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Effect of Farm Saved Maize (*Zea mays* L.) Seed on Intensity of Foliage Diseases

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Abstract

Majority of farmers in Africa recycle farm saved seed from the previous seasons. Such seed is usually contaminated with disease causing pathogens, has low vigor and result in low yields. This study was, therefore, conducted to determine the effect of recycling maize seeds on incidence of foliage diseases. Maize seeds were collected during 2016 short rain season from farmers, local market and Agrovet shops in Busia County of western Kenya. The seeds were subjected to field evaluation during 2017 long rain season at two sites in Busia and Kakamega Counties. Data was collected on emergence, off types, lodging, ear aspect and abnormalities, incidence and severity of diseases and yield. Seeds from local market had significantly higher emergence of up to 66% while the farm saved seeds and local market resulted in the highest percentage of off-types of up to 18%. Crop from farm saved seed and seeds from the local market showed high susceptibility to stalk lodging, ear abnormalities and high levels of diseases. Diseases detected include northern leaf blight, gray leaf spot, rust, brown spot, downy mildew, and ear rots. The study showed that though informal seeds had high plant establishment, they have high level of off types, are susceptible to lodging, diseases and low yields. Therefore, farmer should be encouraged to use certified or improved seeds to enhance crop productivity.

Keywords: disease, emergence, incidence, severity, maize, seed sources, yield

1. Introduction

Maize is the main food crop in Africa (Westengen et al., 2014) but yields remain low below 2,000 kg ha^{-1} compared to average yields of 7,000 to 10,000 kg ha^{-1} in other regions like the United States of America (Huang et al., 2011). Maize productivity is low due to several reasons including poor adoption of improved agricultural technologies and use of low quality farm-saved seeds by small scale farmers, who constitute the majority of food producers. The farm saved seeds make up to 80-90% of the available planting materials (Bruijin et al., 1994, Wright et al., 1994; Delouche, 1982). Farmer saved seeds are of low physiological quality and are usually contaminated with noxious weed seeds and seed borne diseases leading to low field emergence, reduced crop vigor and low yield (Sperling, 2001; Mahender et al., 2015). Louwaars et al. (1997) reported that good quality seed is a crucial input for plant productivity and unique way to maximize on other agricultural inputs.

Seed quality refers to it trueness to varietal type, physical attributes, ability to germinate, vigor and freedom from seed borne diseases. Low quality seeds result in defective seedlings, reduced crop stand, low crop establishment and infection with pests and diseases in the field (Coutts et al., 2008; IRRI, 2013). Therefore, frequent use of low quality seeds by small holder farmers leads to decline in maize productivity (Zegeye et al., 2014). In contrast, the use of certified seeds from the formal system results in crops with low incidence of pests, diseases and abiotic stresses and high yield (Zegeye et al., 2014; Alemu, 2015).

Foliage diseases affecting maize production include downy mildew (*Sclerophthora* spp.), common rust (*Puccinia sorghi*), turcicum leaf blight (*Exserohilum turcicum*), grey leaf spot (*Cercospora zeae-maydis*), stalk rot and ear rots (*Fusarium* spp and *Diplodia* spp). Common virus diseases affecting maize include maize streak virus (MSV) and maize lethal necrosis (MLN) (Tripathi et al., 2011; Wangai et al., 2012). Most of these diseases are transmitted through seed and yield losses due to these diseases are estimated to be up to 20% depending with the disease and the environmental conditions (Mueller et al., 2016).

Accessibility to certified quality seed by small-scale producers is a challenge in most African countries (COMESA, 2014) and therefore, adoption of improved seeds remains low at less than 10% (Langyintuo, 2009). The certified seeds produced under the formal sector go through standards and regulations which differ from country to country. The distinctiveness, uniformity, and stability (DUS) and the value for cultivation and use (VCU) tests are conducted for a variety to be admitted for commercialization (ECAPAPA, 2003). The test, which is also referred to as the National Performance Trial (NPT), should be conducted in at least five to six locations. This makes it expensive for a seed company to release a variety (Setimela & Mwangi, 2009). Use of high quality and clean seeds is likely to increase yields by up to 50% (Atilaw, 2010; Asea et al., 2010; CTA, 2014; Gebremedhim, 2015; Mew & Gonzales, 2002). The study was conducted to determine the effect of farm saved maize seeds on incidence and severity of foliage diseases.

