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Interrelations of seed quality, seedling establishment and early phenological stages in maize

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Abstract

Seed maturity and level mechanical damage are among the critical factors that influence seed quality. In many studies where the effects of these factors on seed quality on the one hand and of seed quality on crop performance on the other define, the two have been examined independent on the other using different genetic materials. We examined the influence of genotype, seed maturity, mechanical operations associated with seed processing, seed size, storage temperature and duration of storage on field establishment and early phenological growth of maize seedling using identical genetic materials. Seeds of two single-cross hybrids were harvested at eight stages during maturation in 2000 and 2001. Different combinations of manual and mechanical seed processing operations were also tried. Hybrid differences played a greater role in determining the speed of emergence and seedling establishment. Mechanical processing impacted seed quality negatively than seed maturity and this was observed as reduction in final field emergence and delayed speed of emergence with duration of storage. Neither maturity stage nor method of seed processing altered the pattern of phenological development. The most critical and longest stage of maize seedling establishment was the transition from the fourth to the fifth leaf stage and hybrid differences influenced the interval more than seed maturity or mechanical damage.

Key words: seed processing, maturity, grading, mechanical damage, growth arres

Zusammenfassung

Zusammenhang zwischen der Saatgutqualität, der Keimlingsentwicklung und den frühen Entwicklungsstadien von Mais

Für die Keimqualität von Mais sind die Kornreife und der Grad der mechanischen Beanspruchung kritische Faktoren. In einer Reihe von Experimenten mit verschiedenen Maisgenotypen wurden diese Einflussgrößen auf die Keimqualität als solche und der Einfluss der Keimqualität auf die Pflanzenetablierung im weiteren analysiert. In den Untersuchungen wurden Parameter von Genotypen unterschiedlicher Keimreife und Korngröße mit verschiedenen mechanischen Verfahren der Saataufbereitung sowie Lagertemperatur und -dauer kombiniert. Diese Untersuchungskombinationen wurden auf die Keimentwicklung und die frühen Entwicklungsstadien geprüft. Als Untersuchungsmaterial dienten verschiedene Einzelhybriden von Mais, die zu acht verschiedenen Reifestadien geerntet wurden. Die Ergebnisse zeigen, dass die Genotypen einen maßgeblichen Einfluss auf die Keimung und Keimlingsentwicklung zeigen. Mechanische Beanspruchung während der Saatgutaufbereitung reduziert unabhängig vom Reifegrad der Karyopsen generell Keimqualität, welches sich in einer eingeschränkten Keimlingsentwicklung niederschlägt. Dieses Situation verschärft sich noch mit zunehmender Lagerdauer. Der Übergang vom vierten zum fünften Blatt bleibt während der Keimlingsentwicklung (Wechsel von der heterotrophen zur autotrophen Phase) unabhängig von dem Reifegrad der Sorten oder der mechanischen Aufbereitung die kritischste Phase in der Etablierung eines Feldbestandes.

Schlüsselworte: Saatgutbehandlung, Reifegrad, Aufbereitung, mechanische Schäden, Entwicklung

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1 Introduction

Seed is a critical and the most important external input in the production of field crops because it is the only living input with quantifiable response to levels of other inputs. Therefore, quality of seeds is an important consideration because it influences field emergence, seedling establishment and subsequent performance of the resultant adult plant (Ellis 1989; 1992; TeKrony et al. 1989a). Botanical seed play different roles as plant propagule for crop production, food for human, feed for livestock and industrial raw materials. For agronomic purposes therefore seed quality is the sum total of all seed properties that affect its performance on farmers' fields (Hampton 2002).

