PC (%)	CR (%)
Transitional	CS	33	10	13	10	7
	FS	53	20	13	10	3
Guinea savanna	CS	30	17	13	13	3
	FS	67	10	17	3	0
Semi-deciduous	CS	43	20	10	10	6
	FS	57	3	13	33	0
Costal savanna	CS	37	33	10	3	3
	FS	60	7	13	10	0
Rain Forest	CS	30	43	0	3	0
	FS	30	30	23	7	0
Mean		44	19.3	12.7	9.3	3
CV (%)		24.68	15.86	12.4	18.68	8.3

AF=*Aspergillusfluvus*.,AN=*Aspergillusniger*,CT=*Colletotrichum*sp.PC=*Penicillium* sp., CR= *curvelaria* sp., ,CS=certified seeds, FS= Farmer-saved seeds.LSD=least significant difference, CV= coefficient of variation, Means followed by the same letters in column do not differ by Tukey test at 5% probability

5. Field Results

5.1 Plant growth rate analysis at 20 days after planting (DAP):

The plant growth analysis took 20 DAP showed that there was a significant difference between certified and farmer-saved seed growers across and within the regions. However, there was no deference variation within the certified seeds across regions. And also the same result under farmer-saved seeds across regions (Table 4).

5.2 Plant growth rate analysis at 40 days after planting:

In this growth rate analysis also, the computed result indicated there was a significant difference between certified and farmer-saved seeds along the regions. But, there is no variations have recorded within the certified seeds and farmer-saved seeds across zones (Table 4).

5.3 Plant growth rate analysis 60 days after planting:

The result conducted during field trial experiment was showed, Farmer-saved seeds from Transitional, semi-deciduous and certified seed from rainforest were significantly different at ($p \leq 0.05$) from farmer-saved seeds in the Rainforest zone, but similar to certified seeds from Transitional, Guinea, and Costal savanna zones (Table 4).

5.4 Plant growth rate analysis 80 days after planting:

As the study result of growth analysis rate showed, the growth rate at 80DAP was reduced when to compare to 20DAP, 40DAP, and 60DAP. The farmer-saved seeds from Guinea savanna were shown significant difference of that the certified seeds from Transitional, Semi-deciduous and Costal savanna zone. Nevertheless, similar with certified seeds from Transitional and semi- deciduous Guinea savanna and farmer-saved, in addition, both seed system from costal savanna and Rainforest zone (Table 4).

Table 4 Mean of plant growth rate analysis at deferent day after panting from Certified and farmer saved seed system from five Agro-ecological zones of Ghana in 2015 minor season at KNUST.

Ecological zones	Types	20DAP	40DAP	60DAP	80DAP	100DAP
Transitional	CS	34.83a	81.08a	52.17ab	9.25b	1.25abc
	FS	25b	68.58b	62.83a	15.5ab	3.33ab
Guinea savanna	CS	35.58a	81.58a	51.92ab	17.08ab	0.17abc
	FS	27.08b	66.92b	51.83ab	21.33a	1.08abc
Semi-deciduous	CS	36.08a	80.67a	51.67ab	9.42b	0.67abc
	FS	26.67b	68.83b	64.67a	12.67ab	1.58abc
Costal savanna	CS	33.33a	81.33a	58.67ab	13ab	-0.75c
	FS	27.08b	68.83b	54.33ab	15.42ab	3.42a
Rain Forest	CS	34.33a	81.33a	60.17a	9.58b	-0.17bc
	FS	27.67b	73.67b	46.08b	18.08ab	3.25ab
Mean		30.77	75.28	55.4	14.1	1.38
L.S.D (0.05)		32.42	6.42	11.92	9.06	3.039
CV (%)		13	10.5	26.6	79.2	271.5

DAP=day after planting, PG= Plant girth in cent meters CS=certified seeds, FS= Farmer-saved seeds LSD=least significant difference, CV= coefficient of variation, Means followed by the same letters in column do not differ by Tukey test at 5% probability.