2. Materials and Methods

2.1 Experimental Design and Layout

The field experiments were conducted during 2017 long rain season in Busia and at the Kenya Agricultural and Livestock Research Organization (KALRO) in Kakamega County. Seeds of maize varieties evaluated included farmer saved landraces Sipindi and Panadol and from local market, farmer saved Duma 43 and IR/Kayongo from and from Agrovet shops. Each variety was planted in 3 m × 4 m plots separated by 1m and laid out in a randomized complete block design with three replicates. Two seeds per hill were planted at a spacing of 75 cm × 30 cm between and within rows, respectively. Two guard rows were installed around the experiment in both sites. Fertilization was done with 10 g diammonium phosphate (DAP) per hill at planting followed by top dressing with calcium ammonium phosphate (CAN) at the rate of 10g per hill when the plants were about 45cm tall (Muiru et al., 2015; Qasim et al., 2010; Halidu et al., 2014). Data was collected on emergence, viral diseases, off types, incidence and severity of fungal diseases, number of cobs per plant, cobs aspect and weight, and yield.

2.2 Assessment of Agronomic Parameters

The agronomic parameters recorded included emergence, dead seed, rotten seeds, lodging and ear aspects. Emergence was determined after 50% seedlings had two fully expanded leaves (Kieran, 2009; Ogunniyan & Olakojo, 2015). Dead seeds were assessed by checking hills where the seed did not emerge whether it was absent or rotten. Off-types crops were assessed in each plot by observing the morphological characteristics of the crop including Leaves shapes, tassel coloration at the base glume, silks color, plant length, ear and kernel coloration (Hipi et al., 2013; UPOV, 2009; Yadav & Singh, 2010). Root and stalk lodging were recorded every month and at harvest as a percentage of the lodged plant over the total number of plants in each plot. Ear aspect was scored by on a scale of 1-5, where 1 is clean, uniform, large, and well-filled and 5 is rotten, variable, small, and partially filled ears (Adebayo & Menkir, 2015).

2.3 Assessment of Incidence and Severity of Foliage Diseases

Disease incidence was based on visual symptoms while assessment of the major maize viral diseases including maize streak virus and maize lethal necrosis, was carried out three times at vegetative stage during the season. Inspection was done as described by CIMMYT (2004) at vegetative stage growth at V5, V10, VT before pollen development and R2, and at harvest. Incidence was determined as the percentage of the plants infected over the total number of plants in each plot. Incidence of viral diseases was determined on all plants in the 3 intermediate rows in each plot as described by Bosque-Perez et al. (1998). Severity was determined on 6 randomly selected plants showing disease symptoms. Two plant were selected in each of the three inner rows in each plot and the disease scored on a scale of 0-5 (Nwanosike et al., 2015; Reid et al., 1996), where, 0 = no symptoms, 1 = very slight infection, one or two restricted lesion on lower leaves; 2 = slight infections, 9-15 lesions on lower leaves; 3 = moderate number of lesions on lower leaves; 4 = abundant lesions on lower and middle leaves which extend to upper leaves; and 5 = abundant infections, no formation of cobs, plant dying prematurely from the disease. Severity of ear rot was scored on rating scale of 1-7 (Shekhar & Kumar, 2012), where 1 = no infection, 2 = 1 to 3%, 3 = 4 to 10%, 4 = 11 to 25%, 5 = 26 to 50%, 6 = 51 to 75 % and 7 = over 75% of ear infected.

2.4 Assessment of Yield and Yield Components

The crop was harvested at physiological maturity by removing the husks from the ears. The number of ears from each plot were counted and the following data collected: number of ears per plant, number of ears with abnormalities and total cob weight per plot. Ear abnormality was determined as incomplete kernel tip set, poor tip fill, bouquet ears, exposed ear tip, extended ear leaves, tassel ears and zipper ears. The data on the number of ears in each category was converted to percentage by dividing by the total number of ear in each plot, multiplied by 100. Grain yield was determined in $kgha^{-1}$ based on weight of unshelled cobs at physiological maturity, considering the commercial grain moisture of 12.5% and shelling factor of 80% as follows (Adebayo & Menkir, 2015):

$$GY\left(\frac{Kg}{ha}\right) = WW \times \frac{100\text{-}FM}{100\text{-}12.5} \times \frac{80}{100} \times \frac{10{,}000}{US} \quad (1)$$

Where, GY is Grain yield, WW the wet weight, FM the field moisture and US the Useful surface.

2.5 Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using GENSTAT 15th edition. Mean separation was done using Fischer's protected Least Significant Difference (LSD) at 5% level of significance.