There is a general consensus that when plant population per unit area is not limiting and quality of seed planted is high, then seed quality has no direct relationship with yield of grain crops including maize (TeKrony et al. 1989a, b; TeKrony and Egli 1991; Finch-Savage 1995). Nevertheless, there is a direct relationship between seed quality, emergence, speed of emergence, establishment and early growth of resultant seedlings and these attributes in turn have a direct impact of crop yield. Maize seeds harvested before physiological maturity, defined as the point when seed dry weight was maximum, established seedlings faster under field conditions than those harvested at or after (Bennett et al. 1988; Ajayi and Fakorede 2000). Size of maize seed is related to quality (Hill et al. 1999) but the significant effect of seed size on maize seedling growth in the field is limited to the early stages when seedlings depend on seed reserves for growth (Hawkins and Cooper 1979; Shieh and McDonald 1982; Verheul 1992; Bockstaller and Girardin 1994; Martinelli and Carvalho 1999; Revilla et al. 1999). Differences attributable to maize seed size decline with plant development and are usually lost during stem elongation (Nafziger 1992; Bockstaller and Girardin 1994). In spite of this wealth of information, little is known about the influence of maize seed quality on early phenological growth. There is also need for a re-assessment of the relationship between seed quality, seedling establishment and early seedling growth because the concept of seed quality is being re-defined and because these relationships were examined for different component of seed quality independent of one another despite that the components are interdependent in their influence on field performance. Consequently, we examined the influence of genotype, seed maturity, mechanical operations associated with seed processing, seed size, storage temperature and duration of storage on early maize seedling growth using identical genetic materials.

2 Materials and methods

2.1 Seed production

Two commercial single cross hybrids, Ulla and Benicia, were used for this investigation. Seeds of Ulla and Benicia were harvested at eight different stages (HN1-8) during development and maturation in 2000 and 2001. Similarly, seeds of the two hybrids were harvested manually and mechanically in combination with other processing operations in order to evaluate the contribution of each operation, solely and cumulatively, to seed quality in relation to field performance. A third hybrid, Dea, known to be tolerant to mechanical damage was included as a control. All seeds were stored in freezers and storage chambers maintained at -20 °C and +20 °C, respectively.

2.2 Field trials

Field emergence and seedling establishment were evaluated in replicated trials in both 2001 and 2002 at the Experimental Station of the Federal Agricultural Research Centre (FAL), Braunschweig, Germany. Seed lots kept in -20 °C were brought out at least three weeks before seeding in order to allow them equilibrate before seeding (Ajayi and Fakorede 2001). Seeds were treated with Aatiram powder (Stähler Agrochemie GmbH & Co. KG, Stade; active ingredient 67 % Thiram) at the rate of 300 g powder per 100 kg seed. Fields were fertilized with 700 kg ha^{-1} Thomaskali (7K:21P:3Mg) before seeding. Seeding was done on May 9 2001 and May 22 2002, with one plant per stand spaced 0.625´0.175m in 4-row plots. 60 kg ha^{-1} fertilizer was applied as Calcium-Ammonium-Nitrate about a week after seeding.

2.3 Data collection

Data were collected from competitive plants in the two middle rows. Emergence counts were made regularly between 6 and 17 days after seeding in both years and final field emergence counts were expressed as percentage of the total number of seeds planted. Emergence index and emergence rate index were calculated according to the method of Fakorede and Agbana (1983) as follows:

$$\text{Emergence index (EI)} = \frac{\sum(Nx)(DAS)}{\text{Total number of seedlings that emerged on final count}}$$

Where

Nx is the number of seedlings that emerged on day after seeding,

DAS is days after seeding.

Emergence rate index (ERI) =

$$\frac{\text{Emergence index}}{\text{Emergence \% (0-1 scale)}}$$

Given the observed rate of emergence (emergence index), emergence rate index indicates the time required to attain 100 % field emergence if all seeds had emerged. Beginning from day of emergence, 10 competitive plants were marked and scored for phenological stages on a daily basis using the BBCH scale (Meier, 1997). A plot was scored for each stage when at least 7 out of the 10 marked plants had reached the stage.

In both trials years, soil temperature at 5 cm depth was consistently higher than air temperature (figure 1). A similar pattern of changes in air temperatures was observed in both years. Rainfall was more evenly distributed in 2002 than 2001. For seed germination, emergence and early seedling establishment, there were significant differences in seed bed conditions between the two trial years. 2001 was dry and seed bed conditions were more stressful for emerging seedlings than in 2002. The fall of temperature

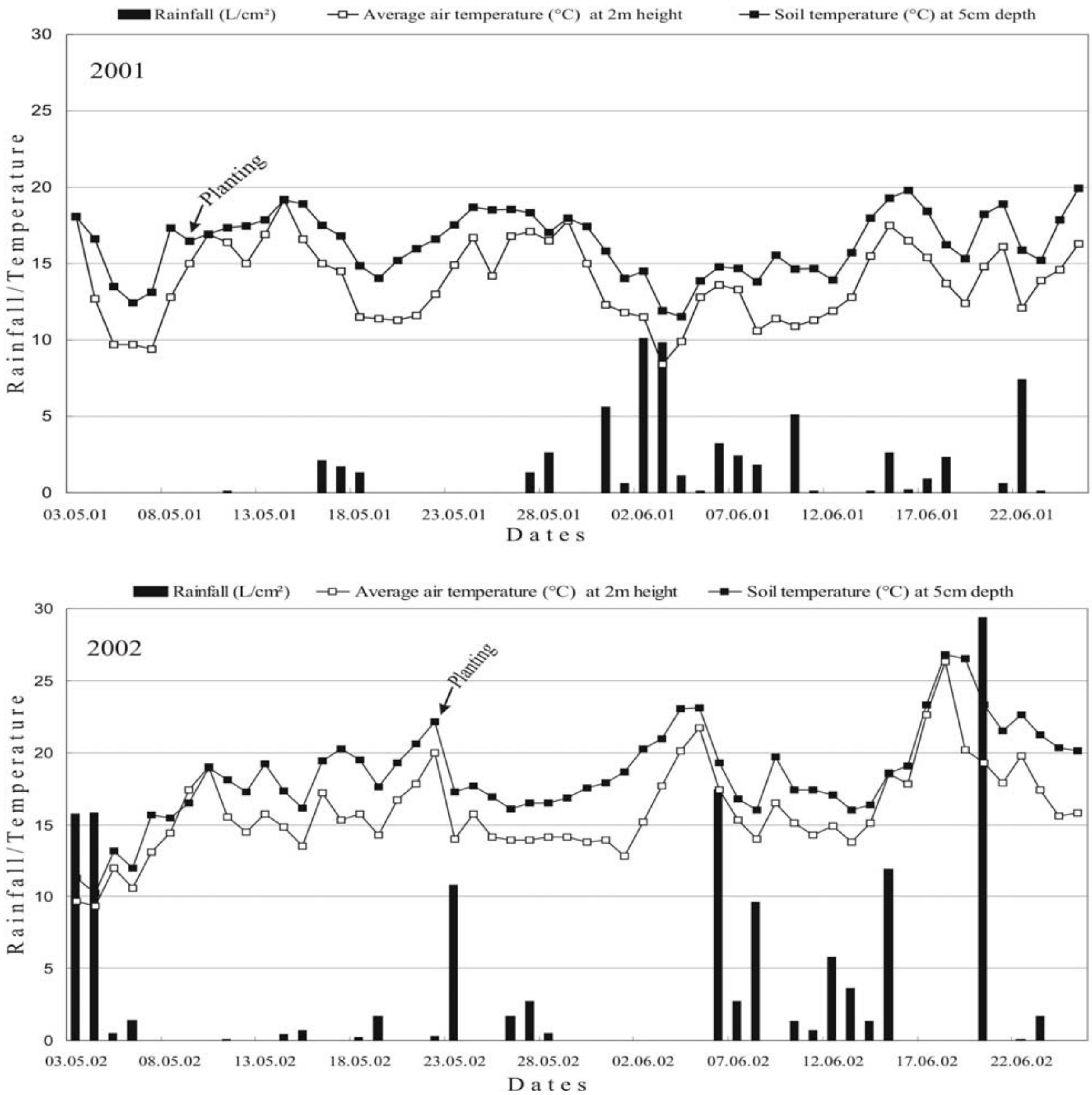


Figure 1:
Pertinent weather factors during field trials at Braunschweig, Germany

to around 10 °C in early June 2001 affected seedling growth in the first field trial and resulted in abnormal leaf formation. The response of the treatments was so wide that observable differences could not be attributed to the treatments alone. Consequently, phenological data collection was terminated after the emergence of the 5th leaf. In 2002, the trial was severely damaged by hail and storm at about the 8th leaf stage. Thus, only data for phenological development up to emergence of the 5th leaf (stage 15 on the BBCH scale, Meier, 1997) in 2001 and of the 7th leaf (stage 17) in 2002 trials for all treatments were reported. Data for stages 16 and 17 in 2002 were included because important and significant phenological changes were observed after stage 15.

2.4 Statistical analysis

Data from the field trials of all seed samples were analysed according to seed production year because of differences in duration of storage and because this form of analyses provided more useful information than the combined analysis. All statistical analyses were done with Statistical Analysis System (SAS) software version 8.1 (SAS Institute, 1999). