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Research Article

Germination and Seedling Growth Rate of Coffee (*Coffea arabica* L.) Seeds as Influenced by Initial Seed Moisture Content, Storage Time and Storage Condition

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ABSTRACT

Coffee seeds have been considered intermediate storage behavior with varying results. It is highly desirable that seeds are stored safely to optimize coffee seedling production at the appropriate time and season with ideal climatic conditions for planting in the field. The objective of this study was to evaluate the effect of time of storage and initial seed moisture content on germination and seedling emergence rate of coffee seeds. In this experiment, the effects of time of storage with six levels and initial seed moisture content with four levels on coffee seed germination and early seedling growth were studied in a split-plot factorial design. The data collected were subjected to Analysis of Variance (ANOVA) using statistical analysis system version 9.2 software (SAS, 2009). Treatment means were separated using LSD at 0.05 probability level. The present findings revealed that seed germination and seedling emergence rate were highest at initial time of storage. Seeds dried to 12% moisture content showed inferior performance throughout the trial period. Storage temperature, time of storage and initial seed moisture contents showed highly significant main and interaction effects and seeds dried to intermediate moisture level (17 & 22%), stored under cold temperature and sown at early times resulted in enhanced germination percentage and field emergence rate. Hence, it is advisable drying coffee seeds to about 17% to 22% moisture contents and keep under storage with relatively lower temperatures at about 15ºC for not more than six months of storage. As the present finding was limited to single cultivar and done under specific environmental condition further investigation is significant.

Key words: Coffee seed, Seedling, Growth

INTRODUCTION

The most prevalent and easiest method of propagation for Arabica coffee is the sexual method using seeds (Rafhuramulu and Purushotham, 1991; Cambrony, 1992). Therefore, in coffee nursery management, the most important consideration is the issue of seed germination, which requires the use of good quality seed (Edjamo, 1986) since in a perennial tree crop like coffee, field planting of vigorous and healthy seedlings is one of the prerequisites to establish a successful and viable plantation. Therefore, production of quality seed and maintenance of high seed germination is of utmost importance in a seed programme (CIP, 1982, Ameha and Belachew, 1983; Veerendra and Raju, 1988).

Storage potential of seed is mainly a genetical factor but is influenced by several factors like environment (Roberts, 1972; Wittington, 1978), period of storage (Reddy, 1987), seed moisture level (Roberts, 1972; Write, 1992). Based on the genetic information, the seed also expresses all the effects of the environment to which it was exposed prior to sowing, and the period for which it remains viable is controlled both genetically and by the environmental factors (Mayer and Mayber, 1975). Storage environment is obviously very important in extending the life of seeds. The general objective is to reduce the metabolism of the seeds as much as possible without damaging them and to prevent attack by microorganisms. Similar to that of other crop seeds, coffee seed deteriorates rapidly at relatively higher levels of temperature and relative humidity (Coste, 1992). Storage of lower temperatures increases the viability of most kinds of seeds, and this relation between temperature and longevity described to be exponential (Legesse, 1986).

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Seed moisture is a key factor influencing seed quality and a continual challenge for coffee seed industry. The standards adopted in Brazil are 12% minimum and 25% maximum moisture content. Tefera (1994) has reported that seed lots stored with high initial seed moisture content (higher than 32%) retained their potential viability and vigour longer than those stored with lower moisture levels if moisture-vapor barrier containers are used. If circumstances force to use porous containers like cloth bags, jute sacks, and open trays, it is beneficial to reduce the initial moisture to relatively lower levels Tefera (1994).

This lower initial moisture content at which seed viability best maintained; however, is not yet studied. Jimma agricultural research center (JARC), which is the sole mandated coffee seed producer in the country, has conventionally using moisture content ranging from 14 to 18% for seed storage. But various users are still debating for seed germination problem and needs for further investigation in order to come-up with the best solution. Therefore, the objective of this study was to evaluate the effect of initial seed moisture content and storage condition and duration on seed germination and seedling emergence rate of Arabica coffee.