3. Results

3.1 Emergence and Plant Lodging

There was significant variation ($p \leq 0.05$) in 50% emergence of the different seed sources between the sites. The result showed higher emergence percentage at Busia compared to Kakamega. Emergence percentage varied significantly among the seed sources at $p \leq 0.05$ (Table 1). Uncertified seeds from farmer-saved and local market had about 43% emergence over the certified seed from agro vet shops. Panadol from local market had the highest emergence rate of about 63% while the certified IR/Kayongo from agro vet had the lowest in both sites. Dead seeds showed significant statistical variation in Busia. Certified seeds from agro vet shops showed high incidence of dead seeds of about 26% over uncertified seeds from farmer-saved and local market seeds. However, IR/Kayongo from agro-vet shop had the highest percentage of dead seeds of about 33% across the sites. Rotten seeds varied between the sites. There was no significant difference at Busia while at Kakamega, the result showed significant variations in percentage of rotten seeds among the seed sources. Certified seeds from agro vet shops had the highest percentage of rotten seeds of about 20% compared to uncertified seeds from farmer-saved and local market seeds. However, IR/Kayongo from agro-vet shop had the highest percentage of rotten seeds in both sites (Table 1).

Table 1. Percentage emergence, dead and rotten seeds of different seed sources in Busia and Kakamega sites

Seed sources	Busia			Kakamega		
	Emergence	Dead seeds	Seed rot	Emergence	Dead seeds	Seed rot
Panadol local Market	65.8_{a}	16.4_{bc}	12.1	60.3_{a}	16.4	11.5_{b}
Sipindi farmer saved	56.4_{b}	16.7_{bc}	14.2	53.3_{ab}	23.3	12.4_{b}
IR/Kayo farmer saved	55.8_{b}	18.2_{bc}	16.1	39.4_{bc}	23.3	18.2_{b}
Sipindi local market	52.4_{b}	18.8_{bc}	14.2	53.3_{ab}	21.5	15.2_{b}
Duma 43 farmer saved	52.4_{b}	20.3_{b}	15.5	48.8_{ab}	17.9	18.5_{b}
Panadol farmer saved	50.0_{b}	19.4_{bc}	17.6	$42.4a_{bc}$	23.3	19.1_{ab}
Duma 43 Agrovet	49.7_{b}	15.2_{c}	12.4	54.2_{ab}	10.3	14.2_{b}
IR/Kayo Agrovet	27.9_{c}	30.6_{a}	25.8	24.2_{c}	35.5	26.4_{a}
Grand Mean	55.9	19.4	16.0	47.0	21.9	16.9
LSD ($p \leq 0.05$)	21.5	5.1	9.8	20.4	23.5	7.7
CV%	21.9	15.0	35.1	24.7	61.2	25.8

The result showed significant variation at $p \leq 0.05$ in off-types among the seeds from the various sources in both sites. Uncertified seeds from farmer saved and local market had high number of off-types of about 9% in contrast to certified seeds from agro vet shops having about 5% at Busia site while at Kakamega, the informal seeds had about 17% of off-type and formal seeds from agro vet shops had about 3%. However, Sipindi from farmer-saved had high number of off-types crops across the sites (Table 2). Stalk lodging did not show significant variation between the sites. At both sites, uncertified seeds from farmer saved and local market had high incidence of stalk lodging at 49.4% over certified seeds from agro vet shops (Table 2).

Table 2. Percentage plant lodging of the seed from various sources at Busia and Kakamega sites

Seed sources	Busia			Kakamega		
	Off-types	Root lodging	Stalk lodging	Off-types	Root lodging	Stalk lodging
Panadol farmer saved	10.6a	7.7	11.5ab	14.6a	5.3	12.2a
Duma 43 farmer saved	10.4ab	7.5	10.4ab	15.3a	6.1	12.9a
Sipindi local market	9.2abc	6.4	14.1a	15.3a	5.8	12.2a
Sipindi farmer saved	8.6abc	7.1	11.2ab	21.9a	6.8	11.7a
IR/Kayongo farmer saved	7.1bc	8.1	10.9ab	14.9a	6.0	11.0a
IR/Kayongo Agro vet	6.7c	7.6	12.1ab	3.4b	5.4	12.2a
Panadol local Market	6.0cd	5.7	8.3bc	18.9a	5.3	11.3a
Duma 43 Agro vet	3.1d	7.9	3.7c	2.7b	5.8	2.8b
Grand mean	7.7	7.3	10.3	13.4	5.8	10.8
LSD ($p \leq 0.05$)	3.4	2.7	5.3	10.3	2.0	2.5
CV %	24.8	21.5	29.4	43.9	19.7	13.3

3.2 Incidence and Severity of Diseases

Major diseases observed included Seedling blight, maize streak, northern leaf blight, grey leaf spot, rust, diplodia, downy mildew, brown spot, eyespot and ear rot. Seedling blight, Northern leaf blight, and downy mildew were the commonest folia diseases affecting the maize from various sources in both Busia and Kakamega sites. Except at Busia, where maize streak virus, rust, brown spot which had significant differences compared to Kakamega where high incidences were observed in northern leaf blight, diplodia, grey leaf spot and downy mildew. There were no much variations in the incidence of seedling blight between the sites at $p \leq 0.05$. At both sites, certified seeds from agro vet shops had the highest incidence of seedling blight and maize streak virus. However, IR/Kayongo from agro vet shops was highly contaminated with seedling blight and maize streak virus at both sites (Table 3).