5.5 Seed emergence percentage (SE):

The mean seed emergence percentage counted after two weeks of planting, seeds from five agro-ecological zones of Ghana planted in 2015 minor season indicated the seeds from certified seed growers have showed better seedling emergence than farmers-saved seeds across all ecological zones. Though, there was a significant difference between certified and farmer saved seeds. However, no variation has seen within certified and farmers saved seeds across regions (Table 5).

5.6 Days to 50 % plants tassel (DT):

The research study result was realized that the farmer saved seed systems from all ecological zones have taken longer days to tassel. However, it was a significant variation between farmers saved and certified seeds across various ecological zones but there wasn't seen variation within farmers saved seed across zones. Nevertheless, mean days of tassel the certified seed from Semi-deciduous and Costal savanna zones were significantly different from Transitional but similar that of Rainforest and Guinea savanna zone (Table 5).

5.7 Days to 50 % plants silk (DS):

When we compare to certify and farmer saved seed systems from five agro-ecological zones on field trial test, the certified seeds take shorter days to silking than farmer-saved seeds across the five ecological zones. Though, there was a significant difference at ($p \leq 0.05$) between certified and farmers saved seeds across the study zones, but no variation had seen within certified seeds across zones and the farmers saved seeds were too (Table 5).

5.8 Days to physiological plant maturity (DPM):

The result of plant maturity parameter was designated that, the farmer-saved seeds were mature earlier than the certified seeds across the regions. And also, there was a significant difference between certified and farmers seeds across regions except Costal savanna zone, but no variation between certified seeds across regions and the farmers too. The result was computed in (Table 5).

Table 5 mean analysis of maize plant maturity from certified and farmers saved seed system from five Agro-ecological zones of Ghana. planted in 2015 minor season at knust.

Ecological zones	Ty	SE (%)	DT (%)	DS (%)	PH(cm)	DPM
Transitional	CS	92.01a	50.42c	61.42b	181.2	104.2b
Guinea savanna	CS	93.06a	51.25bc	61.92b	189.5	103.9b
Semi-deciduous	CS	92.01a	52.08b	62.25b	189.1	104.1b
Costal savanna	CS	89.93a	51.83b	61.92b	187.5	102.6c
Rain Forest	CS	92.01a	51.08b	62b	184.8	104.1b
mean		83.16	53.3	63.77	185.9	104.99
LSD (0.05)		8.57	1.108	1.564	NS	0.988
CV (%)		12.7	2.6	3	8.1	1.2

E=seedling emergences, DT= days of 50 % tassels, DS= days of 50 % silking PH= plant height, DPM=days of plant maturity, CS=certified seeds, FS= Farmer-saved seeds LSD=least significant difference, CV= coefficient of variation, Means followed by the same letters in column do not differ by Tukey test at 5% probability.

5.9 Impacts of seed quality parameters on plant population, grain weight, and grain yield.

5.9.1 Number of maize plants per meter square (P/M²):

We observed during field trial experiment, the certified seed from Guinea savanna zone was significantly different in a number of plants per meter square from both seed system in Transitional and farmers saved seed from Rainforest zone. However, it is similar to certified seed from Semi-deciduous, Costal savanna and Rainforest zone (Table 6).

5.9.2 Maize kernels per cob (K/C):

The computed mean kernels analysis result displayed that, farmer-saved seeds from Semi-deciduous and Costal savanna zones had showed the highest value followed by Guinea, Transitional, and Rainforest zone respectively. However, there wasn't significant variation in certified seed growers across and within agro ecological zones (Table 6).

5.9.3 Hundred Seeds grain weight (GWT):

During this study, we realized that the certified and farmer-saved seeds planted from Transitional zone and Guinea savanna zones were significantly different from that of certified and farmers saved seeds from Costal savanna and Rainforest zones. But there wasn't variation in both systems between certified and farmers saved seeds within agro ecological zones (Table 6).

