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Research Article

Variation in Seedling Quality Attributes of Lentil (Lens *culinaris* Medik.) After Harvested Under Different Sowing Dates

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Abstract

Planting dates are the most important components for Lentil seedling growth and development. Seeds planted in diverse environmental situations lead to changes in various seedling development and the final output of the yield. The present study, aimed to assess the effect of different planting (sowing) dates harvested seeds on the physiological properties of nineteen (19) lentil genotypes. Lentil was growing during two consecutive planting days on average the normal (main) 17/08/2021 and lately 16/09/2021, then harvested seed extract after five months of storage, planted CRD with two factorial designs and three replications under laboratory condition within a white plastic container filled with autoclaved 3.0kg sand applying 100ml distilled water. The lentil was grown per standard, and the lentil's postharvest physiological quality parameters were evaluated. Results indicated that the lowest speed of germination index was obtained during late planting time or stress situations on the genotype Adda (8.78) and ILL-1760 (8.94). Seedling length is the seedling vigor criterion and is statistically significantly different between planting dates at 1%. The effect of planting day on seedling fresh weight was significantly different ($p < 0.01$) on genotype Beredu (0.0022) on the main planting day. The seed viability on vigor index (II) as shown in was affected by planting date ($p < 0.01$) and genotypes ($p < 0.01$). The heritability value of shoot length, root length, and seedling fresh weight equal zero was the variation due to environmental it had no genetic effect after five months of storage both main and late planting. The seedling vigor index, fresh and dry weight traits maximum on the main planting day on the genotype Beredu indicates 0.0445, 0.00218, and 0.00045 respectively. Seeds from the main planting day had the best seedling traits performance and recorded minimal germination time compared to late planting seeds. Lentil seeds planted lately finally recorded lower seedling fresh and dry weight, vigor, and speed of germination index as compared to those harvested lentil seeds in main planting dates. As a result, when there is adequate rainfall necessary for lentil growth, development, and final output.

Keywords

Adaptability, Lentil Seeds, Storage Time, Traits, Viability

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1. Introduction

Lentil (*Lens culinaris* Medik.) is a versatile and profitable pulse crop with higher nutritional food and feed values. Achieving higher yield depends on the use of seeds of optimal quality in terms of vigor, speed of germination, seedling shoot, and, root length. Higher seed quality is essential to ensure proper planting and storage time. The used seed vigor must be high. Seed quality means the ability to germinate, to emerge, and to produce healthy seedlings rapidly, uniformly, under a wide range of environmental conditions, enabling this ability for a great amount of time [1]. Poor-quality seeds can potentially decrease the rate and percentage of germination and seedling emergence, leading to creating not a better new life as a result yield loss in many crops such as corn [2, 3], cotton [4], barely [5, 6], and oil seed [7].

The young or small plants are affected by climatic conditions during seed development [8] such as the frequency of lower water content and amount of water vapor in the air, high temperature, rainfall [9], and genetic factors [10]. Planting dates are the first pivotal point in crop management decisions, especially in areas with environmental constraints such as early and early winter and extreme heat in the middle of summer [11]. Planting date is the most important characteristic that often affects germination characteristics seedling establishment, greenfield, and yield [12]. The studies conducted by [13] on soybeans in early sowing dates (April 30) have lower seed quality than those of the later planting dates (May 15 and 30). They stated that relative humidity and high temperature during seed filling, likely reduce seed quality in the early planting dates. [14] in the research, the effect of seed shrinkages caused by drought and heat stress during seed filling on soybean seed quality explained that the increased shrinkage reduces the germination percentage the final result showed that seeds with more than 50 shrinkage percentages are not suitable for planting. Lentil prefers cool weather, full sun, and a soil pH of 6-8. It grows these in drought-prone areas however, the yields will likely be reduced. Planting time-imposed seed stored under optimum conditions helps to influence seed quality concerning germination, vigor, and viability.

Time of harvesting is the primary determinant of the seed quality of native grasses [15]. Seeds' physiological maturity (defined as the maximum seed dry matter accumulation) and seed water content represent key considerations for identifying the optimum time for seed harvesting [16]. Harvesting seeds before physiological maturity may result in lightweight seeds of reduced viability, whereas harvesting seeds long after physiological maturity may result in seeds lost by shattering. Once seeds reach a maximum dry weight, they undergo an accelerated dehydration phase, until a hygroscopic equilibrium is attained and harvest maturity is reached [17].