Table 3. Incidence of seedling blight and Maize Streak Virus of the seed sources at Busia and Kakamega sites

Seed sources	Busia		Kakamega	
	Seedling blight	Maize Streak Virus	Seedling blight	Maize Streak Virus
IR Agrovet	39.2_{a}	13.4_{a}	46.3_{a}	11.4
Sipindi local market	27.9_{b}	8.5_{bc}	31.7_{b}	0.0
Panadol local Market	21.4_{bc}	7.8_{bcd}	21.9_{bc}	0.0
Panadol farmer saved	20.6_{bc}	10.6_{ab}	29.1_{bc}	0.0
Duma 43 farmer saved	20.3_{bc}	9.8_{ab}	24.2_{bc}	2.4
IR farmer saved	18.7_{bc}	4.8_{cd}	29.5_{bc}	5.3
Sipindi farmer saved	18.4_{c}	8.2_{bc}	20.7_{c}	5.3
Duma 43 Agrovet	7.9_{d}	3.3_{d}	6.5_{d}	0.0
Grand Mean	21.8	8.0	26.2	31.4
LSD (p = 0.05)	9.4	4.9	10.1	10.4
CV%	24.7	33.4	22.0	18.8

The result showed at both sites, highly significant variations of fungal foliage diseases incidence between the seed sources. At Busia site, uncertified seeds from farmer saved and local market were found to be more infected having high incidence of diseases including northern leaf blight (17%), diplodia (6%) rust (4%), brown spot (3%) while certified seeds from agro vet shops had high incidence of downy mildew only. At Kakamega, the result revealed a reverse situation whereby the certified seeds from agro vet shops had a high level of diseases incidence of about 20% for northern leaf blight, grey leaf spot at 6% incidence, diplodia 12% and down mildew 6%. Across the sites, the result showed that certified seeds from agro vet shops had high incidence of northern leaf blight (17%), grey leaf spot (3%), downy mildew (3%) while incidence of rust (4%), brown spot (4%) and eye spot (3%) were highly found in uncertified seeds from farmer saved and local market (Table 4).

Severity score of fungal diseases was significantly different between the sites and among the seed sources. At Busia site, diplodia was significantly different among the seeds sources whereas, at Kakamega, variations were found in northern leaf blight, grey leaf spot, diplodia, and eyespot. Diplodia was found to be severe in uncertified seeds at Busia site while at Kakamega site, high severity scores of northern leaf blight, grey leaf spot were found in certified seeds from agro vet shops (Table 5).

Incidence and severity scores of ear rot were found to be highly significant among the seeds sources at Busia site, whereas at Kakamega there was non-significant difference. Farmer saved and local market seeds had high incidence of 10.5% and severity score of up to 6 indicating 51 to 75% infection on ears compared to certified seeds from agro vet shops. However, local market, although had high plant establishment as indicated in Table 4.1, had high incidence and severity of ear rot (Table 6).

Table 4. Incidence of fungal diseases of seed sources in Busia and Kakamega sites

Seed sources	Northern leaf blight	Gray leaf spot	Diplodia	Rust	Brown spot	Downy mildew	Eyespot
Busia							
IR Agrovet	25.2_{a}	0.0	7.9_{ab}	4.4_{b}	3.4_{bc}	0.0_{b}	0.0
Sipindi local market	22.7_{a}	0.0	8.5_{a}	3.9_{b}	7.8_{a}	0.6_{b}	0.0
Duma 43 farmer saved	22.3_{ab}	0.0	4.9_{bcd}	3.7_{b}	2.4_{bcd}	0.6_{b}	0.0
IR farmer saved	19.1_{b}	0.0	5.4_{abcd}	6.6_{a}	3.0_{bcd}	0.0_{b}	0.0
Sipindi farmer saved	14.6_{c}	0.0	4.1_{cd}	1.8_{c}	1.8_{cd}	1.1_{ab}	0.0
Panadol local Market	13.1_{c}	0.0	5.7_{abc}	1.4_{c}	1.7_{cd}	0.0_{b}	0.0
Panadol farmer saved	12.3_{c}	0.0	5.9_{abc}	3.9_{b}	3.9_{b}	0.0_{b}	0.0
Duma 43 Agro vet	3.9_{d}	0.0	$1._{9d}$	0.0_{c}	1.3_{d}	1.9_{a}	0.0
Grand mean	7.1	0.0	5.5	3.2	3.2	0.5	0.0
LSD ($p \leq 0.05$)	2.3	0.0	3.5	1.9	1.98	1.16	0.0
CV%	18.7	0.0	36.5	34.4	35.6	122.9	0.0
Kakamega							
IR Agro vet	29.8_{a}	12.2_{a}	21.8_{a}	6.7	3.8	10.4_{a}	4.2
Sipindi local market	12.6_{b}	7.1_{b}	10.5_{b}	10.6	3.7	0.0_{b}	10.7
Duma 43 farmer saved	12.2_{b}	2.3_{c}	6.9_{bc}	5.5	2.3	0.8_{b}	6.1
IR farmer saved	9.9_{bc}	4.9_{b}	11.0_{b}	3.2	1.1	1.0_{b}	5.9
Sipindi farmer saved	4.4_{c}	0.0_{c}	7.8_{bc}	4.7	7.7	0.6_{b}	5.6
Panadol local Market	7.7_{bc}	2.4_{c}	11.4_{b}	6.9	4.2	2.5_{b}	5.2
Panadol farmer saved	6.8_{bc}	1.6_{c}	13.5_{b}	0.8	6.4	4.6_{ab}	1.4
Duma 43 Agro vet	9.5_{bc}	0.0_{c}	2.0_{c}	1.2	1.1	1.1_{b}	1.1
Grand mean	11.6	3.8	10.6	4.9	3.8	2.6	5
LSD ($p \leq 0.05$)	6.92	2.39	8.17	8.93	5.62	6.09	5.64
CV%	34	35.8	44	103	84.7	132.3	64.1

Table 5. Severity scores of fungal diseases of seed sources in Busia and Kakamega sites

Seed sources	Northern leaf blight	Gray leaf spot	Diplodia	Rust	Brown spot	Downy mildew	Eyespot
Busia							
IR Agrovet	1.3	0.0	1.7_{bc}	1.0	0.3	1.3	0.0
Sipindi local market	1.7	0.0	2.3_{ab}	1.0	2.0	1.3	0.0
Duma 43 farmer saved	1.7	0.0	2.3_{ab}	1.3	1.0	1.3	0.0
IR farmer saved	1.3	0.0	1.7_{bc}	2.3	1.7	1.0	0.0
Sipindi farmer saved	1.7	0.0	2.3_{ab}	1.7	2.0	1.3	0.0
Panadol local Market	1.3	0.0	3.3_{a}	1.7	1.0	1.0	0.0
Panadol farmer saved	0.7	0.0	2.7_{ab}	1.7	2.0	1.0	0.0
Duma 43 Agro vet	1.3	0.0	0.7_{c}	0.3	0.7	1.7	0.0
Grand mean	1.4	0.0	2.12	1.4	1.3	1.3	0.0
LSD ($p \leq 0.05$)	1.5	0.0	1.2	1.5	1.7	1.1	0.0
CV%	63.2	0.0	32.3	63.7	70.6	48.2	0.0
Kakamega							
IR Agrovet	3.7_{a}	3.7_{a}	2.7_{ab}	0.7	0.3	2.0	0.7_{b}
Sipindi local market	3.7_{a}	2.7_{b}	2.3_{ab}	2.3	1.3	1.0	3.0_{a}
Duma 43 farmer saved	2.7_{b}	1.3_{c}	3.3_{a}	1.3	2.0	1.3	2.0_{ab}
IR farmer saved	2.7_{b}	2.3_{b}	2.3_{ab}	1.0	0.7	1.3	1.3_{b}
Sipindi farmer saved	1.3_{d}	0.0_{d}	2.0_{bc}	1.7	2.0	1.3	2.0_{ab}
Panadol local Market	1.7_{cd}	1.3_{c}	3.0_{ab}	2.3	1.3	2.3	2.0_{ab}
Panadol farmer saved	1.3_{d}	0.3_{d}	2.0_{bc}	1.7	1.0	1.7	0.7_{b}
Duma 43 Agro vet	2.3_{bc}	0.0_{d}	1.0_{c}	0.3	1.3	1.7	0.7_{b}
Grand mean	2.4	1.5	2.3	1.2	1.3	1.6	1.5
LSD ($p \leq 0.05$)	0.8	0.9	1.2	2.0	1.3	1.2	1.4
CV%	19.2	35.1	28.3	98.8	57.0	43.6	52.2