5.9.4 Evaluation of maize grain yield to certified and farmer-saved seeds(Y/ha):

When we conducted the experimental study on grain yield, certified and farmer saved seeds from five agro-ecological zones of Ghana, the certified seed systems gave better yield than the farmer saved seed systems across all zones.

Despite of that, the maximum mean value of grain yield was eminent that in the certified seed from Guinea savanna zone (664 kg/ha) and the minimum value was observed in the farmer-saved seed from Transitional zone (390.5 kg/ha) However, there was a significant difference between certified and farmers saved seeds along all the study zones but no variations were observed in farmer-saved seeds in all zones. Also, the same result was showed in certified seeds except Guinea savanna zone (Figure 1).

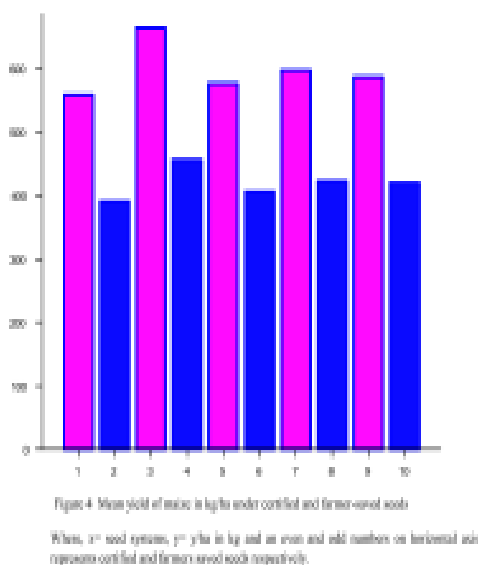


Table 6 Analysis of mean grain yield of maize seed from certified and farmers saved seed from five Agro-ecological zones of Ghana planted in 2015 minor season.

Ecological zones	Types	P/M ²	K/C	G/C	100GWT	Y/ha (kg)
Transitional	CS	4.25b	9cd	230cd	34.25a	559.1b
	FS	4bc	10.17abc	301abca	34.08a	390.5c
Guinea savanna	CS	5.33a	9.33cd	255bcd	33.64a	664.1a
	FS	4.08bc	10.83ab	332ab	33.02a	456.1c
Semi-deciduous	CS	4.8abc	9.33cd	257bcd	32.8a	576.8b
	FS	4.6abc	11.17a	353a	27.51b	405.9c
Costal savanna	CS	4.7abc	8.33d	201d	27.33b	597.3b
	FS	4.5abc	11.2a	344a	26.83b	423c

Table 7 correlation coefficients between mean seed quality parameters and agronomic traits of maize under certified and farmer-saved seeds from five agro-ecological zones of Ghana planted in 2015 minor season at knust.

	PS	BS	DS	PDS	SS	SE	PP	PLS	G/C	GW T	Y/ha
PS	1										
BS	-0.89**	1									
DS	-0.935**	0.794**	1								
PDS	-0.912**	0.723**	0.842**	1							
SS	-0.917**	0.742**	0.779**	0.810**	1						
SE	0.563**	-0.598*	-0.503*	0.454 ^{NS}	-0.045 ^{NS}	1					
PP	0.313 ^{NS}	-0.313 ^{NS}	-0.296 ^{NS}	-0.274 ^{NS}	-0.266 ^{NS}	0.164 ^{NS}	1				
PLS	0.629**	-0.466**	-0.564**	-0.622**	-0.651*	0.525**	0.073 ^{NS}	1			
G/C	-0.172 ^{NS}	0.319 ^{NS}	0.173 ^{NS}	0.118 ^{NS}	0.032 ^{NS}	-0.168 ^{NS}	0.094 ^{NS}	-0.262 ^{NS}	1		

