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# Quality of Farm Saved Maize (*Zea mays l.*) Seeds and its Effect on Field Establishment

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***Abstract*** **– Farmer saved seed consist of inappropriate varieties, infected seeds of poor germination potential resulting in low seedling vigor, crop stand and high incidence of diseases leading to poor yield. The study was conducted to determine the quality of farm saved maize seeds and its effect on field establishment. Maize seed samples were collected from farmers, local market, agro vet shops and major seed distributors in two agro ecological zones in Busia County. The seed samples were analyzed for physical purity, germination, and vigor and seed health. Germination was determined by paper towel method while seed health test was conducted using agar plate method. Samples were subjected to field experiment at Kakamega and Busia Counties for field establishment and off-types evaluation. The purity of the seed from the various seed sources was below the 99% legislated limit but the seeds met the recommended standard of 90% germination. Farmer saved seed was contaminated with diseases pathogens mainly *Fusarium sp, Aspergillus sp,* and *Penicillium sp* by up to 70.9%. Landrace panadol from local markets had the highest emergence rate. Farmer saved and local market seeds are of poor quality with high off type crops though they had high field establishment. Therefore, Farmer should be encouraged to use certified or improved seeds to enhance crop productivity. Agro dealer should adhere to seed regulation to maintain seed quality, especially on storage conditions.**

***Keywords*** **– Emergence, Maize, Seed Health, Seed Quality, Seed Sources.**

## I. INTRODUCTION

Maize constitutes the principle food for more than 85% household in Kenya [1]. In the country, more than 38% of agriculture actors produce maize [2]. Small-scale farmers count for 70% of maize production [3]. The crop is mostly for subsistence, holding between 50 – 70% of the total food production [4]. Maize yield in the region is between 500kg to 1500kg per hectare [5]. Maize production has numerous limitations preventing producers from attaining full production potential. Low quality seed, poor soil fertility, high cost of labor, pre and post-harvest pests, diseases, poor agronomic practices, among others, are some of the problems limiting maize production [6]-[7]-[8]. Adoption of improved maize hybrid varieties is very low, while qualified to be resistant and tolerant to pests, diseases, and abiotic stresses, farmer saved seed is the predominant source of planting material [9]-[5].

Farmer saved maize seeds constitute about 80%. Though maize sector appears the most organized with numerous certified varieties from different seed companies, the use of certified maize seeds still low, less than 10% [10]-[11]. Farmer saved seeds is of inappropriate varieties, infected seeds of poor quality attribute leading to poor yield [12]. The Kenyan seed industry is well organized, with a quit number of seed companies producing maize hybrid seeds [11]-[13]. However, small-scale farmers continue to recycle maize grain from previous season production. Approximately 90% of maize planting materials are from informal system [14]-[5]-[15].

[16]-[17] Indicated that farmer saved seeds are produced under uncontrolled system, as consequence, they result in poor quality with high level of infection with seed-borne diseases. Seed transmitted diseases constitute the main challenge in the world concerning seed dissemination. They are the most cause of poor performance of the crop from field emergence up to the yield [18]-[19]-[20]-[21]. The rate of seed deterioration is determined by a number of factors such as soil degradation, kind or variety of the seed, storage, temperature, relative humidity, seed moisture content, biological factors including fungi that create their own biological niche [22]-[23]-[24]. [25] Observed that seed storage is crucial for seed quality. It can have impact on the whole feature of seeds quality attributes and contributes to seed ageing that decreases seed viability. The significant aspect of seed and seed production depends on how a particular crop is pollinated and whether it is self-pollinated and cross-pollinated or open-pollinated or hybrid [26].

[27] Indicated that good agronomic practices in association with use of improved varieties are the way to enhance production and food security, thus alleviating poverty. Famers recycling their own on farm saved seeds of unknown quality may lead to spread of noxious weeds leading to decline in yields [28]. Facilitating farmer accessing disease-free seeds of high viability of wanted plant species is essential for producers to utilize their farm and expenses resources for great output anticipation [12]. This study aimed to determine the quality of recycled maize seeds in Busia County and its effect on field establishment.