Table 6. Incidence and severity score of ear rot of the different seed sources in Busia and Kakamega sites

Seed sources	Busia		Kakamega	
	Incidence	Severity scores	Incidence	Severity scores
Panadol local Market	14.2_{a}	5.3_{ab}	44.4	7.0
Sipindi local market	11.0_{b}	6.3_{a}	49.6	7.0
Duma 43 farmer saved	10.2_{bc}	4.3_{b}	55.5	7.0
Panadol farmer saved	9.4_{bc}	5.3_{ab}	54.3	6.0
IR Agro vet	9.3_{bc}	3.7_{b}	53.9	5.0
IR farmer saved	$8.3b_{cd}$	4.0_{b}	51.7	6.0
Sipindi farmer saved	7.9_{cd}	4.0_{b}	34.7	6.0
Duma 43 Agro vet	5.7_{d}	1.7_{c}	52.8	7.0
Grand mean	9.5	4.0	49.6	6.0
LSD ($p = 0.05$)	3.0	2.0	16.1	1.6
CV%	18.3	25.9	18.5	15.0

3.3 Yield and Yield Components

At both sites, ears had developed some abnormalities including incomplete kernel tip set, poor tip fill, bouquet ears, exposed ear tip, tassel ear and zipper ear. There were significant variations between the seed sources in ear abnormalities at the two sites. Uncertified seeds from farmer saved and local market had high number of ears having abnormalities at both sites including incomplete kernel tip set, poor tip fill, bouquet ears, tassel ear and zipper ear, while the certified seeds from agro vet shops had high number of exposed ear tip and ears with extended leaves at both sites (Table 7). There was no significant variation in number of ears per plant in both sites while the result showed significant variation in ear length and grain yield in the two sites. Seeds from agro vet shops were found to have high ear length and grain yield at both sites depending on the variety type.

However, Duma 43 from agro-vet shop performed with high ear length and grain yield of up to 6.461 kg ha^{-1} (Table 8).

Table 7. Percentage Ear abnormalities of various seed sources in Busia and Kakamega sites

Seed sources	Incomplete kernel tip set	Poor tip fill	Bouquet ear	Exposed ear tip	Ear with extended leaves	Tassel ear	Zipper ear
Busia							
Sipindi local market	17.7_{a}	21.3	0.0_{d}	8.5_{bcd}	5.8_{bc}	0.0_{b}	7.8_{ab}
Panadol local Market	16.3_{ab}	24	6.6_{a}	12.4_{a}	2.9_{cd}	0.0_{b}	3.4_{d}
Sipindi farmer saved	12.3_{bc}	18	1.2_{c}	6.7_{d}	0.6_{d}	1.2_{b}	3.7_{d}
Panadol farmer saved	11.0_{cd}	20.7	3.3_{b}	10.1_{abc}	5.6_{bc}	0.0_{b}	8.3_{a}
Duma 43 farmer saved	10.3_{cd}	18.3	0.0_{d}	11.4_{ab}	4.6_{bc}	0.0_{b}	4.6_{cd}
IR farmer saved	7.0_{de}	18	0.0_{d}	10.9_{ab}	7.7_{ab}	3.7_{a}	3.6_{d}
Duma 43 Agrovet	4.0_{e}	18.7	0.0_{d}	7.1_{cd}	6.5_{ab}	0.0_{b}	4.3_{d}
IR Agrovet	4.0_{e}	17.7	0.0_{d}	9.3_{bcd}	9.3_{a}	0.0_{b}	6.2_{bc}
Grand mean	10.3	19.6	1.4	9.6	5.4	0.6	5.2
LSD ($p \leq 0.05$)	4.4	5.4	0.99	3.1	3.3	1.4	1.7
CV%	24.1	15.8	41.1	18.3	35.3	128.4	18.6
Kakamega							
Sipindi local market	37.9_{b}	46.2_{b}	8.9	15.9_{bc}	10.6_{b}	0.0_{c}	10.7_{a}
Panadol local Market	41.5_{a}	42.5_{bc}	8.4	10.9_{cd}	7.3_{b}	0.6_{bc}	4.9_{b}
Sipindi farmer saved	25.7_{d}	35.4_{c}	6	3.7_{e}	6.4_{b}	1.3_{bc}	3.7_{b}
Panadol farmer saved	29.6_{c}	54.4_{a}	8.5	10.5_{cd}	15.3_{ab}	0.0_{c}	10.7_{a}
Duma 43 farmer saved	16.3_{e}	46.9_{ab}	8.6	8.8_{de}	6.9_{b}	3.4_{a}	6.0_{ab}
IR farmer saved	36.1_{b}	48.2_{ab}	5.3	21.1_{b}	11.3_{b}	1.8_{ab}	2.6_{b}
Duma 43 Agrovet	11.8_{f}	16.6_{d}	3.7	27.6_{a}	5.8_{b}	1.3_{bc}	1.5_{b}
IR Agrovet	11.1_{f}	17.4_{d}	6.3	9.6_{d}	24.9_{a}	0.0_{c}	5.2_{ab}
Grand mean	26.3	38.5	7	13.5	11.1	1	5.7
LSD ($p \leq 0.05$)	3.3	7.42	4.75	5.9	10.7	1.7	5.7
CV%	7.1	11	39	25	55.3	94	57.1

Table 8. Ear length and grain yield (kg ha^{-1}) of various seed sources in Busia and Kakamega sites

Seed sources	Busia		Kakamega	
	Ear length	Grain Yield kg ha^{-1}	Ear length	Grain Yield kg ha^{-1}
Duma 43 Agrovet	21.3_{a}	6543_{a}	19.5_{a}	6379_{a}
Panadol farmer saved	18.3_{b}	5733_{ab}	16.4_{c}	3934_{b}
Duma 43 farmer saved	17.8_{bc}	5564_{ab}	18.9_{ab}	4321_{b}
Sipindi local market	17.6_{bc}	4956_{b}	19.4_{a}	3916_{b}
IR farmer saved	17.4_{bc}	5407_{ab}	17.8_{abc}	3734_{b}
Panadol local Market	17.1_{bc}	6115_{ab}	17.6_{bc}	4270_{b}
Sipindi farmer saved	17.1_{bc}	5166_{b}	18.0_{abc}	4157_{b}
IR Agrovet	16.5_{c}	3061_{c}	17.4_{bc}	3094_{b}
Grand mean	17.9	5318	18.1	4225.6
LSD ($p \leq 0.05$)	1.64	1203.9	1.8	1578.1
CV%	5.2	12.9	5.5	21.3

4. Discussion

The uncertified seed from local market and farmer saved 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 incidences were higher in certified seeds from agro vet shops. Similar study done by Bishaw et al. (2012) reported a higher level of germination rate in informal seeds compared to certified seeds. FAO (2016b) also reported an isolated case of certified seeds which failed to germinate. This is contrary to the finding of Sperling (2001) and Mahender (2015) who found that informal seeds are usually of low germination potential in field due to low quality. Also, IRRI (2013) and Coomes et al. (2015) reported that poor seed quality results in uneven seedling stands and more unhealthy seedlings. This is similar to other research by Paplomatas (2006), Niaz and Dawar (2009) which reported that seed quality refers to its ability to germinate.

Mostly, farmer saved seeds are selected from the previous harvest and maybe 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. Wekesa et al. (2003) observed that improved cultivars do not have good storability compared to landraces, thus certified seeds lose their potential to germinate faster. Adetumbi and Olakoje (2010) also indicated that seed storage is critical for seed quality. It can have an impact on the whole feature of seeds quality attributes and contributes to seed ageing that decreases seed viability. Also, Bennett and Klich (2003) observed that good 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 (Anteneh, 2015).

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 (Du et al., 2001; Rajput et al., 2005; Munkvol & White, 2016; Mueller et al., 2016). In relation to seed testing, storage is important when testing date and planting date are far apart (Rao et al., 2006). Study done by Du et al. (2001), Rajput et al. (2005), Niaz and Dawar (2009), Paplomatas (2006) indicated that seed quality refers to it trueness to it varietal type, physical attribute. Same result was obtained by Sperling (2001) who reported that seeds from the informal system are inappropriate varieties. Badu et al. (2014) also reported that informal seeds do not go through guarantee standards and controlled production networks and therefore could be of poor quality.

Lodging sensitivity of the crops was possibly the effect of seed-borne pathogens observed in the seed samples after laboratory test which reduced resistance to stress due to low vigor. Presence of fungal seed borne pathogens decreases the germination potential and vigor of seeds thus reduces plant development especially when the environment is favorable for disease development (Botelho et al., 2013; Pathak & Zaidi, 2013). Similar study by Badu (2007) also found that recycled seeds are most of the 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 (IRRI, 2013; FAO, 2009).