Rain Forest	CS	4.4abc	8.83cd	237cd	26.73b	586b
	FS	3.8c	9.33bcd	248cd	24.92b	419bc
mean		5.25	9.73	276	30.11	507.9
Ls d (0.05)		1.9	1.36	75.41	3.113	63.18
CV (%)		17.8	17.2	33.7	12.8	15.4

P/M²=plant per meter square, C/P= cobs per plant, C/M²=cobs per meter square, K/C=Kernel per cob, G/C= grain per cob, GWT= grain weight, Y/ha (kg) = yield per hectare in kilogram, CS=certified seeds, FS= Farmer-saved seeds LSD=least significant difference, CV= coefficient of variation, Means followed by the same letters in column do not differ by Tukey test at 5% probability.

5.9.5 Association of selected seed quality parameters, growth, maturity and yield traits.

The correlation coefficient showed positive significant association with yield per hectare ($r = 0.737^{**}$), grain weight ($r = 0.876^{**}$), plant stand ($r = 0.629^{**}$) and seed emergence ($r = 0.563^{**}$) respectively. However, negative significant association with broken ($r = -0.892^{**}$), dead ($r = -0.912^{**}$), pest damage ($r = -0.917^{**}$) and shriveled seeds ($r = -0.917^{**}$) but non-significant relation with number of plant per meter square and grain per cob ($r = -0.313^{NS}$ and $r = -0.172^{NS}$) respectively (Table 7). On another hand, broken seed showed non-significant association with a number of plant per meter square and plant stands ($r = -0.313^{NS}$ and 0.466^{NS} correspondingly). But has positive and negative significant association with dead, pest damage, and shriveled seeds ($r = 0.794^{**}$, 0.723^{**} and 0.742^{**}) and yield per hectare, grain weight, and seed emergence ($r = -0.63^{*}$, -0.693^{**} and -0.598^{*}) respectively (Table 7). As observed from the correlation coefficient analysis, both dead and pest damaged seeds were non-significantly correlated with a number of plant per meter square and grain per cob but negatively correlated with yield, grain weight, and plant stands. However, they were positively related with shriveled seeds (Table 7). In addition, shriveled seeds were negatively correlated with plant stands ($r = -0.622^{*}$), grain weight ($r = -0.836^{**}$) and yield per hectare ($r = -0.722^{**}$) but non-significant relation with grain per cob ($r = 0.032^{NS}$), number of plant per meter square ($r = -0.274^{NS}$) and seed emergence ($r = -0.496^{NS}$). Beside these, seed emergence was non-significantly correlated with all the tested parameters except yield per hectare ($r = 0.526^{*}$) and also on the other hand number of plant per meter square, plant stand and grain per cob were non-significant in all tested parameters but grain weight was positively correlated with yield per hectare (Table 7).

GWT	0.876**	-0.693**	-0.780**	-0.836**	-0.889**	0.349 ^{NS}	-0.038 ^{NS}	0.483**	-0.206 ^{NS}	1
Y/ha	0.737**	-0.63**	-0.649**	-0.722**	-0.702**	0.526*	0.073 ^{NS}	0.612**	-0.252 ^{NS}	0.56
										3*

Where, PS=pure seeds, BS= broken seeds, DS=discoloured seeds, PDS=pest damaged seeds, SS=shrivelled seeds, SE= seed emergence, PP=plant population, PLS=plant stands, G/C=grain per cob, GWT=grain weight, Y/ha= yield per hectare in kilogram, NS, * and **non-significant, significantly different at 5% and 1 % respectively.