MATERIALS AND METHODS

Experimental materials

Following the conventional procedures widely applied in coffee seed preparation (Van der Vossen, 1979; Goodman, 1980; Rothofs, 1980), fully ripe red cherries were harvested from selected mother trees in the seed orchard of cultivar 74110 (which was selected as it is widely adapted, highly demanded and much produced) at, JARC, on 21st November 2011 growing season. This cultivar was selected for the present study, because it is high-yielding CBD resistant, widely adaptable, highly demanded and produced much. The cherries were sorted out and pulped in a hand pulp separator. After pulping the selected cherries, the wet parchment beans were again sorted out, thoroughly washed, and taken to drying room, hut made of grass roof.

Then the wet parchment coffee was laid on wire mesh for drying under shade and when its skin dried dressed with fine wood ash following the JARC conventional practice and kept till it attained the desired four levels of moisture contents (27, 22, 17 and 12% [fresh weight base]). One kg of parchment coffee seeds was taken on 5th January 2012 till 2nd July 2012 from each of the four batches and kept separately in each of the two storage conditions. The storage conditions used in this study were cold store with 15^0C (SC1) and a room at ambient temperature (SC2). All the seed lots with four levels of MCs were kept under both storage conditions.

Representative samples of seeds were taken every month from each treatment combinations and were subjected to a series of tests in the laboratory and nursery trials to evaluate the potential viability (germination) and early seedling growth potential status of each seed lot.

Treatments and experimental design

A split-split plot factorial design was used with three replications.

Factors

A. Storage condition (cold 15°C & ambient temperature)
B. Time of storage (sowing after 1, 2, 3, 4, 5 & 6 months of storage)
C. Initial seed moisture content (12%, 17%, 22% & 27%)

As presented in Table1, in this experiment, storage conditions (SC) was assigned to main plot, time of storage (ST) was assigned to sub-plots while seed initial moisture level was assigned to sub-sub-plots. Total number of treatment combinations were 48 (2*6*4) replicated three times and the total number of experimental plots were 144. The treatments were randomly and independently assigned to main plots, sub plots and the sub-sub plots. Every routine nursery activity was practiced uniformly to all experimental units as per the recommendation of the JARC (Institute of Agricultural Research, 1996).

The model

Three factor analysis of variance model was used with General Linear Model (GLM) Procedures of SAS Version 9.2. The linear statistical model for the split-split-plot design would be:

$Yijk = \mu + \alpha i + \beta j + \gamma k + (\alpha x\beta)ij + (\alpha x\gamma)ik + (\beta x\gamma)jk + (\alpha x\beta x\gamma)ijk + £ \mu ijk$ Where

Yijk = the response measurement for the ijkth observation
μ = is the overall mean effect.
αi = is the effect of the ith level of sub-sub-plot
βj = is the effect of the jth of main plot
γk = is the effect of the kth of sub-plot
(αxβ)ij = is the effect of the interaction b/n actor A&B
(αxγ)ik = is the effect of the interaction b/n factor A&C
(βxγ)jk = is the effect of the interaction b/n factor C&B
(αxβxγ)ijk = the effect of interaction b/n the three factors
£μijk = is a random error component for all factors

Sampling and data collection

The observations were recorded on seed germination percent, field emergence, rate of emergence, mean days to emergence and they were explained below.

Seed viability (germination) evaluation

Germination test, which is one of the most reliable and easy-to-handle techniques, was used to determine seed viability. The petridish method was used to run the pre-germination test in the laboratory at JARC. Random samples of 60 seeds in three replications were taken by reducing from each treatment combination in the store, and their parchments were removed. The seeds were placed with their flat side down at a spacing of one by one cm in a four by five arrangement on soft paper in the petridish, which were kept moist throughout by frequent watering. The germinated seeds were counted and recorded at 15th day. Seeds were considered germinated when their extending radicle were about three to five mm long showing a positive geotropic response. The total percentage of germination was then computed and recorded as percentage of seed germination.

Seedling emergence evaluations

To evaluate the field emergence and subsequent growth potentials of the seed lots, random samples of 60 seeds were taken from each treatment combination in three replications and sown parchment intact on prepared 10 × 22 cm polyethylene tubes filled with standard nursery media consisting of soil, manure and sand in 4:2:1 ratio. Two seeds per bag were sown in a ten polythene tube per replication with their flat side facing downward at a depth of about one cm and were thinly covered with fine soil. The beds were covered with about five cm thick grass mulch and watered daily. All the routine coffee nursery management practices including weeding and disease and pest control were applied following the conventional techniques practiced at JARC nursery site.

The beds were constantly checked for emerging seedlings starting from the 30^{th} day after sowing, and when seedlings emerged the mulch was removed and a moderate level of over-head shade was constructed over each bed. In this experiment, emergence is defined as the appearance of a normal hypocotyls following sowing in polythene bag, as described by (Perry, 1970). Thus, the number of seedlings that emerged above the soil surface and attained the soldier-stage of growth was counted and recorded every five days till all the seeds that are capable of emerging and produce seedlings in each plot (Coste, 1992).

The percentages of emerged seedlings (%E) were then determined. Thus, based on the records of the emergence data, mean days to emergence (MDE), and the rate of seedling emergence (ER) of each seed sample was computed following the procedures outlined by (Magurie, 1962; and Nicolls and Heyydecker, 1966).

The formulae used to calculate these two indices were:

Mean Days to Emergence (MDE) = $\sum$ (nt)

$\sum$n (Nicolls and Heydecker, 1966),

Where: n= number of newly germinated seeds at time t,

t= days from sowing

Rate of Emergence(ER)

The number of seeds emerged was recorded daily up to the day of final count. The speed of emergence was calculated by adopting the fallowing formula and expressed in number (Magure, 1962).

Rate of Emergence (ER) = $\sum$ (n/t) (Magurie, 1962)

Where: n= number of newly germinated seeds at time t,

t= days from sowing

RESULTS AND DISCUSSION

Laboratory germination (G%)

The analysis of variance of the data from germination and early seedling growth tests of *C. arabica* seeds carried out showed that the main and interactions effects among storage temperature, time of storage and initial seed moisture content significantly ($P \leq 0.01$) affected percentage of seed germination (Table1). The combinations of seeds dried to 27% moisture content, stored under cold condition ($15^{O}C$) and sown at first month resulted in significantly higher germination (99.00%). However, seeds stored under cold condition ($15^{O}C$) that dried to 22% and sown at first and second month and that dried to 17% and sown at first month and stored under ambient condition that dried to 27 and 22% sown at first month did not show significant difference (Table2). As indicated by Da Silva and Dias (1985), this could probably be due to the fact that coffee seeds stored with higher initial moisture contents might retain their potential viability and thus favoured early growth of seedlings than the dried ones.

While significantly lower germination was recorded for seed dried to 12% moisture that stored under ambient condition and sown after six months of storage (43.67%) but statistically non significant from seeds dried to 27% moisture content that stored under ambient condition and sown after six months of storage. With the advancement of storage period, germination percent declined irrespective of storage condition, initial seed moisture content and their interactions (Table2). Percent seed germination progressively decreased with prolonged time of storage and it showed drastic change after the third month especially for seeds with lower (12%) and higher (27%) moisture levels that stored under ambient condition. The later (reduced germination in 27% after six months of storage) may be due to promotion of hydrolysis of seed substances increased in seed metabolic processes that lead to seed deterioration (Legesse, 1986). This result agrees with suggestion given by Ellis, 1991 who reported that at higher and lower moisture contents reduced viability was observed and in contradiction with the generalization of Da Silva and Dias (1985); Tefera, (1994) who stated that coffee seeds stored with higher initial seed moisture contents retain their potential viability longer.