Attainment of physiological maturity is a genotypic character influenced by environmental factors [18, 19]. The amount of seed vigor and delayed planting reduce seed quality due to the development and ripening of seed in adverse environmental conditions [20].

However, despite this, the environment and even when initial physiological quality is high, some species are better at maintaining viability in storage than others. Achieving long storage is a genotypic character influenced by external and internal factors. Store Lentil seeds at optimum conditions and stage of crop is essential to obtain better seed quality. Therefore, there is an urgent need to help communities around central Ethiopia to halt and reverse planting dates. The additions of seeds of improved varieties represent the primary sources of increasing productivity. So far, however, there is limited information on different planting days and the seed quality of improved genotypes was released at the research institute.

Therefore, to investigate the importance of two planting dates on nineteen improved lentil genotypes and its effects on seedling quality traits like seedling vigor, gemination index, and seedling fresh and dry weight, after five months of storage in central Ethiopia.

2. Materials and Methods

2.1. Experimental Design

The experiment was conducted at the Seed Testing Laboratory of the Debre-Zeit Agricultural Research, with seeds obtained from freshly harvested planted during the 2021/22 cropping season were stored in bags for periods up to 5 months with initial moisture contents of 16 to 20% (wet basis) to determine the effects of two planting days on seedling quality of lentil (*Lens culinaris* Medik.) by completely randomized design (CRD) with two replications under laboratory conditions. The samples used were from pure seed lots. The seeds were tested for Laboratory comparison by observing the principles of germination of Lentil as described by ISTA and selecting ten normal seedling materials from each tray. The first germination count was made seven days after planting and the final count was made on the twelve. The percentage of healthy germinated seeds is recorded. The evaluation of the seed quality attributes such as Seedling Fresh and Dry Weight, Vigor Index (VI) one (I) and two (II), Seedling Shoot, and Root Length (m) was carried out five months after harvesting.

Testing of Late (Factor B) and Main (Factor A) planting seed's replication/location that showed traits of seedlings had an impact on the initial growth and development of lentils (*Lens culinaris* Medik.) genotypes (Ada, 94-003L, R-186, ILL-1760, 96006L-984005, Alemtena, Alemaya, Dz-2012-Ln238, Gudo, ILL2178, X125-54, 09583227-04, Jiru, Beredu, Challew, Dz2012-Ln0050, ELL142, Teshale and Derash) at the field.

2.2. Determination of Physiological Quality

2.2.1. Germination Percent

A germination percentage was carried out according to [21]. A germination test was performed by planting fifty (50) pure seeds per genotype per harvest date. Each experimental plot (tray) within a white box regulated at a constant temperature, seeds distributed and filled on auto-cleaved 3.0 kg sand with 100ml distilled water and consisted of five rows. The white boxes were on a laboratory table at room temperature (25±2℃). After twelve days normal seedlings were counted. Germination was calculated as the ratio of normal seedlings to the total number of pure seeds and expressed as a percentage.

2.2.2. Seed Vigor Test

Root and Shoot Length: The seedling root and shoot lengths were determined in the standard germination test after the final count. After twelve days, ten plants were randomly selected to study shoot and root length, taking from each replicate of each treatment. The seedlings' root and shoot lengths were measured in meters (m). The shoot length was measured from the point of attachment to the embryo (endosperm) to the tip of the shoot. Similarly, the root length was measured from the point of attachment to the embryo (endosperm) to the tip of the root. The shoot and root lengths were computed by dividing the total shoot and root lengths by the total number of normal seedlings measured (ISTA, 1996).

Seedling Fresh and Dry Weight: From ten randomly selected seedlings, the root's fresh weight, and the shoots of the seedlings were recorded. Then, each replicate was cut from the embryo and placed in white paper bags to be dried in an oven at 70℃ for 24 hours. After cooling in desiccators, the dry weight was taken to the nearest gram using a sensitive balance and changed into an international SI unit kilogram (kg). Finally, the average seedling dry weight was measured.

Seedling Vigor: For each sample two seed vigor indices were calculated. Seedling Vigor was calculated as Vigor Index – I (VI): multiplying percent germination with the average sum of the length of shoot and root. Vigor index – II (VII): multiplying percent germination with the mean dry weight of the seedling.

Speed of Germination Index (SGI): Each sample was sown in the sand and kept at room temperature ((20^0C) for twelve (12) days, and the speed of germination (SG) was calculated. Determined by daily counts of the number of normal germinated seeds on days eight (8) to twelve (12) after sowing. The index was calculated according to the formula ($SGI = G1/N1 + G2/N2 + ... + Gn/Nn$), proposed by [22, 23]. where: SGI = speed of germination index, G1, G2, and Gn = number of seedlings counted in the first, second, and last count; and N1, N2, and Nn = number of days from sowing until the first, second, and last count.

2.3. Statistical Analysis

Data were analyzed with ANOVA ($P \leq 0.05$), using R software version 4.1.2, combining different planting times with genotypes. Differences among means were compared using the Duncan test.

3. Results and Discussions

3.1. Seedling Shoot and Root Length

In this research, seedling length is regarded as the seedling vigor criterion and is statistically significantly different between planting dates at 1% (Table 1). The tallest shoot Length on the main planting date on the genotype X-125-54 (0.112) and the shortest on the genotype Adda (0.046) on the late planting day. The increased growth of the stem due to the favorable and prevailing, seed-filling period, and the development of the seed embryo condition for planting during main planting day was important for Lentil species. Root Length was affected by planting dates and by species ($p < 0.01$), on the other hand, there was no interaction ($p > 0.05$) between planting dates and species (Table 4). Root length was similar between main and late planting dates, the mean value was higher on the genotype Beredu (0.103) on the main planting day and lowest on the species Adda (0.0475) on the late planting day. A similar result may have been caused by high rainfall intensity during anthesis, which has been shown to reduce seed set in grass [24].

3.2. Speed of Germination Index (SGI)

In the present study, germination is considered a criterion for SGI in Lentil genotypes. The effect of different planting and long storage times on the germination index is significantly different at 1% between late planting days on the genotypes ILL-2178 (12.35), this may be due to the inner power that stands in adverse situations. The lowest speed of germination index was obtained during late planting time or stress situations on the genotype Adda (8.78) and ILL-1760 (8.94). In Table 1 shoot and root length after five-month storage during main and late planting time, the cumulative mean value was 0.084 and 0.081 respectively. On lately planting day, shoot elongation decreases compared to the other tested genotypes on Adda (0.0465). The favorable conditions for the seed planting first-period impact on the growth of root and stem show that the grain filling period and formation of seed embryo have a determinative effect on Lentil.

3.3. Seedling Fresh and Dry Weight

In this experiment, the effect of planting day on seedling fresh weight was significantly different ($p < 0.01$) on genotype Beredu (0.0022) on the main planting day. [25] stated that increased seed weight provides more food for fetal growth. However, on late planting days or in stressful situations, a small value was measured on the genotype Adda (0.0008). The seedling fresh weight decreases during the late planting day associated with long-term storage. Seedling dry weight is one of the best seed rate criteria for the emergence of seedlings in the field. Seeds planted both times had higher values of seedling fresh and dry weight on the genotype Beredu compared to other tested ones, seeds from this genotype would be more suitable to grow on the field. Moreover, planting day closets to vegetative growth is the rate at which the maximum dry weight accumulation does not occur. It has been argued that fresh and dry weight involves a variety of life history traits like plant size and longevity to the final time of reproduction. The higher seed weight resulted in the formation of more normal seedlings with higher dry weight and delayed planting followed by a reduction in 100 seed weight, normal seedling percentage, and dry weight of normal seedlings [16].

Table 1. *Mean value of Speed of Germination Index (SGI), Shoot Length (SL) and Root Length (RL) in meter.*

Genotypes	SGI		SL(m)		RL(m)	
	Main	Late	Main	Late	Main	Late
Adda	9.42^{cde}	8.78^{e}	0.092^{a}	0.0465^{b}	0.0565^{ab}	0.0475^{b}
94-003L	10.51^{abcde}	10.86^{abcde}	0.0923^{a}	0.0915^{a}	0.101^{a}	0.0715^{ab}
R186	9.83^{bcde}	11.58^{ab}	0.0765^{ab}	0.0915^{a}	0.071^{ab}	0.089^{ab}
TILL-1760	10.78^{abcde}	8.94^{de}	0.084^{a}	0.0855^{a}	0.0745^{ab}	0.089^{ab}
96006L-984005	9.75^{bcde}	10.52^{abcde}	0.0935^{a}	0.0965^{a}	0.07^{ab}	0.1^{ab}
Alemtena	9.84^{bcde}	10.25^{abcde}	0.0925^{a}	0.0895^{a}	0.0695^{ab}	0.09^{ab}
Alemaya	10.26^{abcde}	11.44^{abc}	0.0885^{a}	0.0795^{a}	0.107^{a}	0.093^{ab}
Dz-2012-Ln-238	10.026^{bcde}	11.21^{abc}	0.085^{a}	0.085^{a}	0.103^{a}	0.094^{ab}
Gudo	9.94^{bcde}	10.52^{abcde}	0.0835^{a}	0.086^{a}	0.095^{ab}	0.099^{ab}
ILL-2178	12.35^{a}	9.36^{cde}	0.091^{a}	0.082^{a}	0.087^{ab}	0.081^{ab}
X-125-54	10.71^{abcde}	10.8^{abcde}	0.087^{a}	0.09^{a}	0.0855^{ab}	0.0855^{ab}
09583227-04	10.24^{bcde}	10.79^{abcde}	0.112^{a}	0.101^{a}	0.072^{ab}	0.0815^{ab}
Jiru	10.76^{abcde}	11.26^{abc}	0.094^{a}	0.0915^{a}	0.076^{ab}	0.091^{ab}
Beredu	10.54^{abcde}	10.76^{abcde}	0.0935^{a}	0.09^{a}	0.0975^{ab}	0.092^{ab}
Challew	10.33^{abcde}	11.01^{abcd}	0.09^{a}	0.095^{a}	0.103^{a}	0.066^{ab}
Dz2012-Ln0050	10.81^{abcde}	11.55^{ab}	0.0885^{a}	0.0885^{a}	0.0935^{ab}	0.0925^{ab}
ELL-142	10.79^{abcde}	11.71^{ab}	0.081^{a}	0.0835^{a}	0.076^{ab}	0.0795^{ab}
Teshale	10.64^{abcde}	11.18^{abc}	0.0855^{a}	0.0865^{a}	0.09^{ab}	0.086^{ab}
Derash	10.78^{abcde}	11.19^{abc}	0.0967^{a}	0.0945^{a}	0.0995^{ab}	0.0945^{ab}
Mean	0.987		0.012		0.025	
LSD	8.41		17.74		26.73	
CV	10.01		0.084		0.080	

Note: Same letter in some column not significantly different between genotypes.

3.4. Seedling Vigor Index I and II

The seed viability on vigor index (II) as shown in Table 2 was affected by planting date ($p < 0.01$) and genotypes ($p < 0.01$). Seed vigor index (II) was higher on the main planting day on the genotype Beredu (0.0445) and the value of the others intermediate indicating seeds planting lately and twelve days after germination was not enough for some seeds to develop a functional and mature embryo. There was no interaction (p > 0.05) between planting days and genotypes (Table 4). The tested genotype during the five-month storage period had the highest vigor index which indicates seeds of the best field performance. Seedling vigor is the ultimate engine of growth and a fundamental challenge for yield continues advancing.

Table 2. *Mean value of Seedling Fresh Weight (SFW), Seedling Dry Weight (SDW) and Vigor Index (II) during main and late planting day.*

Genotypes	FW		SDW		V(II)	
	Main	Late	Main	Late	Main	Late
Adda	0.0018abc	0.000755d	0.000125de	0.00027bcd	0.0125de	0.027bcd
94-003L	0.0019abc	0.00183abc	0.000255bcd	0.00027bcd	0.0255bcd	0.027bcd
R186	0.00153abc	0.00152abc	0.00022bcd	0.00021bcd	0.022bcd	0.021bcd
TILL-1760	0.00182abc	0.00163abc	0.000265bcd	0.000185bcd	0.0265bcd	0.0185bcd
96006L-984005	0.00194abc	0.00151abc	0.000325ab	0.000185bcd	0.0325ab	0.0185bcd
Alemtena	0.00169abc	0.00173abc	0.00027bcd	0.000215bcd	0.027bcd	0.0215bcd
Alemaya	0.00205abc	0.00128cd	0.00025bcd	0.000235bcd	0.025bcd	0.0235bcd
Dz-2012-Ln-238	0.00185abc	0.00191abc	0.000265bcd	0.000255bcd	0.0265bcd	0.0255bcd
Gudo	0.00162abc	0.00193abc	0.000295abcd	0.000285abcd	0.0295abcd	0.0285abcd
ILL-2178	0.00178abc	0.0016abc	0.000305abcd	0.000175bcd	0.0305abcd	0.0175bcd
X-125-54	0.00178abc	0.00178abc	0.000255bcd	0.000255bcd	0.0255bcd	0.0255bcd
09583227-04	0.00153abc	0.00136bcd	0.000165bcde	0.00014cde	0.0165bcde	0.014cde
Jiru	0.00197abc	0.00185abc	0.000305abcd	0.000175bcd	0.0305abcd	0.0175bcd
Beredu	0.00218a	0.00194abc	0.000445a	0.00032abc	0.0445a	0.032abc
Challew	0.00165abc	0.00164abc	0.000275abcd	0.000165bcde	0.0275abcd	0.0165bcde
Dz2012-Ln0050	0.00187abc	0.00156abc	0.000245bcd	0.000235bcd	0.0245bcd	0.0235bcd
ELL-142	0.00149abc	0.00132cd	0.000165bcde	0.000155bcde	0.024bcd	0.0155bcde
Teshale	0.00211ab	0.00194abc	0.0003abcd	0.00027bcd	0.03abcd	0.027bcd
Derash	0.00191abc	0.00131cd	0.000255bcd	0.000325ab	0.0255bcd	0.0325ab
Mean	0.00035		8.53e-05		0.0085	
LSD	19.3036		30.24		29.24	
CV	0.001623		0.0002346		0.0234	

Note: Same letter in same column not significantly different between genotypes.

Seed germination percent and vigor index (I) were not affected by both planting dates and species (p > 0.05) (Table 3). There was no interaction between planting days and genotypes. There was no germination problem between the tested genotypes on main and late planting, which indicates the absence of dormancy planting after a five-month storage period. However, regardless of vigor index (I) the higher on the genotype X-125-54 (11.15) on main planting days and the lower on the genotype Adda (4.65) on late planting dates (Table 3). However, there was no significant difference (p > 0.05) and no interaction effect between planting dates and species. This seed phenological pattern suggests that chilling is required before germination is possible [26, 27].

3.5. Broad Sence Heritability

The study shows that the heritability value of shoot length, root length, and seedling fresh weight equals zero was the variation due to environmental it had no genetic effect after five months of storage both main and late planting day (Table 5). The application of mean square on the tested locations revealed very highly significant differences in traits of seedling fresh weight, seedling dry weight, vigor index II, and speed of germination index. However, the mean square of the tested genotypes between traits like seedling dry weight and vigor index II at P < 0.01.

In general, our results in overall arrangements of different planting dates affect seed maturity at harvest it also influences all readily measurable seed quality traits. The seed's physiological maturity (maximum seed dry matter accumulation) and seed water content represent key considerations for identifying the optimum time for harvesting. The stage of seed maturity at harvest is also the main determinant for seed vigor [28], a trait defined as the sum of those properties of seeds that their ability to germinate and establish seedlings across diverse environmental conditions [29]. Harvesting before seed physiological maturity may result in low vigor science, seed vigor characteristics have been acquired, whereas harvesting too late may decrease enzymatic activity and gene expiration and increase the risk of shattering, the seed deterioration due to unfavorable weather conditions [30]. Seed harvest time is just one of the native elements of the seed supply chain [31]. The other elements are processing (cleaning and quality testing [32]), storage, and seed enhancement (treatments applied to the seed to enhance germination [33]).

Table 3. *Result of Germination Percent (G%) and Vigor Index (I) on Lentil Varieties after five-month storage.*

Genotypes	G%		VI(I)	
	Main	Late	Main	Late
Adda	100[a]	100[a]	9.2[a]	4.65[a]
94-003L	100[a]	100[a]	9.15[a]	9.15[a]
R186	100[a]	100[a]	7.65[ab]	9.15[a]
TILL-1760	100[a]	100[a]	8.4[a]	8.55[a]
96006L-984005	100[a]	100[a]	9.35[a]	9.65[a]
Alemtena	100[a]	100[a]	9.25[a]	8.95[a]
Alemaya	100[a]	100[a]	8.85[a]	7.95[a]
Dz-2012-Ln-238	100[a]	100[a]	8.35[a]	8.5[a]
Gudo	100[a]	100[a]	8.35[a]	8.6[a]
ILL-2178	100[a]	100[a]	9.05[a]	8.2[a]
X-125-54	100[a]	100[a]	8.7[a]	9.05[a]
09583227-04	100[a]	100[a]	11.25[a]	10.15[a]
Jiru	100[a]	100[a]	9.4[a]	9.15[a]
Beredu	100[a]	100[a]	9.35[a]	9[a]
Challew	100[a]	100[a]	9[a]	9.5[a]
Dz2012-Ln0050	100[a]	100[a]	8.85[a]	8.85[a]
ELL-142	100[a]	100[a]	8.1[a]	8.35[a]
Teshale	100[a]	100[a]	8.55[a]	8.65[a]
Derash	100[a]	100[a]	9.675[a]	9.45[a]
Mean	1.81e-13		1.21	
LSD	11.77		17.74	
CV	97.43		8.4	

Note: Same letter in same column not significantly different between genotypes.

Table 4*. Effect of Main (Factor A) and Late (Factor B) planting in seedling traits.*

Character	Sources of Variation			
	Factor A (Main planting)	Factor B (Late planting)		
	Genotype	Genotype	A*B	Error
Shoot Length (SL)	0.00177***	0.000041	0.00013821	0.000222
Root Length (RL)	0.00192***	0.000762	0.000246	0.000465
Seedling Fresh Weight (SFW)	7.3338e-07***	8.1204e-07**	1.0091e-07	9.8160e-08
Seedling Dry Weight (SDW)	2.0682e-08***	2.7011e-08*	5.2139e-09	5.3754e-09
Vigor index I [VI(I)]	17.7615***	0.4133	1.3821	2.2235
Vigor Index II [VI(II)]	2.0682e-04***	2.7011e-04*	5.2139e-05	5.3754e-05
Speed of Germination Index (SGI)	23.4026***	6.4960**	0.8512	0.7158

Note: * shows that = significantly different; ** shows that = highly significantly different; *** = Very highly significantly different.

Table 5*. Broad-sense heritability and Mean square of Lentil seed planting during main and late planting time.*

Character	Sources of Variation			
	Heritability	Mean square		
		Rep (Environment)	Genotype	Error
Shoot Length (SL)	0	0.00038340**	0.00013906*	0.00007244
Root Length (RL)	0	0.00155946*	0.00027407	0.00032141
Seedling Fresh Weight (SFW)	0	4.3661e-07***	1.1859e-07*	6.1450e-08
Seedling Dry Weight (SDW)	nan	3.0493e-08***	8.4025e-09**	3.6272e-09
Vigor index I [VI(I)]	0.187	3.8340**	1.3906*	0.7244
Vigor Index II [VI(II)]	non	3.0493e-04***	8.4025e-05**	3.6272e-05
Speed of Germination Index (SGI)	0.136	10.3868***	0.7901	0.4848

Note: * shows that = significantly different; ** shows that = highly significantly different; *** = Very highly significantly different.

4. Conclusions and Recommendations

The differences in genotypes in vigor and other seedling traits due to the quality differences which were caused by planting dates. Based on the result, the Germination Percent was not affected by planting dates (sowing dates), however, tested Lentil genotypes can maintain a decent germination percentage and perform better at the main planting day (17/August/2021 up to 02/September/2021) it had a significant difference in seedling growth traits such as fresh and dry weight, shoot and root length, sped of germination index finally on the vigor. It concludes that around central Ethiopia lentil seeds planted from the mid-August up to the first of September had better performance. In addition, the reduction of water interferes with the water absorption process by different genotypes, it affects the germination, and vigor of seedlings. From the tested germination-related traits under changing environments (main and lately planting date) greatly depend on the ability of different genotypes to tolerate water logging during planting, then heat, and moisture stress. These genotypes identified as tolerant to water logging and stress on the Beredu and R-186 can be recommended in the breeding program compared to other tested genotypes.

Abbreviations

SL	Shoot Length
RL	Root Length
SFW	Seedling Fresh Weight
SDW	Seedling Dry Weight
VI (I)	Vigor Index One
VI (II)	Vigor Index Two
SGI	Seedling Germination Index
M	Meter
Ta	Adda
T94-003L	94-003L
TR186	R-186
TILL-1760	ILL-1760
T96	96006L-984005
Talt	Alemtena
Tal	Alemaya
Tln238	Dz-2012-Ln-238
TG	Gudo
TILL2178	ILL-2178
TX	X-125-54
T09	09583227-04
TJ	Jiru
TB	Beredu
Tca	Challew
TDz	Dz2012-Ln0050
TE	ELL-142
Tte	Teshale
Tde	Derash

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Author Contributions

Melkam Anteneh: Data curation, Investigation, Writing – original draft, Writing – review & editing

Asnake Fikre: Methodology, Supervision, Visualization

Tileye Feyissa: Supervision, Writing – review & editing

Data Availability Statement

The data used to support the findings of this study are available from the corresponding authors up on request.

Conflicts of Interest

The authors declare no conflicts of interest.

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