6 General discussions

The result revealed that, the certified seed systems across all the study zones were gave superior results than farmer-saved seeds in the tested parameters. However, significant difference was observed between certified and farmer-saved seeds on analytical quality parameters across ecological zones. The farmer-saved seeds showed poor crop stands during field trial test. Several reports have shown poor stand establishment caused by low seed quality and consequently yield loss in corn [20]. Under the farmer-saved seed grower system, the maximum recording was at the Semi-deciduous zone and the minimum at the Guinea savannah and Costal savanna zone. But under the certified seed grower system maximum and minimum recordings were at the Guinea savanna and Semi-deciduous zone respectively. The difference in values recorded may be due to locations of production, climatic conditions, drying methods, storage conditions and the duration of storage. [21]& [22] storage of grains is influenced by air movement within the grain sometimes resulting in moisture condensation and mould spoilage. The hundred seed weight observed in the study for certified seeds ranging between 27.1g and 30.4g whilst that for the farmer saved seeds was between 23.7g and 34.4g. Under the certified seed grower system, seed weight observed for the Rainforest zone was found to be heavier than those for the Transitional, Semi-deciduous, Costal savanna and Guinea savanna zones respectively. But under the farmer saved seed grower system, the Transitional zone recorded a higher value followed by the Costal savanna, Guinea savanna, Rainforest, and Semi-deciduous zones respectively [23] also reported that, the seed size plays a major role in the process of germination and it is usually associated with seedling vigour, which is very important for future crop plants. However, Sulewska and Hanna study also reported that there was impacts of grain seed weight on vigour, crop establishments, and productivity[24]. According to Fu,[25] seed quality is a right important factor that governs the early development and growth of agricultural crops The percentage seed viability observed within and across the zones indicated that; within the zones, both seed production systems for the Guinea savanna zone gave a good seed viability percentage of 93.9 % (certified seed) and 83.3 % (farmer

saved seed). The average percentages recorded across the zones showed a significant difference between the seed samples from each seed production system were the certified seed out-performed the farmer saved seed. According to kulkarni report[26] that, 'Germination and seedling vigor are severely affected if seed is stored at high relative humidity and deterioration is much faster if the storage temperature is also high.

7. Conclusion

It is clear from the study that the analytical seed quality and mycological tests conducted had showed that seeds from certified seed systems were superior to those farmer-saved systems in all parameters across all zones. And also has realized that the quality parameters have impacts on germination, growth, maturity, and grain yield. Farm-saved seeds have limitations on seed qualities that lead to reduce yield. This is why the current productivity of maize is low in Ghana.

The information generated through this study has important implication the impact of seed quality parameters on yield. However, similar further studies are warranted at a major season and various locations using different varieties of maize to provide the conclusive recommendation.

7.1 Recommendations

- To increase the productivity of maize yield in the country, more certified seed should be available to the farmers.
- Government and concerning body should motivate the farmers to use certified seeds.
- A seed quality program should be put in place to ensure regular monitoring of crop seed for the seed-borne pathogen in the seed quality surveillance activity.
- Seed health analysis should be included as part of seed certification in Ghana.
- It is important to strengthening farmers' capacity in seed production and more reliable storage techniques should be given to farmers.

References

- [1] Westengen, O.T., et al., *Modern maize varieties going local in the semi-arid zone in Tanzania*. BMC evolutionary biology, 2014. **14**(1): p. 1.
- [2] Smale, M., D. Byerlee, and T. Jayne, *Maize revolutions in sub-Saharan Africa*. 2013: Springer.
- [3] Ranum, P., J.P. Peña-Rosas, and M.N. Garcia-Casal, *Global maize production, utilization, and consumption*. Annals of the New York Academy of Sciences, 2014. **1312**(1): p. 105-112.
- [4] Byerlee, D. and P.W. Heisey, *Evolution of the African maize economy*. Africa's Emerging Maize Revolution, 1997: p. 9-22.
- [5] Asare, D., et al., *Biomass Production by Rainfed Maize Cultivars in a Coastal*