Table 1: Analysis of Variance for Seed Germination Percentage (G%), Percentage of Seedling Emergence (EM%), Emergence Rate (ER) and Mean Days to Emergence (MDE)

Source of variation	DF	G%	EM%	ER	MDE
Rep	2	13.51^{ns}	23.38^{**}	0.13^{**}	4.72^{*}
SC	1	6012.71^{**}	9360.56^{**}	14.38^{**}	641.78^{**}
Error (a)	2	16.51^{ns}	25.52^{**}	0.25^{**}	31.51^{**}
ST	6	3226.92^{**}	3844.26^{**}	0.07^{**}	1046.73^{**}
SC*ST	6	535.99^{**}	935.15^{**}	9.67^{**}	26.11^{**}
IMC	3	642.83^{**}	253.47^{**}	2.05^{**}	99.49^{**}
SC*IMC	3	3.27^{ns}	6.54^{*}	0.28^{*}	3.65^{*}
ST *IMC	18	24.48^{**}	22.01^{**}	0.15^{**}	4.28^{**}
SC*ST*IMC	18	9.42^{ns}	16.02^{**}	0.05^{**}	2.11^{**}
Error (b)	12	16.61^{*}	10.56^{**}	0.03^{*}	2.72^{*}
CV%		3.30	1.92	4.77	1.86

*, ** = Indicate significant differences at the 5% and 1% probability levels, respectively. ns = non-significant at 5% probability levels.

The present result revealed that, even though, seeds with 27% initial moisture gave higher seed germination performance at initial time, it drastically declined after two months and seeds dried to 22% moisture content and stored in cold condition best maintained higher germination percentage followed by seeds dried to 17% moisture content than both the higher and lower moisture levels. The result also indicated that cold condition is better to prolong storage life of coffee seeds and it is consistent with the findings of Barboza and Herrera, (1990); Ellis *et al*., (1990, and 1991) who have proposed the use of low temperatures (around $15^{0}C$) to preserve coffee seed viability for a considerable period of time.

Seedling field emergence (E%)

There were highly significant ($P<0.01$) main and interaction effects among the levels of storage condition, storage time and initial seed moisture content on seedling emergence (Table1). The combinations of seeds dried to 27% initial moisture content that stored under cold condition and sown at first month also resulted in significantly higher seedling emergence (95.00%) and followed by 27% seed moisture that sown at the second month, seeds dried to 22 & 17% moisture and sown at first month and seeds dried to 27% moisture that stored under ambient condition and sown at first month. These results could also be related to the positive impact of high seed moisture levels in retaining high seed viability at early stages (Perry, 1970; Van der Vossen, 1979; Osei-Bonsu, *et al*., 1989), which may result in higher percentages of seedling emergence and subsequent rapid growth of seedlings during their earlier stages of development. While, the lowest seedling emergence was recorded on combinations of seeds dried to 12% moisture content that stored under ambient condition and sown after six months of storage (Table3). This could be attributed to the general decline in viability of seed lots as a result of prolonged storage, fluctuation of temperature and high respiration under ambient condition. It declined slowly at first and then rapidly as seeds age with much more pronounced reduction in seedling emergence capacity starting after the third month under ambient condition. These results are in agreement with those reported by Da Silva and Dias (1985); and Reddy (1987).

The result of present study showed that regardless of the variability in the prevailing climatic conditions, a high consistency was observed between laboratory germination and field emergence, which agrees with findings of (Perry, 1978; Hall and Wiesner, 1990). The result of this experiment revealed that for prolonged coffee seed storage both higher and lower moisture levels are not suitable and seeds dried to 22% moisture best maintained higher field emergence longer than did the other treatment combinations followed by seeds dried to 17% moisture. The result is in agreement with the suggestions of (Agrawal, 1980; Legesse, 1986) who reported that the optimal moisture content with which a seed should be stored depends on the intended time of storage. This result also agrees with suggestion given by Ellis, 1991 who reported that at higher and lower moisture contents reduced viability was observed and in contradiction with the generalization of Da Silva and Dias (1985); Tefera, (1994) which states that coffee seeds stored with higher initial seed moisture contents retain their potential viability longer.

