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Effect of Seed Storage Period in Ambient Condition on Seed Quality of Common Bean (*Phaseolus vulgaris* L.) Varieties at Haramaya, Eastern Ethiopia

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Abstract

Common bean is used as one of the cheapest source of protein apart from being the major source of cash income in Ethiopia. Its reasonable protein content (22%) made it the poor man's meat securing more than 16.7 million rural people against hidden hunger. Despite the common bean significance contribution to Ethiopian people food and nutrition security and income generation, its production and productivity is low. Among many factors that contribute to the low yield of common bean, low access of seeds of improved varieties and the use of seeds stored for a longer period of time. The length of seeds stored under ambient conditions is a critical aspect of seed quality management. The longer seeds stored under ambient conditions, are the risks of losing the stored beans to storage pests and other seed quality deterioration factors. Therefore, generating information from research is required on effect of seeds stored under ambient conditions on different varieties of common bean. The analysis of variance showed that storage period and variety had significant influence on all seed quality parameters considered except no significant effect on number of hard seeds. No significant differences among varieties were observed on abnormal seedlings, number of hard, fresh ingeminated and dead seeds. However, storage period and variety interacted to influence significantly thousand seed weight, seedling shoot length, nd vigor index I and seedling fresh weight. Due to seeds stored for a long period of time in ambient conditions would make the seed deteriorate and loss its quality during storage. This indicates that, seed deterioration is the result of changes within the seed that decrease the ability to survive.

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Keywords

Seed storage period, Common bean varieties and Seed quality

Introduction

Common bean (*Phaselous vulgarise* L.) is one of the most important legumes worldwide because of its high commercial value, extensive production, consumer use and nutrient values (Popovic *et al*., 2012). It is an annual crop which belongs to the family Fabaceae and it grows best in warm climate at a temperature of 18 to 24 C (Teshale *et al*., 2005). Furthermore; the crop is the most important food legume and offers a low cost alternative to beef and milk, as a source of protein, iron, fibers and complex carbohydrates (Hacisalihoglu *et al*., 2005; Mwale *et al*., 2008). In Ethiopia common bean is the third most produced legume next to faba bean and field pea. It is one of the major grain legumes widely cultivated and grown as source of protein and cash by small holder farmers in the eastern and southern Ethiopia (Fekadu, 2013). It is grown suitably in areas with an altitude ranging between 1200 to 2200 meter above sea level with range of 16 to 28^{0}C temperature and a rainfall of 350 upto500 mm well distributed over the growing season. It performs best on deep, friable and well aerated soil with good drainage, high nutrient content and PH range of 5.8 to 6.5 (MOARD, 2010). Moreover it is used for human utilization and export. It grows in most of the agro ecology zones of low and mid altitude areas of the country. A market demand for the common beans both in the domestic and export market has become the main mechanism for the growing trends in quantity of production (Frehiwot, 2010).

Common bean is used as one of the cheapest source of protein apart from being the major source of cash income in Ethiopia. Its reasonable protein content (22%) made it the poor man's meat securing more than 16.7 million rural people against hidden hunger (CSA, 2014). It is usually consumed in the form of boiled grain, which is locally known as Nifro (Kristin *et al*., 1997; Mekibib, 1997). Its short growth period earlier than other crops made it an ideal food deficit filler crop and its suitability for double or triple production per year enabled its production on off season free lands and relatively cheaper labor force. In addition to this, it plays an important role in the soil fertility amendment practices of low input farming systems (Legesse *et al*., 2006).

Despite the common bean significance contribution to Ethiopian people food and nutrition security and income generation, its production and productivity is low. Among many factors that contribute to the low yield of common bean, low access of seeds of improved varieties and the use of seeds stored for a longer period of time. The length of seeds stored under ambient conditions is a critical aspect of seed quality management. The longer seeds stored under ambient conditions, are the risks of losing the stored beans to storage pests and other seed quality deterioration factors. Seed storage period may affect the viability of seeds, as the reduction in seed viability is directly proportional to the increase of storage duration (Bortey *et al.*, 2016). According to CRS, (2014) farmers in Ethiopia stored their beans for 1-5 months (68%), more than 5months (31%) and less than one month (1%).Though farmers who stored beans for longer periods fetched relatively higher prices, seeds stored for different time deteriorate and loss their quality attributes. In Eastern Ethiopia. The farmers have different seed sources in which seeds are stored for wide range of duration. In this part of the country, lack of understanding for using timely stored and quality seed with appropriate varieties of common bean are some of the bottle neck problems that aggravates for low quality and yield of the crop (Fekadu, 2007). The effect of storage duration in seed quality, yield and yield related traits of improved varieties is not well known. Therefore, generating information from research is required on effect of seeds stored under ambient conditions on different varieties. This has paramount importance to overcome the production problems and increase the productivity of the crop.

Objective

To assess the effect of seed storage period under ambient conditions on seed quality traits of common bean.

Materials and Methods

Description of the study area

The experiment was conducted in seed science and technology laboratory of Haramaya University.

Experimental material

The three varieties of common bean viz. *Haramaya*, *Dursitu* and *Fadis* were used for the Experiment. The seeds of the varieties were taken from Haramaya University common bean Improvement project. The description of the varieties is given in Table 1. The seeds of three varieties of common bean were harvested during 2013, 2014 and 2016, and stored for About 9, 33 and 45 months with in the same material this is pallid sack after harvest. The Storehouse that the seed was stored had a constant relative humidity of ten percent (10%).

Treatments and experimental design

The seed quality test was conducted in complete randomized design with four replications. The treatments consisted of factorial combinations of three storage period and three common bean varieties as a result 9 treatment combinations were formed (Table 2).

Experimental procedures

Seed quality test

The physiological (germination and vigor) seed quality test was conducted using the sample seeds which were taken from each storage period of each variety amounting to 1kg as a composite sample results from thoroughly mixed of primarily sample. The sample seeds were taken from in each suck of the seed lot that was stored in ambient condition in were house, and then the composite sample divided by using a seed divided into four equal parts until 250g was obtained. Each sample was sorted to four components including (I) pure seed, (ii) other crop seeds, (iii) inert mater and (IV) weed seeds.

After the physical seed quality test was completed, 200 pure seeds were randomly selected from the total pure seeds obtained from the sample seeds. The seeds were treated by Mankuzeb fungicide to remove the microorganisms and to prevent the growth of fungus. The sterilized seeds were divided into four replication and each 50 seed with in replication placed on the double layered cotton cloth to drain the water from seeds. The sample seeds were used for standard germination test which was conducted using sand as substratum, the sand was sieved to discard particles bigger than 0.8 mm and smaller than 0.05 mm in diameter and for every test new sand was used. The 50 seeds of each treatment was sown in 10 rowson a uniform layer of moist sand in one tray and then covered to a depth of 10 mm with sand as one replication, which was left loose. The seeds were kept moist with gently applied water until the germination test completed. The germination of seeds in each flat tray filled with sand was counted every day starting five days of sowing. The number of normal and abnormal seedlings was counted separately. Abnormal seedlings are badly diseased, discolored or distorted seedlings. In addition to that other seed quality parameters were taken after the seed germination which was indicated in the data collection section.

Data collection

Thousand seeds weight (TSW)

Randomly taken thousand seeds of each storage period and in each variety combination in each replication was weighted in gram and recorded.

Moisture content (MC)

Ten gram of seeds from each variety and each storage duration combination in each replication was taken from the sample seeds, grinded weighted poured in a small container and covered with aluminum foil for pre-dry measurement. Samples were dried in an oven adjusted at temperature of 130 ^{0}c +/-^{0}c1for two hours. At the end of two hours containers were placed in desiccators for 30 minutes. After cooling, the container weighed with its cover and contents, and the moisture content of seeds was determined by the following formula ISTA (2014).

$$\text{Moisture content of seed (\%)} = \frac{M_2-M_3}{M_2-M_1} \times 100$$

Where; M1 is the weight of the container; M2 is the weight of the container with the

Weight of the seed and M3 is the weight of the seed with the container after oven dried.

Standard germination test (SGT)

Germination test was done for all seed samples obtained from store as initial seed samples of three varieties and different treatment Combinations from field experiment. Two hundred (200) seeds of the pure seeds Components were divided into four replicates of fifty (50) seeds each, which were sown in germination sand. On the final days of the standard germination test, germinated seedlings was divided into normal seedlings, abnormal seedlings, hard, fresh and dead seeds to determine the percentage of each category of seedlings (ISTA, 2014).

$$\text{Germination percentage (\%)} = \frac{\text{Number of Normal seedlings}}{\text{Total seeds sowen}} \times 100$$

Speed of germination (SP)

The same procedures was used with that of germination Percentage, but the only difference was, the number of normal germinated seeds daily recorded, until there was no further germination. It was calculated by adding the ratio of daily counts of normal seedlings divided by the number of days of germination.

$$\text{Speed of germination} = \frac{N1}{C1} + \frac{N2}{C2} + \ldots\ldots \frac{NF}{C_F}$$

Where: N1= number of normal seedlings at first count, N2= number of normal seedlings at second count, NF= number of normal seedlings at final count, C1= days to the first count, C2= days to the second count and CF= days to the final count.

Seed vigor test

The seedlings shoot length and root length was measured after the final count in the standard germination test by randomly taken ten normal seedlings from each treatment combination from each replication. The shoot and root length was measured from the point of attachment to the tip of the shoot and root of the seedlings, respectively.

The average seedling shoot and root length was determined as per ISTA (2014).

Seedling dry weight (SDW)

Ten randomly taken seedlings treatment combination from each replication was placed in an envelope to be dried in an oven at a temperature of 80 ^{0}C +1^{0}C FOR 24 hours. The dried seedlings were weighed in gram using a sensitive balance ISTA (2014).

Vigor Index I and II

The seedling vigor index I and II were calculated according to the formula described by Abdul-Baki and Anderson (1973) as follows: Seed vigor index I= GP x SL (mean shoot length and mean of root length) where: GP is germination percentage and SL is seedling length (mean of shoot length and mean of root length). Seed vigor index II= GP x SDW (g)**,** where: GP germination percentage and SDW is seedling dry weight.

Data analysis

The data was subjected to analysis of variance (ANOVA) following standard procedure as indicated by Gomez and Gomez (1984). The ANOVA was computed with *Genstat201616th edition.* The comparison of treatment combinations was done following the significance of mean squares using Least Significant Difference (LSD) at 1% and5% probability level.

Results and Discussions

The analysis of variance showed that storage period and variety had significant influence on all seed quality parameters considered except non significant effect on number of hard seeds. A non significant difference among varieties was observed on abnormal seedlings, number of hard, fresh ungerminated and dead seeds. However, storage period and variety interacted to influence significantly thousand seed weight, seedling shoot length, and vigor index I and seedling fresh weight. This might be due to seeds stored for a long period of time in ambient conditions would make the seed deteriorate and loss its quality during storage.

This indicates that, seed deterioration is the result of changes within the seed that decrease the ability to survive. Shelar *et al.,* (2008) reviewed on the aspects of soybean seed deterioration during storage, especially the seed moisture content; the authors indicated that the seed moisture content increases seed mycroflora, which play an important role in deterioration of soybean seed quality due to lipid per-oxidation of seeds, and subsequently resulting in loss of seed viability at different storage duration. Suma *et al.,* (2013) suggested that seed deterioration would occur relatively slowly at low moisture and temperature. Since seed is a viable organism, it needs optimum moisture for its survival. Moreover, Hillary *et al.,* (2016) reported highly significant difference (P=0.001) among various storage durations of Cowpea varieties on germination and seedling vigor. The observed reduction in percentage of seed germination over time could be due to reduction in enzyme activity within the seed and differences in the seed storage potential or capacity to withstand ageing conditions of the varieties of the crop within a species. However, Gladys *et al.,* (2012) reported that seeds deteriorated due to long storage duration can have high germination percentages if the embryo axes, including the meristematic cells of the radical and the plumule, are able to germinate and produce a seedling under ideal conditions than non deteriorated seeds of soybeans. This might be due to deteriorated seeds loss endosperm molecules easily that helps to supply the nutrients and feed the young seedlings. Generally, Laxman *et al.,* (2017) observed that chickpea seeds stored in ambient condition for longer period of time results in lower germination percentage, seedling shoot and root length, seedling fresh and dry weight, seedling vigor index I and II.

Effect of seed storage period and variety on seed quality parameters of Common bean

Thousand seeds weight and moisture content

The seed samples of *Fadis* variety stored for about 9 months followed by 33 months had significantly highest mean values of 418.9 and 404.9g for thousand seed weight, respectively, without significant differences between the mean values. The seed samples of *Dursitu* variety stored for 9 months and 33 months as well as the seed samples of *Haramaya* variety stored for about 45 months had significantly lower mean values of 218.8, 203.7 and 211.3g, respectively (Table 3) for thousand seed weight without significant difference among the mean values. The reduction in thousand seed weight of common bean seeds were due to the prolonged seed storage duration for about 9-45 months in ambient condition, this leads to deterioration of seeds and also loss of moisture from the seed. The seed size of the variety inherent characteristics might be also a factor for thousand seed weight such as seeds of the variety *Fadis* had large in size than seeds of the variety *Dursitu*. Sadeghi *et al.,* (2011) in sunflower and Samanta *et al.,* (1999) in Mungbean varieties found that the larger sized seeds measure high thousand seed weight than small sized seeds. However, thousand seed weight in a given situation increased with the increase of storage period because seeds absorb moisture from the environment when the physiological moisture content of the seed is low (Khalequzzaman, 2012).

Seed moisture content considerably affected the physiological behavior of the seed although in the store, the seed samples of common bean varieties stored for about 9 and 45 month shad the highest and lowest moisture content mean values of 12.62and8.42% respectively (Table 4). This indicates that, the seed moisture content declined as the storage period prolonged. This might be due to disintegration of the seed coat and the embryo which results in loss of moisture from the seed. However, as the storage period increase the moisture content of the seed also increase because the seed absorbs moisture from the surrounding environment, until the seed moisture content and the relative humidity of the environment becomes in equilibrium (Mwale *et al.,* 2008). Other researchers also indicated that several factors, namely, temperature, nature of the seed, relative humidity and storage duration can influence the moisture content of a seed (Onyekwelua and Fayose,2007; Pradhan and Badola,2008).

Standard seed germination and speed of germination

The results of standard germination includes germination percentage, in which the percentages calculated to the nearest whole number of normal seedlings, hard seeds, fresh ungerminated seeds, abnormal seedlings and dead seeds (ISTA, 2014). In this study, the germination percentage was significantly influenced by the seeds storage period and variety. Significantly difference in mean value germination percentage of 94.67%observed in seed samples stored for about 9 months. The two varieties, *Haramaya* and *Dursitu* had the same mean value germination percentage of78.50% which in significantly different from the mean values (69.17%) of *Fadis* variety. But no significant difference was observed between the two varieties of mean values (Table 5).

The variation of germination percentage might be due to the fact that shorter time stored Seeds encountered less effect on seed quality damaging factors than seeds stored for longer period of time. Thus shorter time stored seeds in ambient condition exhibited good quality that contributed to the highest germination percentage. Whereas seeds store for a longer period of time could be attributed to the disintegration of seed coat membrane which aggravated seed mortality as compared to shorter time stored seeds. This indicates that seed deterioration during storage likely to result in membrane damage, enzymes, proteins, and nucleic acids that eventually leads to lost percent germination and the death of the seed (Badawi *et al*., 2017). Another researcher Akhter *et al.,* (1992) also suggested that decreasing in germination percentage of the crop might be related to chromosomal aberrations that occur under long storage conditions. Moreover, decreasing of germination percentage in aged seeds can be due to reduction of a-amylase activity and decrease in carbohydrate content (Bailly, 2004).

Rozman *et al.,* (2010) also reported that, seed germination percentage had reduced due to increasing of seed storage period which had stayed above 9 months in ambient condition. On the other hand different varieties of common bean showed different germination capacity, due to the germination potential of the varieties of the crop. Mahesha *et al.,* (2001b) reported that different varieties of lentil differed significantly on germination percentage. Shelar (2002) also reported that the germination percentage of soybean varieties decreased with increasing of seed storage period, Irrespective of the varieties.

The percentage of normal, abnormal seedlings, fresh ungerminated and dead seeds were significantly influenced by the seeds storage period. In which significantly difference mean value of normal seedlings percentage (94.67%) observed in seed samples stored for about 9 months and mean abnormal seedlings percentage of 1.06%, mean fresh ungerminated seeds percentages of 0.94% and mean value dead seed percentage of 1.05% were observed in seed samples stored for about 45 months. The two varieties, *Dursitu* and *Haramaya* had higher mean value normal seedling percentage of 78.50%that was significantly different from the mean values of *Fadis* variety but no significant difference between the mean values of the two varieties (Table 5). This significance variation might be due to the fact that the differences on seed storage duration in which the storage duration of the seed increase and thereby seeds were deteriorated which results Weak seedlings among the germinated seedlings.

Bass (1988) point out that increase of dead seed proportion is probably the result of protein degradation, damages of chromosomes and DNA caused by seed aging and external factors. Rokich *et al.,* (2000) also suggested that seed storage period (aging) processes leads to deterioration in seed quality and aged seed show decreased vigor leading to weak seedlings which cannot withstand the various weather condition when introduced to field conditions. Furthermore, consequence of seed storage for a longer period of time leads to physiological aging progressively resulted in reduction of germination rate, and increases the percentage of abnormal seedlings and dead seed (Wang and Hampton, 1990). Regarding with the percentage of normal seedlings, the highest was recorded from recent time stored seeds that was for about 9 months others are remain low due to the elongation of storage period. This might be due to the fact that seeds which are alive at normal condition are able to give normal seedlings. The percentage of normal seedling was decreased with the increase of storage period where as the number abnormal seedlings were increased with the increase of storage period (Khalequzzaman, 2012).

The speed of germination was significantly influenced by the seeds storage period and variety in which significantly different speed of germination mean values of 8.87,6.44 and 5.69were observed in seed samples stored for about 9, 33 and 45 months, respectively. The two varieties, *Haramaya* and *Dursitu* had higher speed of germination mean values of 7.35 and 7.68, respectively, significantly different from the mean values of *Fadis* variety but nonsignificant difference between the two mean values of varieties (Table 5). This might be due to the storage duration of the seed that the seed try to resist such factors for exposing to deterioration by sacrificing its internal nutrient content such as carbohydrate, this leads to the seed reduction in germination speed as a result of underprovided of energy.

The seeds of common bean varieties were stored for a number of months; their speeds of germination as well as germination capacity from one storage period to the others fluctuate. This indicates that seed deterioration is a result of changes within the seed that decrease the vigor followed by reductions in germination energy that leads to reduction in germination speed (McDonald, 2004). Amjad and Anjum (2002) reported that speed of germination were higher in seed lots stored for one or two years compared with those stored for three or four years in ambient condition. Furthermore, seeds that have high germination speed were found vigorous in the field and could escaped harsh climatic conditions due to the variety nature to breakout the harsh climatic condition with in low soil moisture. This finding is supported by assumption that the speed of germination indicates the rate at which the seeds are germinating rapidly and seedling can emerge and escape adverse field conditions (Tesfaye, 2015).

Seedling vigor

The seed samples of *Fadis* variety stored for about 9followed by 33months had significantly the highest mean values of 20.77 and 13.46cm for seedling shoot length, respectively, with significant differences between mean values of the two and seedlings emerged from seeds which had 45 months storage duration (Table 6). Seedling root length was significantly influenced by the seeds storage period and variety in which significantly difference seedling root length of 10.40 cm, was observed in seed samples stored for about 9 months. The two varieties, *Haramaya* and *Fadis* had higher seedling root length of10.51and 9.53cm, respectively and significantly different from the mean values of *Dursitu* variety but nonsignificant difference between the two mean values of the varieties (Table 7). The seed samples of *Haramaya* variety stored for about 9 months had significantly the highest mean values of 2896 seedling vigor index I, and it was significantly different from the other two interaction results of the same variety with in 33 and 45 months storage duration, respectively (Table 6). The mean values of seedling vigor index I were decreased as the storage period increased from 9 to 45 months for all varieties. This might be due to shorter time stored seeds resulting in improvement in germination percentage and seedling length than longer time stored seeds. The higher germination percentage and seedling length might lead to an increased seedling vigour index I, since seedling vigour index I was determined by germination percentage and seedling length.

The reduction in root and shoot length might be attributed to storage duration of seed, which induced decline in germination as well as the damage caused by seed storage affecting factors such as fungi, insects and also toxic metabolites which might have hindered the seedling growth. This could be because of the storability of seeds in various period of time make difference in seedling growth and performance due to the ability of the seed-endosperm nourishment of the young seedlings.
Kandil *et al.,* (2013) reported that root length, shoot length and dry weight of normal seedlings decreased after being stored for 12 months when compared to the 3,

6 and 9 months storage period of soybean seeds. The mean values of seedling vigor index I were better in seeds stored for shorter period within the varieties seed samples, this might be due to the higher germination and seedling length achievement of shorter time stored seeds.

Gore *et al.*, (1997), who reported that higher seedling vigour index, probably due to the associated effect of germination percentage and seedling length. Kapoon *et al.*, (2010) also reported that the significant declining of seedling length and vigor as the storage period increased in seeds of chickpea varieties.

Seedling fresh weight was significantly influenced both by the two main factors and the interaction. The seed samples of *Fadis* variety stored for 9, 33 and 45 months had significant different seedling fresh weight of 14.68, 11.90 and 10.50g, respectively (Table 8). In contrast, seedling dry weight was significantly affected by the two main factors (variety and storage period) but not the interaction of the two factors. The highest and significantly different seedling dry weight of 1.18g was observed in seed samples stored for about 9months. The two varieties, *Haramay* and *Fadis* had higher seedling dry weight of 1.08 and 1.23g, respectively, significantly different from the mean values of *Dursitu* (Table 7).

Table.1 Description of three common bean varieties

Variety Name	Pedigree	Year of release	Yield (ha^{-1})	Breeding center	Days to Maturity
1.Haramaya	G-843	2006	15-30	HU	85-110
2.Dursitu	DOR-811	2008	17-30	HU	85-100
3. Fadis	ECAB-0060	2012	10-22	HU	80-95

Source: MoARD (1998): Crop variety register (1995-2013), in farmer's field.

Table.2 Treatment combination

Seed storage period	Variety		
45 mounths	Haramaya	Dursitu	Fadis
	Haramaya	Dursitu	Fadis
	Haramaya	Dursitu	Fadis
33 mounths	Haramaya	Dursitu	Fadis
	Haramaya	Dursitu	Fadis
	Haramaya	Dursitu	Fadis
9 mounths	Haramaya	Dursitu	Fadis
	Haramaya	Dursitu	Fadis
	Haramaya	Dursitu	Fadis

Table.3 Interaction effect of seed storage period and variety on thousand seed weight

Storage period (month)	Variety		
	Haramaya	Dursitu	Fadis
45	211.3[d]	169.4[e]	326.9[b]
33	240.9[c]	203.7[d]	404.9[a]
9	257.5[b]	218.8[d]	418.9[a]
LSD (5%)		23.4	
Grand mean		272.1	

Means in columns and rows followed by the same letter(s) are not significantly different from each other at 5% probability level. LSD (5%) =least significant difference at P=0.05, CV = Coefficient of variation.

Table.4 Effect of seed storage period and variety on seed moisture content and thousand Seeds weight

Storage period (month)	Seed moisture content (%)	Thousand seed weight (g)
45	8.42[c]	235.9[c]
33	11.04[b]	283.9[b]
9	12.62[a]	297.4[a]
LSD (5%)	1.307	13.49
Grand mean	10.69	272.1
Variety		
Haramaya	10.92	236.6[b]
Dursitu	10.71	196.3[c]
Fadis	10.46	383.6[a]
LSD (5%)	NS	13.49
Grand mean	10.69	272.1

Means in column in each seed quality parameter and main factor followed by the same letter(s) are not significantly different from each other at 5% probability level. LSD (5%) =least significant difference at P≤0.05.

Table.5 Effect of seed storage period and variety on germination and speed of germination of common bean

Storage period (month)	GP	SPG	SFW	NSE	ABS	FUS	DS
45	52.72[b]	5.687[c]	9.68[c]	52.72[b]	1.0657[a]	0.9421[a]	1.0518[a]
33	57.01[b]	6.436[b]	10.61[b]	57.01[b]	1.0390[a]	0.9418[a]	1.0158[a]
9	80.04[a]	8.867[a]	12.33a	80.04[a]	0.7638[b]	0.7704[b]	0.7276[b]
LSD (5%)	6.05	0.652	0.682	6.05	0.0591	0.0821	0.7345
Grand mean	63.3	7.000	10.87	63.3	0.956	0.885	0.932
Variety							
Haramaya	65.45[a]	7.348[a]	11.61[c]	65.45[a]	0.9606	0.8936	0.9018
Dursitu	65.60[a]	7.678[a]	8.64[b]	65.60[a]	0.9239	0.8929	0.9383
Fadis	58.72[b]	5.966[b]	12.36[a]	58.72b	0.9839	0.8678	0.9550
LSD (5%)	6.05	0.652	0.682	6.05	NS	NS	NS
Grand mean	63.3	7.000	10.87	63.3	0.956	0.885	0.932

Means in column in each seed quality parameter and main factor followed by the same letter(s) are not significantly different from each other at 5% probability level. LSD(5%) =least significant difference at P≤0.05, NS = non significant, GP = germination percentage, SPG=Speed of germination, SFW=seedling fresh weight NSE=number of normal seedling, ABS=abnormal seedling, FUS= fresh ungerminated seed and DS =dead seed.

Table.6 Interaction effects of storage period and variety on seedlings shoot length and vigor Index I

	Shoot length (cm)			Seedling vigour index I		
Storage period (month)	Haramaya	Dursitu	Fadis	Haramaya	Dursitu	Fadis
45	18.72[bc]	17.36[d]	9.64[f]	1950[bc]	1611[cd]	1077[d]
33	21.13[a]	19.29[bc]	13.46[e]	2197[b]	2497[ab]	1273[d]
9	20.23[abc]	21.26[a]	20.77[ab]	2896[a]	2839[a]	2765[a]
LSD (5%)		1.75			555.7	
Grand mean		17.38			2123	

Means in columns and rows in each seed quality parameter followed by the same letter (s) are not significantly different from each other at 5% probability level. LSD (5%) =least Significant difference at P=0.05, CV= Coefficient of variation.

Table.7 Effect of seed storage period and variety on seedling root length (cm), vigor index II and seedling dry weight (g) of common bean.

Storage period (month)	SRL	VI II	SDW
45	9.091[b]	0.5578[c]	0.908[b]
33	9.303[b]	0.6945[b]	1.017[b]
9	10.40[a]	1.1075[a]	1.183[a]
LSD (5%)			
Grand mean			
Haramaya	10.507[a]	0.8592[a]	1.075[b]
Dursitu	8.755[b]	0.6263[b]	0.800[c]
Fadis	9.533[ab]	0.8743[a]	1.233[a]
LSD (5%)	0.989	0.1157	0.1104
Grand mean	9.6	0.79	1.04

Means in column in each seed quality parameter and main factor followed by the same Letter (s) are not significantly different from each other at 5% probability level. LSD (5%) =least significant difference at P=0.05, NS = nonsignificant and CV= cofiecent of variation.

Table.8 Interaction effect of storage period and variety on seedling fresh weight (g) of Common bean

Storage period (month)	Variety		
	Haramaya	Dursitu	Fadis
45	10.73[cd]	7.80[g]	10.50[de]
33	11.33[cd]	8.60[ab]	11.90[bc]
9	12.78[b]	9.53[fg]	14.68[a]
LSD (5%)		1.18	
Grand mean		10.87	

Means in columns and rows followed by the same letter(s) are not significantly different from each other at 5% probability level. LSD (5%) =least significant difference at P=0.05 and CV= Coefficient of variation.

Berzy *et al.*, (2013) reported that as duration of seed storage increases, there was an equivalent decline in the vigor and quality of the seed, resulting in retarded germination, slow development and shorter seedlings under stress conditions of the crop. Furthermore some of the factors that affect the duration of seeds in storage could be the genotype of seed, storage conditions, and moisture content among others. Even within the same plant species, different varieties may exhibit different storing abilities either from genetic variations or other external factors (Simic *et al.*, 2007). Seeds which have low deterioration ability are able to nourish the young seedlings in sufficient way because those seeds are store in shorter period of time which leads to increment of seedling dry weight. This indicates that fresh weight and dry weight of seedlings decreased with increase in storage period. This might be due to storage time (aging) which resulted in deterioration of seed, so that the food source for nourishing the young seedling decreases. This results in a reduction of seed germination percentage, seedling length, seedling stand and vigor (Laxman *et al*., 2017).

Seedling vigor index II was significantly influenced by the seeds storage period and variety in which significantly difference seedling vigor index II of 1.11 was observed in seed samples stored for about 9 months. The two varieties, *Haramaya* and *Fadis* had higher seedling vigor index II mean values of 0.86 and 0.87, respectively, significantly different from the mean values of *Dursitu* variety but nonsignificant difference between the mean values of the two varieties (Table 7). Moreover seeds which have shorter storage duration resulted in good seedling vigor index II than seeds with longer storage duration. This might be due to the genetic makeup of the variety and the effect of storage of seeds on seed deterioration thereby leads to stunt seedlings root and shoot length, seedlings dry weight and seedling vigor index II.

The effect of seed sizes which is more of the function of varietal difference on seedling vigour index was reported by Borate *et al.,* (1993) that seedling vigour index was higher in large size seeds than small sized seeds of groundnut. Furthermore, Verma (2014) who reported that the decrease in the seed vigour index II might be due to age induced by decline in germination percentage, decrease in root and shoot length and seedling dry weight. Sun *et al.,* (2007) indicated that seedlings vigor and its components (germination rate, seedling length, root length, seedling fresh weight, and seedling dry weight) are quantitative traits and determined by the environment during seed storage period. Khalequzzaman (2012) also indicated that seedling vigor index decreased with the increase of storage period in soybean seeds.

Summary and Conclusion

In conclusion; the seed quality test showed that thousand seed weight, seedling shoot length, seedling vigor index I and seedling fresh weight were significantly affected by the interaction of variety and seeds storage period that enabled determination of the seed quality of the crop. All these parameters were higher on the variety *Fadis* and *Haramaya* which were stored for about recent (nine) months in ambient condition. Generally, the results indicated that as the storage period of the seed increased from 9 to 45 months, the values of those seed quality parameters declined due to the prolonged storage period of the seed irrespective of the varieties of the crop. Moreover it is necessary to conduct controlled experiments on the seed storage period along with different storage methods to determine the effect of seed aging on seed quality on common bean is very important.

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