Uncertified seeds from farmer saved and local market showed high incidence and severity of fungal diseases though certified was highly susceptible to seedling blight and maize streak virus depending on the variety type. Similar study done by Tonu et al. (2017) found that fungal diseases intensity was highly expressive in farmer saved wheat than cleaned seeds (Bishaw et al., 2012). There was variation in number of fungal infections in farmer saved and local market seeds and this was highly expressed in Kakamega site. This situation may be explained by environment agro climatic difference whereby Kakamega site is relatively humid than Busia. This was also confirmed by Badu et al. (2007) who reported that seed borne fungi whereof, are usually severely manifested in an environment with high relative humidity. Fungal diseases develop better in zones with high humidity (Mueller et al., 2016; Munkvold & White, 2016; Wise et al., 2016).

Fungal diseases were more expressed in farmer saved and local market seeds. Common diseases were northern leaf blight, grey leaf blight, rust, brown spot, diplodia, eyespot and ear rots. Though they were observed in all the material, they were severe in the uncertified seeds compared to the seed from agro vet shops. Du et al. (2001), Rajput et al. (2005), Niaz and Dawar, (2009), and Paplomatas (2006) reported that 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. Poor seed quality results in defective seedling stands and more unhealthy plants in the field reducing sensibly production and quality of end product (Dornbos, 1995; Powell et al., 1984; AGRA, 2017; Ali, 2016).

Farmer saved and local market seeds have developed ear abnormalities including incomplete kernel tip set, poor tip fill, bouquet ears, exposed ear tip, extended ear leaves, tassel ear and zipper ear compared to certified maize seed from the agro vet shops. Peter and Allen (2015) determined that abnormal ears are caused by multiple factors including temperature pressure (cold threat) during initial ear development which can cause bouquet ear; tillers (Suckers) when the growing point is destroyed or injured by hail, frost, flooding, herbicides, and automated damage can cause tassel ears. Poor ear tip fill and incomplete kernel tip set can occur when there is poor fertilization of ear tip ovules at silking. It can occur due to inadequate pollen supply caused by uneven crop development, herbicides, insect feeding and foliar diseases (Nielsen, 2006, 2009; Elmore et al., 2006; Thomison, 2007).

Uncertified seeds from farmer saved and local market seeds performed poorly compared to the certified seeds from agro vet shops which performance was dependent on the variety type. The certified Duma 43 from the agro vet shops performed well having low incidence and severity of diseases leading to high yield in both sites. Similar study done by Furtas (2016), and Joshi et al. (2016) indicated that certified seeds of newly developed cultivar are of high yield, diseases confrontation and stresses acceptance (Desalegn, 2017). Also, Sperling (2001) reported that farmer seeds are unsuitable varieties, contaminated, the seed quality attributes are below the standards limiting producers' crop output. Good quality of planting material is crucial for better production. It allows a rational estimation of farm expectation (FAO, 2016; Finch-Savage & Bassel, 2016; Timu et al., 2014; Rodriguez et al., 2015). Mirza (2015) reported that poor quality seed results in skips, excessive thinning or yield reduction diminishing profitability.

Frequent use of seed of unknown quality by agriculture small-scale producers results in the decline in maize productivity. On the other hand, Wambugu et al. (2012) gave an option of the view on farmer saved seed that even though farmer seed seems to have its limitation that causes loss in quality and decrease in yield, it also has its strength such as the presence of local varieties/Landraces that are able to perform well under unfavorable conditions. McGuire (2007) added that farmer seed practices in addition to knowledge and social associations are at the heart of tactics not only for filling the lack of seed but also for handling biotic and abiotic stresses including diseases, pests, and drought. In addition, Seed of open-pollinated variety can be used for more than three years and they retain their genetic characteristics of production (Doss et al., 2003; Spielman et al., 2010). Opposite to the finding of Mueller et al. (2016), Munkvold and White (2016), and Wise et al. (2016) who reported that maize diseases cause important yield loss depending on the disease and the year.

5. Conclusion

Seeds from farmer saved and local market are infected with diseases leading to imperfect seedling, susceptible to lodging. Farmer saved seed may constitute the main foundation of dangerous pathogens and may carry unwanted plants which by time could spread and exacerbate the problem in the environment. Though all the seeds sources showed infections of fungal diseases, farmer saved and local market seeds showed high incidence and severity of various diseases compared to the certified seeds from the agro vet. Certainly, certified seed should be of high quality compare to uncertified seed to convince agriculture producers to adopt the improved variety seeds. Seed quality care should be thoroughly controlled and followed up to agro-dealers' stores. Farmers are encouraged to utilize certified seeds to improve crop production, thus to enhance food security.

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