Rate of seedling emergence (ER)

According to the results obtained in this investigation, it was observed that the rate of seedling emergence resulted showed a significantly ($P<0.01$) affected by the storage condition, time of storage, and the initial seed moisture content and their interaction (Table1). The rate of seedling emergence was also synchronized with the emergence performance of seedlings. With the advancement of storage period, rate of emergence declined irrespective of moisture content, storage environment and their interactions (Table4). Treatment combinations of seeds stored in cold condition dried to 27% mc and sown at first month showed significantly higher rate of emergence (3.60) but statistically did not significantly differed from treatment combinations of seeds dried to 22% moisture content that stored under cold store and sown after a month of storage and 27% moisture content under ambient condition and sowing after a month of storage (3.47 & 3.50, respectively). These moisture levels probably enables the emergence process to continue smoothly, while in seeds with low moisture germination interrupted till enough moisture is reabsorbed (Ellis *et al*., 1991).

The least rate of emergence of was recorded in the seeds stored in ambient condition dried to 27% mc and sown at sixth month of storage (0.87). Such a progressive decline in emergence rate with prolonged storage time confirms the reports by Reddy (1987), and Ellis *et al*., (1990). The reason for this could be related to the general tendency of seed viability to deteriorate through time, fluctuation of temperature and high respiration under ambient condition (Magurie, 1962; Evers, 1991).

The result of this experiment revealed that, even though, seeds with 27% gave higher performance at initial time it drastically declined beyond two months. Seeds dried to 17% moisture content and stored in cold condition best maintained higher rate of emergence with prolonged time of storage followed by seeds dried to 22% moisture content than both the higher and lower moisture levels, which agrees with findings of (Perry, 1978; Hall and Wiesner, 1990). The result of this experiment revealed that for prolonged coffee seed storage both higher and lower moisture levels are not suitable.

Table 2: The interaction effects of storage condition (SC), storage time (ST) and initial seed moisture content (IMC) on seed germination (%).

SC	IMC	Storage Time (in month)					
	%	1	2	3	4	5	6
Cold (15°C)	12	87.00^{f-i}	84.67^{g-k}	81.67^{j-n}	79.00^{l-p}	76.67^{opq}	71.00^{rs}
	17	94.50^{abc}	91.67^{c-f}	89.17^{d-g}	87.33^{f-i}	82.00^{j-n}	78.00^{nop}
	22	97.50^{ab}	95.00^{abc}	92.33^{cde}	89.00^{d-g}	85.67^{g-j}	78.33^{m-p}
	27	99.00^{a}	93.67^{bcd}	88.67^{efg}	83.67^{h-l}	80.33^{k-o}	74.67^{pqr}
Ambient	12	85.67^{g-j}	80.00^{k-o}	73.00^{qr}	67.33^{stu}	52.33^{w}	43.67^{x}
	17	91.67^{c-f}	87.67^{e-i}	80.33^{k-o}	70.67^{rst}	63.67^{u}	52.67^{vw}
	22	95.00^{abc}	88.00^{e-h}	83.00^{i-m}	76.33^{opq}	66.00^{tu}	55.67^{vw}
	27	95.33^{abc}	89.00^{d-g}	84.67^{g-k}	66.33^{stu}	57.33^{v}	45.00^{x}
CV%		3.66					
LSD (5%)		4.71					

Means followed by the same letter(s) are not significantly different at 5% level of probability.

Table 3: The interaction effects of storage condition (SC), storage time (ST) and initial seed moisture content (IMC) on seedling emergence (%).