- Savannah Agro-Ecological Environment*. World Journal of Agricultural Sciences, 2012. **8**(3): p. 286-292.
- [6] Msuya, D. and J. Stefano, *Responses of maize (Zea mays) seed germination capacity and vigour to seed selection based on size of cob and selective threshing*. World J Agr Sci, 2010. **6**: p. 683-688.
- [7] Louwaars, N. *Integrated seed supply: a flexible approach*. in *Seed Production by Smallholder Farmers: Proceedings of the ILCA/ICARDA Research Planning Workshop held in ILCA, Addis Ababa, Ethiopia*. 1994.
- [8] Bishaw, Z., P. Struik, and A. Van Gastel, *Farmers' seed sources and seed quality: 1. Physical and physiological quality*. Journal of Crop Improvement, 2012. **26**(5): p. 655-692.
- [9] Ragasa, C., et al., *Patterns of adoption of improved maize technologies in Ghana*. IFPRI Ghana Strategy Support Program Working Paper, 2013. **36**.
- [10] Awotide, B.A., et al., *The impact of seed vouchers on poverty reduction among smallholder rice farmers in Nigeria*. Agricultural Economics, 2013. **44**(6): p. 647-658.
- [11] Pruesse, E., et al., *SILVA: a comprehensive online resource for quality checked and aligned ribosomal RNA sequence data compatible with ARB*. Nucleic acids research, 2007. **35**(21): p. 7188-7196.
- [12] Finch-Savage, W., *Influence of seed quality on crop establishment, growth and yield*. Seed quality: Basic mechanisms and agricultural implications, 1995: p. 361-384.
- [13] Hossain, M., *Impact of Fertilizers on the Seed Quality of Aromatic Rice*. Journal of Agricultural Science, 2014. **6**(6): p. 35.
- [14] Matthews, S., et al., *Evaluation of seed quality: from physiology to international standardization*. Seed Science Research, 2012. **22**(S1): p. S69-S73.
- [15] Basra, A.S., *Seed quality: basic mechanisms and agricultural implications*. 1995: Food Products Press.
- [16] Powell, A.A., S. Matthews, and M.d.A. Oliveira, *Seed quality in grain legumes*. Advances in applied Biology, 1984.
- [17] Mehta, D., T. Singh, and R. Kanwar, *Effect of head decapitation and planting density on quality seed production of sprouting broccoli (Brassica oleracea var. italica L.)*. Journal of Applied and Natural Science, 2015. **7**(1): p. 471-476.
- [18] Oskouei, B. and S. Sheidaie, *Study of different kinds of seed packaging and storage durations on seed vigor of Canola using electrical conductivity test*.
- [19] Oskouie, B. and M. Divsalar, *The effect of mother plant nitrogen on seed vigor and germination in rapeseed*. ARPN Journal of Agricultural and Biological Science, 2011. **6**(5): p. 49-56.
- [20] Cruz-Garcia, F., et al., *Seed deterioration and respiration as related to DNA metabolism in germinating maize*. Seed Science and Technology, 1995. **23**(2): p. 477-486.
- [21] Arendt, E.K. and E. Zannini, *2 - Maizes*, in *Cereal Grains for the Food and Beverage Industries*, E.K. Arendt and E. Zannini, Editors. 2013, Woodhead Publishing. p. 67-115e.
- [22] Mills, J., *Quality of stored cereals*, in *Cereal Grain Quality*. 1996, Springer. p. 441-478.
- [23] Sulewska, H., et al., *Seed size effect on yield quantity and quality of maize (Zea mays L.) cultivated in South East Baltic region*. Zemdirbyste-Agriculture, 2014. **101**(1): p. 35-40.
- [24] Kalton, R.R., R.E. Barker, and R.E. Welty, *Seed production*. Cool-Season Forage Grasses, 1996(coolseasonforag): p. 383-411.
- [25] Fu, Y.-B., Z. Ahmed, and A. Diederichsen, *Towards a better monitoring of seed ageing under ex situ seed conservation*. Conservation Physiology, 2015. **3**(1): p. cov026.
- [26] Kulkarni, M., R. Street, and J. Van Staden, *Germination and seedling growth requirements for propagation of Dioscorea dregeana (Kunth) Dur. and Schinz—a tuberous medicinal plant*. South African Journal of Botany, 2007. **73**(1): p. 131-137.