## II. MATERIALS AND METHODS

### A. *Maize seed samples collection*

A field survey was conducted during 2016 short rain season. The study was conducted in Busia County using a multistage stratified sampling design as described by [29]. Two Agro Ecological Zones were selected, LM1 and LM2 sub-AEZ as described by [30-[31]-[32]. Maize grower Farmers was interviewed using semi-structured questionn--aire to obtain information on maize seed sources, awareness, availability and affordability of improved maize seeds, the challenges faced in the production. The sample

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size was obtained using the formula as in (1) as described by [33].

$$n = N/(1 + N(e)2 \quad (1)$$

Where n is the sample size, N the population size assuming 95% level of confidence, P = 0.5 and the margin of error (e) is 0.1.

About 76 maize seed samples were collected from maize producer households and local market and eight samples from Agro vet in each agro ecological zone. Other four samples were obtained from major seed distributors. All the material collected was subjected to laboratory analysis for seed quality and field experiment. Samples for routine tests were stored in botany laboratory and the portion for seed health test was stored in the fridge in pathology laboratory before analysis.

### B. *Assessment of Physical Purity of Maize Seeds*

Physical purity test was done to separate the pure seeds, inert matter, weed seeds, insect damage and shriveled seeds content in the sample as described by [34]. Samples were well mixed to get homogeneity and a representative sample was taken for analysis and 400g was divided into four replicates of 100g each. Seeds were placed on a white manila paper and separated into pure seeds, other crop seeds, inert matter weed seeds, and insect damage seeds, shriveled and discolored seeds using a forceps. Each fraction from each replicate was weighed separately and the percentage calculated as in (2):

$$Component\ (\%) = Component\ weight\ x \frac{100}{Total\ seed\ weight} \quad (2)$$

### C. *Determination of Germination and Seedlings Vigor*

Germination test was carried out using paper towel method using 400 seeds in four replicate of 100 seeds from each seed sample [34]. The seeds were surface sterilized in 2% sodium hypochlorite for 3 minutes, and washed off in 3 changes of sterile distilled water and dried on sterile paper towel [34]-[35]. Three layers of absorbent paper towel were placed in a sandwich box, moistened with sterile distilled water and the seeds were placed on the paper towel. Two layers of wet paper towels were placed on top of the seeds. The boxes closed and the seeds incubated under source of natural light. The number of germinated seeds was counted at 6, 9 and 12 days after planting. After 12 days, the seedlings were evaluated and the numbers of normal seedlings, infected seedlings, hard seeds and moldy seeds in each replicate of 100 seeds [34]. Germination percentage and germination index were calculated as in (3):

$$Germination\ (\%) = Germinated\ x \frac{100}{Numberofthe\ seed\ on\ tray} \quad (3)$$

$$G.index = \frac{Germinated\ 1st\ count}{Days\ of\ 1st\ count} + \frac{Germinated\ 2ndcount}{Days\ of\ 2nd\ count} + \frac{Germinated\ 3rd\ count}{Days\ of\ 3d\ count}$$

Pure live seed (PLS) was calculated as in (4) to determine viable seeds with germination potential [36]-[37].

$$PLS = Germination\ percentage\ x\ Percentage\ Pure\ seed \quad (4)$$

Vigor index was determined in two different ways [38] as in (5).

$$Seedllng\ Vigor\ Index\ I = Germinate\%\ x\ Seedling\ length \quad (5)$$
$$Seedlling\ Vigor\ Index\ II = Germinate\%\ x\ Dry\ weight$$

### D. *Determination of Seed Infections with Disease-Causing Pathogens*

Infection of the seed with fungal disease-causing pathogens was determined by using Agar plate method. Seeds were surface sterilized in 2% sodium hypochlorite for 2 to 3 minutes and rinsed in three changes of distill sterilized water. The seeds were aseptically plated on Potato Dextrose Agar (PDA) amended with streptomycin to inhibit bacteria growth. Five seeds were plated on the molten media in each plate and a total of 40 seeds were plated for each sample. The plates were incubated for 7 to 10 days with alternating 12 hours light and 12 hours darkness [39]-[35]-[40]. The number of infected seeds in each Petri dish was counted and recorded in a data sheet as this was used to determine the percentage seed infection. Each of the fungi presented was then be sub-cultured on fresh PDA to identify the cultural characteristics. Since different fungal colonies were formed on the agar, the most common appearing colony was identified. Examination was done both visually and microscopically. Slides of the fungal growth were prepared and observed under a microscope and the results were recorded and fungi were identified on the basis of their typical structure and basic characteristics including mycelium type, colony size, color [41]-[42].

### E. *Assessment of field Emergence and Off type Crops*

Field experiment was conducted during 2017 long rain season in farmer field at Busia County which is described in *A*., and Kakamega County at the KALRO field station located at 1554m Altitude, Latitude 00°17'N and Longitude 34°47'E. Mean rainfall is between 1600 and 2000mm, the soil is a Nitosol well-drained, deep dark red friable [43]. The experimental design was randomized complete block with three replicates. Treatments included farmer saved seeds, seed from local market, and seed from agro vet shops. Two grains per hill were planted in a plot of 3m x 4m. Crops in each plot were spaced by 75cm between rows and 30cm between crops on a row. As described by [44] fertilization was applied at the rate of 10g of DAP per hill at the planting and CAN top dressing at rate of 10g per hill applied at knee high stage of crop as described by [45]. The emergence rate was determined after 50% of the new seedlings had two fully expanded leaves as described by [46]-[47]. Off-types crops were assessed in each plot as described by [48], by observing the morphological characteristics of the crop including Leaves shapes, tassel coloration at the base glume, silks color, plant length, ear and kernel based on their descriptors coloration [49]-[50].

### F. *Statistical Data Analysis*

Data collected were subjected to analysis of variance (ANOVA) using GENSTAT 15th edition. Mean was separated using Fisher's protected LSD at 0.05 confidences.

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## III. RESULTS

### A. *Physical Purity of Maize Seed*

The physical purity showed variation in pure seeds, other variety, and inert matter, shriveled and damaged seeds in both agro ecological zones of Busia County. Pure seeds significantly varied ($p \leq 0.05$) among the zones and the seeds from different sources. In agro ecological zone1 (LM1), seed from distributors (WH507, WH505, and Duma43), had high percentage of pure seeds while the seed from farmer saved and from local market had the lowest pure seed. Farmer saved seed and seeds from local markets had the highest percentage of inert matter and insect damaged seeds. In agro ecological zone 2 (LM2), maize from Distributors including WH507 and WH505 had the highest percentage of pure seeds followed by the distributor Duma 43 and seed from agro vet shops. None of the seed sources met required regulation purity threshold of 99%. In term of inert matter, IR/Kayongo from distributor followed by local market and farmer saved seeds and seeds from agro vet shops had percentage inert matter over the required regulatory limit of 0.95% maximum (Table 1).

### B. *Seed Germination and Seedlings Vigor*

There were significant differences among the different seed sources from the two agro ecological zones in percentage germination, normal seedlings. Farmer saved and markets sourced seeds had significantly lower percentage germination and normal seedlings in both agro ecological zones. Excluding distributor IR/Kayongo, there was no significant variation in germination index, pure live seeds and vigor index among the seed from distributors including Wh507, WH505, and Duma43. Farmer saved and local market seeds had lower pure live seeds and vigor index in both agro ecological zones (Table 2).

Table 1. Percentage purity of maize seed from various sources in two agro ecological zones in usia County during the long rain season 2017.

| Seed sources/variety | PS | OV | IM | SS |
|---|---|---|---|---|
| **Lower Midland Zone I** | | | | |
| Distributor (WH 507) | $96.3_{a}$ | $0.0_{c}$ | $0.8_{d}$ | $2.9_{c}$ |
| Distributor (WH 505) | $95.7_{a}$ | $0.0_{c}$ | $0.9_{d}$ | $3.4_{c}$ |
| Distributor (Duma 43) | $93.4_{a}$ | $0.0_{c}$ | $1.4_{c}$ | $5.2_{c}$ |
| Distributor (IR/Kayongo) | $76.6_{b}$ | $0.0_{c}$ | $3.4_{a}$ | $19.5_{ab}$ |
| Agro vet (WH 507, WH 505, Duma 43, IR/Kayongo) | $75.7_{b}$ | $0.0_{c}$ | $1.5_{c}$ | $17.7_{b}$ |
| Farmer saved (Sipindi,Panadol, Duma 43, IR/Kayongo) | $69.9_{c}$ | $11.8_{a}$ | $1.5_{c}$ | $16.2_{b}$ |
| Local market (Sipindi and Panadol) | $66.7_{d}$ | $7.8_{b}$ | $1.9_{b}$ | $22.2_{a}$ |
| Mean | 74.4 | 6.5 | 1.7 | 16.7 |
| LSD ($p \leq 0.05$) | 3.9 | 1.4 | 0.3 | 3.7 |
| CV% | 4.7 | 19.3 | 18 | 20.2 |
| **Lower Midland Zone II** | | | | |
| Distributor (WH 507) | $96.3_{a}$ | $0.0_{b}$ | $0.8_{e}$ | $2.9_{f}$ |
| Distributor (WH 505) | $95.7_{ab}$ | $0.0_{b}$ | $0.9_{e}$ | $3.4_{ef}$ |
| Distributor (Duma 43) | $93.4_{b}$ | $0.0_{b}$ | $1.4_{de}$ | $5.2_{e}$ |
| Distributor (IR/Kayongo) | $76.6_{d}$ | $0.0_{b}$ | $3.4_{a}$ | $19.5_{a}$ |
| Agro vet (WH 507, WH 505, Duma 43, IR/Kayongo) | $88.2_{c}$ | $0.0_{b}$ | $1.7_{d}$ | $7.3_{d}$ |
| Farmer saved (Sipindi,Panadol, Duma 43, IR/Kayongo) | $72.2_{e}$ | $10.9_{a}$ | $2.2_{c}$ | $14.1_{c}$ |
| Local market (Sipindi and Panadol) | $70.2_{f}$ | $11.2_{a}$ | $2.5_{b}$ | $15.8_{b}$ |
| Mean | 79.3 | 6.8 | 2 | 11.5 |
| LSD ($p \leq 0.05$) | 1.8 | 0.8 | 0.5 | 1.6 |
| CV% | 2.1 | 10.2 | 21.6 | 12.2 |

PS = Pure seed; OV = Other Varieties; IM = Inert Matter; SS = Shrivelled Seeds.

Table 2. Germination and seedling vigor of maize seeds from various sources in two agro ecological zones in Busia County.

| Seed sources | G% | NS | GI | PLS | VI1 | VI2 |
|---|---|---|---|---|---|---|
| Low Midland zone I | | | | | | |
| Distributor (Duma 43) | $98_{a}$ | $82.7_{b}$ | $35_{a}$ | $92_{a}$ | $3,725_{a}$ | $3,986_{a}$ |
| Distributor (WH 505) | $98_{a}$ | $90.3_{a}$ | $35_{a}$ | $93_{a}$ | $3,518_{ab}$ | $3,730_{a}$ |
| Distributor (WH 507 ) | $98_{a}$ | $92.1_{a}$ | $35_{a}$ | $94_{a}$ | $3,147_{abc}$ | $3,732_{a}$ |
| Farmer saved (Sipindi,Panadol, Duma 43, IR/Kayongo) | $95_{ab}$ | $75.4_{bc}$ | $34_{ab}$ | $66_{b}$ | $2,628_{c}$ | $2,456_{c}$ |
| Local market (SIpindi and Panadol) | $92_{bc}$ | $75.4_{bc}$ | $33_{bc}$ | $66_{b}$ | $2,606_{c}$ | $2,158_{cd}$ |
| Agro vet (WH 507, WH 505, Duma 43, IR/Kayongo) | $90_{cd}$ | $69.8_{c}$ | $32_{c}$ | $67_{b}$ | $2,847_{bc}$ | $3,065_{b}$ |
| Distributor (IR/Kayongo) | $86_{d}$ | $14.4_{d}$ | $30_{d}$ | $66_{b}$ | $676_{d}$ | $1,732_{d}$ |
| Grand mean | 93 | 71.9 | 33 | 70 | 2,707 | 2,693 |
| LSD ($p \leq 0.05$) | 5.4 | 10.6 | 2.2 | 14.0 | 824 | 567 |
| CV% | 5.1 | 13.6 | 6.1 | 18.5 | 28 | 19 |
| Low Midland zone II | | | | | | |
| Distributor (Duma 43) | $98_{a}$ | $82.7_{bc}$ | $35_{a}$ | $92.0_{ab}$ | $3,725_{a}$ | $3,986_{a}$ |
| Distributor (WH 505) | $98_{ab}$ | $90.3_{ab}$ | $35_{a}$ | $93.7_{a}$ | $3,518_{ab}$ | $3,730_{a}$ |
| Distributor (WH 507 ) | $98_{ab}$ | $92.1_{a}$ | $35_{a}$ | $94.4_{a}$ | $3,147_{abc}$ | $3,732_{a}$ |
| Farmer saved (Sipindi,Panadol, Duma 43, IR/Kayongo) | $95_{bc}$ | $81.8_{c}$ | $33_{b}$ | $68.5_{c}$ | $2,424_{c}$ | $2,405_{c}$ |
| Local market (SIpindi and Panadol) | $94_{bc}$ | $81.4_{c}$ | $33_{b}$ | $70.9_{c}$ | $2,429_{c}$ | $2,153_{cd}$ |
| Agro vet (WH 507, WH 505, Duma 43, IR/Kayongo) | $94_{c}$ | $87.2_{ab}$ | $33_{b}$ | $80.0_{b}$ | $2,816b_{c}$ | $3,160_{b}$ |
| Distributor (IR/Kayongo) | $86_{d}$ | $14.4_{d}$ | $29_{c}$ | $66.1_{c}$ | $676_{d}$ | $1,732_{d}$ |
| Grand mean | 94 | 81.0 | 33 | 75.6 | 2,594 | 2,704 |
| LSD ($p \leq 0.05$) | 3.4 | 6.9 | 1.3 | 13.1 | 782 | 566 |
| CV% | 3.3 | 7.9 | 3.6 | 16.0 | 28 | 19 |

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C. *Infections Seed-borne disease Causing Pathogens*

Farmer saved and local market seeds had high incidence of infected seedlings, *Fusarium sp*, *Aspergillus sp* and *Penicillium sp* diseases causing pathogens in both agro ecological zones (Table 3).

D. *Field Emergence and off type Crops*

There was significant variation ($p \leq 0.05$) in 50% emergence of the different seed from various sources between the sites. Panadol local market had the highest emergence while the certified IR/Kayongo from agro vet shop was the wast in both sites. The rest of the seed sources had non-significant difference forming one homogenous group designated by letter b as presented in Table 4. Dead seeds showed significant statistical variation in Busia site while in Kakamega site there was no variation among the seed sources.

IR/Kayongo from agro vet had the highest incidence of dead seeds compared to Duma 43 from agro vet which had the lowest. All the seed from informal system including farmer saved and local market formed a homogenous group. Seeds rot was statistically equal between the materials used at Busia experiment whereas, at Kakamega, the seed sources formed two groups in which there is no significant difference one another.

IR/Kayongo from agro vet shop had the highest incidence of rotten seed while other sources formed a group with non-significant differences (Table 4). Farmer saved and local market seeds had higher number of off-types crops in contrast with the certified Duma 43 and IR/Kayongo from Agro vet in both sites. The result on Root lodging in both sites did not show any significant variance. Opposite stalk lodging, only Duma 43 from agro vet was not affected significantly (Table 5).

Table 3. Percentage of Fungal genera isolated from maize seed sources in two Agro Ecological Zones in Busia.

| Seed sources | Infected seedlings | *Fusarium sp* | *Aspergillus sp* | *Penicillium sp* |
|---|---|---|---|---|
| **Low Midland Zone I** | | | | |
| Local market (Sipindi and Panadol) | $37.9_{a}$ | $32.0_{a}$ | $16.6_{b}$ | $12.4_{bc}$ |
| Farmer saved (Sipindi, Panadol, Duma 43, IR/Kayongo) | $30.9_{b}$ | $29.9_{a}$ | $15.3_{b}$ | $39.2_{a}$ |
| Distributor (IR/Kayongo) | $11.0_{c}$ | $27.5_{ab}$ | $35.0_{a}$ | $27.5_{ab}$ |
| Distributor (WH 505) | $1.0_{d}$ | $17.5_{bc}$ | $0.0_{c}$ | $0.0_{c}$ |
| Distributor (WH 507) | $0.8_{d}$ | $15.0_{cd}$ | $0.0_{c}$ | $0.0_{c}$ |
| Agro vet (WH 507, WH 505, Duma 43, IR/Kayongo) | $6.2_{cd}$ | $8.8_{cd}$ | $30.0_{a}$ | $4.4_{c}$ |
| Distributor (Duma 43) | 1.3d | $6.8_{d}$ | $0.0_{c}$ | $0.0_{c}$ |
| Grand mean | 21.1 | 19.6 | 13.8 | 11.9 |
| LSD (p=0.05) | 6.03 | 10.4 | 8.2 | 15.2 |
| CV% | 26.5 | 35.8 | 40.1 | 85.9 |
| **Low Midland Zone II** | | | | |
| Local market (Sipindi and Panadol) | $30.3_{a}$ | $36.8_{a}$ | $35.3_{a}$ | $33.3_{a}$ |
| Farmer saved (Sipindi, Panadol, Duma 43, IR/Kayongo) | $27.3_{a}$ | $23.7_{b}$ | $35.0_{a}$ | $35.0_{a}$ |
| Distributor (IR/Kayongo) | $11.0_{b}$ | $20.0_{bc}$ | $31.1_{a}$ | $10.0_{b}$ |
| Distributor (WH 505) | $1.0_{c}$ | $15.0_{bc}$ | $0.0_{c}$ | $10.0_{b}$ |
| Distributor (WH 507) | $0.8_{c}$ | $12.5_{c}$ | $0.0_{c}$ | $12.5_{b}$ |
| Agro vet (WH 507, WH 505, Duma 43, IR/Kayongo) | $4.2_{c}$ | $11.3_{c}$ | $12.5_{b}$ | $5.6_{b}$ |
| Distributor (Duma 43) | $1.3_{c}$ | $12.5_{c}$ | $0.0_{c}$ | $5.0_{b}$ |
| Grand mean | 17.5 | 18.8 | 16.3 | 15.9 |
| LSD (p = 0.05) | 6.2 | 10.1 | 8.8 | 9.7 |
| CV% | 32.6 | 36.1 | 36.4 | 41.2 |

Table 4. Percentage emergence, dead and rotten seeds of different seed sources in Busia and Kakamega sites.

| Seed sources | Emergence | Dead seeds | Seed rot |
|---|---|---|---|
| Busia | | | |
| Panadol local Market | $65.8_{a}$ | $16.4_{bc}$ | 12.1 |
| Sipindi farmer sav | $56.4_{b}$ | $16.7_{bc}$ | 14.2 |
| IR/Kayo farmer sav | $55.8_{b}$ | $18.2_{bc}$ | 16.1 |
| Sipindi local market | $52.4_{b}$ | $18.8_{bc}$ | 14.2 |
| Duma 43 farmer sav | $52.4_{b}$ | $20.3_{b}$ | 15.5 |
| Panadol farmer sav | $50.0_{b}$ | $19.4_{bc}$ | 17.6 |
| Duma 43 Agrovet | $49.7_{b}$ | $15.2_{c}$ | 12.4 |
| IR/Kayo Agrovet | $27.9_{c}$ | $30.6_{a}$ | 25.8 |
| Grand Mean | 55.9 | 19.4 | 16 |
| LSD (p≤0.05) | 21.5 | 5.1 | 9.8 |
| CV% | 21.9 | 15 | 35.1 |
| kakamega | | | |
| Panadol local Market | $60.3_{a}$ | 16.4 | $11.5_{b}$ |
| Sipindi farmer sav | $53.3_{ab}$ | 23.3 | $12.4_{b}$ |
| IR/Kayo farmer sav | $39.4_{bc}$ | 23.3 | $18.2_{b}$ |
| Sipindi local market | $53.3_{ab}$ | 21.5 | $15.2_{b}$ |
| Duma 43 farmer sav | $48.8_{ab}$ | 17.9 | $18.5_{b}$ |
| Panadol farmer sav | $42.4a_{bc}$ | 23.3 | $19.1_{ab}$ |
| Duma 43 Agrovet | $54.2_{ab}$ | 10.3 | $14.2_{b}$ |
| IR/Kayo Agrovet | $24.2_{c}$ | 35.5 | $26.4_{a}$ |
| Grand Mean | 47 | 21.9 | 16.9 |
| LSD (p≤0.05) | 20.4 | 23.5 | 7.7 |
| CV% | 24.7 | 61.2 | 25.8 |

Table 5. Percentage off types and plant lodging of the seed sources at Busia and Kakamega sites.

| Seed sources | Off-types | Root lodging | Stalk lodging |
|---|---|---|---|
| Busia | | | |
| Panadol farmer saved | $10.6_{a}$ | 7.7 | $11.5_{ab}$ |
| Duma 43 farmer saved | $10.4_{ab}$ | 7.5 | $10.4_{ab}$ |
| Sipindi local market | $9.2_{abc}$ | 6.4 | $14.1_{a}$ |
| Sipindi farmer saved | $8.6_{abc}$ | 7.1 | $11.2_{ab}$ |
| IR farmer saved | $7.1_{bc}$ | 8.1 | $10.9_{ab}$ |
| IR Agrovet | $6.7_{c}$ | 7.6 | $12.1_{ab}$ |
| Panadol local Market | $6.0_{cd}$ | 5.7 | $8.3_{bc}$ |
| Duma 43 Agrovet | $3.1_{d}$ | 7.9 | $3.7_{c}$ |
| Grand mean | 7.7 | 7.3 | 10.3 |
| LSD (p≤0.05) | 3.4 | 2.7 | 5.3 |
| CV % | 24.8 | 21.5 | 29.4 |
| Kakamega | | | |
| Panadol farmer saved | $14.6_{a}$ | 5.3 | $12.2_{a}$ |
| Duma 43 farmer saved | $15.3_{a}$ | 6.1 | $12.9_{a}$ |
| Sipindi local market | $15.3_{a}$ | 5.8 | $12.2_{a}$ |
| Sipindi farmer saved | $21.9_{a}$ | 6.8 | $11.7_{a}$ |
| IR farmer saved | $14.9_{a}$ | 6 | $11.0_{a}$ |
| IR Agrovet | $3.4_{b}$ | 5.4 | $12.2_{a}$ |

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| | | | |
|---|---|---|---|
| Panadol local Market | $18.9_a$ | 5.3 | $11.3_a$ |
| Duma 43 Agrovet | $2.7_b$ | 5.8 | $2.8_b$ |
| Grand mean | 13.4 | 5.8 | 10.8 |
| LSD ($p \leq 0.05$) | 10.3 | 2 | 2.5 |
| CV % | 43.9 | 19.7 | 13.3 |

## IV. Discussion

Certified seeds from Distributors and Agro vet shops had high percentage of pure seeds than uncertified seeds but all the maize seed sources did not meet the recommended maize seed purity of the Kenyan laboratory standard (99%). The current result is consistent to finding of [51] and [52] who observed variations in pure seed content of farmer seed in Western Kenya. Previous studies done by [53] found that seeds from the formal sector are not adulterated, they are pure comparing to the seed from own saved [54]. [12]-[55] Also indicated that seed quality refers to it trueness to it varietal type and physical attribute [56].

All the seed sources met the recommended germination percentage, 99%, except distributor IR/Kayongo which had germination rate of 86.3% and low percentage of normal seedlings. Farmer saved and market maize seed were highly contaminated and had low vigor index. Fungal seed borne was isolated from all sources though informal seeds were found to have more different fungal genera. This is in agreement with the found of [57] who observed that seed recycling leads to poor seed quality, influencing production. [58] Also indicated that seed quality consists of it genetic purity, physical purity, germination potential, vigor and free from seed borne pathogens [59]. Various studies found that farmer saved seed does not meet the finest quality [60]-[61]. [62] Concluded that seed borne pathogens reduce germination potential. Seeds from informal sector are of waste quality, inappropriate varieties, infected seed of low germination potential with compromised yield [63].

This aspect could be attributed to the reason that farmer seeds are produced in ordinary agriculture production system with no regulation regarding harvest and handling, drying and storage [51]. [64] Also found that about 80% of the amount of the maize seeds used by farmers in western Kenyan counties are from own farm production as observed [65] that this kind of seed production seams to ignore certain aspects of seed quality. Though informal seeds constitute about 60-80% of the total planting material used in East and Central Africa, they are of underestimated quality [14].

Farmer saved and local market seeds were highly infected with high number of fungal pathogens. This is in agreement with the find of [63] who reported that informal seeds are of poor quality, infected seed with compromised yield. [14] also found that though seeds from informal system constitute the main source of planting material used in East and Central Africa, they are of poor quality [57]-[58]-[60]-[61]. [66] Found that farmer saved cowpea seeds were highly infected with multiple seed-borne disease-causing pathogens. [67] Also indicated that own saved seeds of onion had high infection of fungal pathogens.

Farmers' seeds are most of the time produced in the combined standards of crop production system. Seeds are selected from seasonal production after harvest or earlier planting. Farmers' methods of seeds (re-) production and handling are at the same time rudimentary. These seeds are out of control or not certified and tested by the seed certification agency, thus, result in poor quality which may be induced by poor farm management, Storage system and period, store conditions that favor growth of different seed-borne fungi. This statement is in agreement with [16]-[17] who indicated that farmer saved seeds are produced under uncontrolled system, as consequence, they result in poor quality with fungal seed borne and mycotoxin. [68] Observed that seed storage is crucial for seed quality. It can have impact on the whole feature of seeds quality attributes and contributes to seed ageing that decreases seed viability. Storage is necessary for seed fitness maintenance. Store environments must remain properly cleaned to prevent leftover contagions from diseased vegetable or seed material saved from previous harvest. In relation to seed testing, storage is important when testing date and planting date are far apart [69]-[70]-[71]-[72].

The uncertified seed from local market had high plant establishment while both market and farmer saved seeds highly lodged and counted high number of off-type crops. Dead seeds and rotten seed incidence was higher in certified seeds from agro vet shops depending on the variety type. Similar study done by [72] reported a higher level of germination rate in informal seeds compared to certified seeds. Contrary to the finding of [12]-[55] who found that informal seeds are usually of low germination potential in field due to low quality. Also, [63] reported that poor seed quality results in uneven seedling stands and more unhealthy seedlings. This is similar to other research by [21]-[20] which reported that seed quality refers to its ability to germinate.

Mostly, farmer saved seeds are selected from previous harvest and may be having the probability to emerge faster than the seeds stored for a time. Agro dealer may store their maize seeds for a long time as farmers rely on their own production. [73] Observed that improved cultivars do not have good storability compared to landraces, thus certified seeds lose their potential to germinate faster. Seed storage is critical for seed quality. It can affect the whole feature of seeds quality attributes that reduce seed viability. Storage is necessary for seed fitness maintenance [25]. Store environments must remain properly cleaned to prevent leftover contagions from diseased vegetable or seed material saved from previous harvest. Seed transmitted diseases constitute the main challenge in the world concerning seed dissemination. They are the most causes of poor performance of the crop from field emergence up to the yield [18]-[19]. In relation to seed testing, storage is important when testing date and planting date are far apart [74].

Studies done by [18]-[19]-[20]-[21] indicated that seed quality refers to it trueness to it varietal type, physical attribute. Same result was obtained by [12] who reported that seeds from informal system are inappropriate varieties [75]. [5] Also reported that informal seeds do not go through guarantee standards and controlled production networks.

Lodging sensibility of the crops was possibly the effect

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of seed-borne pathogens observed in the seed samples after laboratory test which reduced resistance to stress because of low vigor. Presence of fungal seed borne pathogens decreases the germination potential and vigor of seeds thus reduces plant development especially when the environme--nt is favorable for disease development [76]. Similar study of [77] also found that recycled seeds are most of time infected with seed borne pathogens that can reduce crop resistance due to low vigor, can cause lodging, thus lead to low productivity. Poor seed quality results in defective seedling stands and more unhealthy plants in field confirmed [63]-[78].

## V. Conclusion and Recommendations

Although quality tests of the different seed sources raised essential questions on the quality attributes of certified maize seeds, farmer saved and local market seeds are of poor physical purity, infected seeds, poor vigor with an important number of fungal seed-borne pathogens. Seed from farmer saved showed notable germination rates, vigor index but with incidence of infected seeds compared to certified maize seed from the agro vet and distributors. Use of certified is necessary for limiting spread of diseases and improve crop productivity. Large sensitization of small-scale maize producers on adoption of improved maize variety is crucial for food security enhancement. It is also much important that agro-dealers adhere to seed regulations and standards.

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