SC	IMC	Storage Time (in month)					
	%	1	2	3	4	5	6
Cold ($15^{O}C$)	12	87.00^{cde}	84.00^{e-h}	78.00^{lmn}	75.00^{nop}	76.00^{nop}	70.00^{qr}
	17	89.33^{bc}	85.00^{d-g}	83.33^{f-j}	80.67^{i-l}	75.00^{nop}	71.00^{qr}
	22	91.67^{b}	87.67^{cd}	86.00^{def}	84.33^{e-h}	80.33^{jkl}	75.00^{nop}
	27	95.00^{a}	90.00^{bc}	84.00^{e-h}	82.00^{g-k}	77.00^{mno}	73.00^{pq}
Ambient	12	86.00^{def}	80.00^{klm}	74.67^{op}	59.33^{st}	45.67^{w}	32.00^{z}
	17	83.67^{f-i}	80.67^{i-l}	75.67^{nop}	56.67^{t}	49.67^{uv}	36.33^{y}
	22	83.67^{f-i}	81.67^{h-k}	80.00^{klm}	68.67^{r}	51.33^{u}	47.33^{vw}
	27	89.33^{bc}	84.67^{d-h}	75.00^{nop}	60.33^{s}	51.00^{u}	40.00^{x}
CV%		2.72					
LSD (5%)		3.2415					

Means followed by the same letter(s) are not significantly different at 5% level of probability.

Table 4: The interaction effects of storage condition (SC), storage time (ST) and initial seed moisture content (IMC) on rate of emergence.

SC	IMC	Storage Time (in month)					
	%	1	2	3	4	5	6
Cold ($15^{O}C$)	12	2.73^{efg}	2.57^{ghi}	2.37^{i-l}	2.10^{no}	1.70^{st}	1.50^{tu}
	17	3.20^{b}	2.97^{cd}	2.67^{fgh}	2.43^{ij}	2.07^{nop}	1.87^{p-s}
	22	3.47^{a}	3.20^{b}	2.83^{def}	2.33^{j-m}	1.97^{o-r}	1.80^{qrs}
	27	3.60^{a}	3.17^{bc}	2.97^{cd}	2.50^{hij}	2.00^{n-q}	1.53^{tu}
Ambient	12	2.20^{k-n}	2.13^{mno}	1.77^{rs}	1.27^{vw}	1.03^{xy}	0.87^{y}
	17	2.43^{ij}	2.17^{l-o}	1.80^{qrs}	1.40^{uv}	1.20^{vwx}	1.03^{xy}
	22	2.80^{def}	2.40^{ijk}	2.13^{mno}	1.83^{qrs}	1.50^{tu}	1.20^{vwx}
	27	3.50^{a}	2.93^{de}	2.43^{ij}	1.70^{st}	1.33^{uv}	1.10^{wx}
CV%		6.66					
LSD (5%)		0.2332					

Means followed by the same letter(s) are not significantly different at 5% level of probability.

Table 5: The interaction effects of storage condition (SC), storage time (ST) and initial seed moisture content (IMC) on mean days taken to emergence (no of days).

SC	IMC	Storage Time (in month)					
	%	1	2	3	4	5	6
Cold ($15^{O}C$)	12	49.00^{cde}	54.00^{ij}	58.67^{l-o}	60.67^{q-t}	62.00^{s-v}	62.00^{s-v}
	17	47.67^{abc}	52.33^{ghi}	55.67^{jkl}	58.00^{m-p}	59.67^{pqr}	62.00^{s-v}
	22	46.67^{ab}	50.00^{def}	53.67^{hij}	56.33^{klm}	57.33^{l-o}	60.33^{qrs}
	27	45.67^{a}	48.33^{bcd}	54.33^{ijk}	58.67^{n-q}	61.33^{r-u}	63.33^{u-x}
Ambient	12	51.00^{efg}	57.00^{lmn}	62.67^{t-w}	65.00^{vw}	67.67^{x}	71.00^{z}
	17	49.00^{cde}	54.00^{ij}	59.33^{o-r}	63.00^{u-x}	66.67^{wx}	70.33^{yz}
	22	48.33^{bcd}	52.33^{ghi}	57.67^{l-p}	60.33^{qrs}	64.67^{uvw}	67.67^{x}
	27	47.00^{abc}	51.67^{fgh}	58.67^{n-q}	62.00^{s-v}	63.67^{vwx}	68.33^{xy}
CV%		2.48					
LSD (5%)		2.3237					

Means followed by the same letter(s) are not significantly different at 5% level of probability.

Mean Days to Seedling Emergence (MDE)

The result obtained from the present study revealed that the main effects of storage condition, storage time, seed moisture content and their interactions on mean days to emergence were highly significant (P<0.01) (Table1). With the advancement of storage period, mean days to emergence prolonged irrespective of moisture content, storage environment and their interactions (Table5). The treatment combination of seeds stored in cold condition that dried to 27% initial moisture content and sown at first month still resulted in significantly faster mean days to emergence of (45.67 days). However, non significantly differed with seeds dried to 22 and 17% moisture contents that stored under cold condition and sown at first month (46.67 & 47.67 days, respectively) and seeds stored under ambient condition that dried to 27% moisture content and sown at first month (47 days). While, the prolonged mean days to emergence was recorded in the interaction of treatment combination of seeds stored under ambient condition dried to 12% initial moisture contents and sown at sixth month of storage (71 days) but not significantly differed from seeds stored under ambient condition dried to 12% initial moisture contents and sown at sixth month of storage (70.33 days).

The study also revealed that, even though, seeds with 27% gave higher performance at initial time it drastically declined beyond two months same as for germination and seeds dried to 17% moisture content and stored in cold condition best maintained higher rate of emergence for prolonged seed storage followed by seeds dried to 22% moisture content than both the higher and lower moisture levels. Rapid and uniform emergence is the most important economic manifestation of seed vigor (Nichols and Heydecker, 1968; Perry, 1978, Wurr and Fellows, 1984; Pandey 1988).

Summary and conclusion

Despite considerable effort at vegetative propagation of coffee plants, they still are propagated by seedlings produced from seeds. An undesired trait of coffee seeds is that they have slow and asynchronous germination, which makes it difficult to obtain seedlings of desirable quality. The effect of moisture content and temperature on the survival of *Coffea Arabica* cul. 74110 seeds were investigated in order to better understand their seed storage behavior.

The present study was carried out with the objective of determining the quality seed germination and early seedlings growth potentials of coffee produced from seeds stored for six months with 27%, 22%, 17% and 12% initial seed moisture contents under storage conditions at 15°C and ambient temperature at JARC using split-split-plot factorial Design.

Storage condition, time of storage and initial seed moisture contents showed highly significant interaction effects and seeds dried to intermediate moisture level (17 & 22%), stored under cold condition and sown at early times resulted in enhanced early seedling growth and increase germination percentage, field emergence, speed of germination and uniformity in seedling. Hence, for storing coffee seeds, it is advisable drying the seeds to about 17% to 22% moisture contents and keep under storage with relatively lower temperatures (at about 15^{o}C) for not more than five or six months of storage is advisable.

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REFERENCES

Agrawal RL, 1980. Seed Technology. Mohan Primlani for Oxford and IBH Publishing Comp Pvt Ltd, New Dehli.

Barboza, R and J Herrera, 1990. Seed vigor in coffee seeds and its relations to drying temperature, moisture content and storage conditions. Agronomy, 14: 1-7.

Cambrony HR, 1992. Coffee Growing. The MacMillan Press Ltd, London.

Coffee Improvement Project (CIP), 1982. A report on the project program and budget of CIP- II and evaluation of CIP- IA Technical Report. June, 1982 Addis Ababa, Ethiopia pp: 1-26.

Coste R, 1992. Coffee: The plant and the product. Macmillan Press Ltd, London.

Da Silva WR and MCLL Dias, 1985. Effect of coffee seed moisture content on keeping quality. Press of Agropec Bras, Brasilia, 20: 551-560.

Ellis RH, TD Hong and EH Roberts, 1990. An intermediate category of seed storage behaviour I. Coffee J Exp Bot, 41: 1167-1174.

Ellis RH, TD Hong and EH Roberts, 1991. An intermediate category of seed storage behavior. II Effects of provenance, immaturity, and imbibition on desiccation-tolerance in coffee. J Exp Bot, 42: 653-657.

Evers GW, 1991. Germination response of subterranean. Berseem and rose clovers to alternating temperatures. Agron J, 83: 1000-1004

Goodman JH, 1980. Coffee nursery management in Guidelines on coffee management. Unpublished manual. Extension, CIP/MCTD pp: 1-16.

Hall, RD and LE Wiesner, 1990. Relationship between seed vigor tests and field performance of regar meadow brome grass. J Crop Sci, 30: 967-970.

Institute of Agricultural Research (IAR), 1996. Recommended production technologies for coffee and associated crops. Research extension task force of Jima Research Centre. Addis Ababa, Ethiopia.

Magurie JD, 1962. Speed of germination-aid in selection and evaluation for seedling emergence and vigor. Crop Sci, 2: 176-177.

Mayer AM and PA Mayber, 1975. The germination of seeds (2nded). Perganon Press, New York, No 5, 152-175.

Ameha M and B Belachew, 1983. Coffee nursery research review. Paper presented to coffee Agronomy Workshop. CPDC/MCTD, Feb, 1983. AA, Ethiopia, pp: 1-8.

Legesse N, 1986. Effect of climate, insulation and ventilation on effective temperatures in open seed stores in the tropics. MSc Thesis University of Edinburgh, Scotland.

Nicolls, MA and W Heyydecker, 1966. Two approaches to the study of germination data. Proc Int Seed Test Ass, 33: 531-540.

Osei-Bonsu K, K Opoku-Ameyaw, FM Amoah and K Acheampong, 1989. Coffee seed germination. I Effect of ripening and processing on coffee (*Coffea canephora*) seed germination. Café Cacao, 33: 219-222.

Pandey DK, 1988. Electrolyte efflux into hot water as a test for predicting germination and emergence of seeds. Hort Sci, 63: 223-228.

Perry DA, 1970. Seed vigor and field establishment. Hort Abst, 42: 334-342.

Perry DA, 1978. Report of vigor test committee 1974-1977. Seed Sci and Technol, 6: 159-181.

Raghuramulu Y and K Purushotham, 1991. Effect of pre-storage and mid-storage treatments on the germination of coffee seeds. J Coffee Res, 21: 42-51.

Reddy LS, 1987. Effect of different stages of maturity and post harvest treatments on seed viability of *Coffea arabica* L. Indian Coffee, 49: 12-16.

Roberts EH, 1972. Storage environment and the control of viability. In *Viability of seeds*. Ed EH Roberts. London: Chapman and Hall P479.

Rothofs B, 1980. Coffee production. Hamberg: Gordian-Max-Rieck.

SAS (Statistical Analysis System), 2009. SAS user's guide: statistics, 5th ed, Statistical Analysis System Software. Version 92 SAS Inst, Cary, NC.

Van der Vossen HAM, 1979. Methods of preserving the viability of coffee seed in storage. Seed Sci Technol, 7: 65-74.

Van der Vossen HAM, 1980. Methods of preserving the viability of coffee seeds in storage. Kenya Coffee 45: 31-35.

Veerendra KMM and T Raju, 1988. Seed germination and seedling growth of robusta (C. canephora Pierre ex Froehner) as influenced by nursery soil mixture. Indian coffee, 52: 5-7

Wittington WJ, 1978, Genetic aspect of fungal emergence and rate of emergence. Seed Abst, 2: 167.

Tefera W, 1994. The influence of duration of storage, initial moisture content and type of container on the viability of coffee (*Coffea arabica* L.) seeds An MSc Thesis, Alemaya University, Ethiopia.

Write C, 1992. Moisture determination. In: Techniques in Seed Science and Technology. Ed By PK Agrawal and M Dadlani South Asian Publishers Pvt Ltd, New Dehli, pp: 54-60.

Wurr DCE and JR Fellows, 1984. Further studies on the slant test as a measure of the vigor of crisp lettuce seed lots. Ann Appl Boil, 105: 575-580.

Edjamo Y, 1986. Review of Coffee Nursery at Jimma Research Centre (Melko). In: Proceeding of the First Coffee Symposium in Ethiopia, 21-26, August, 1986, Addis Abeba, Ethiopia.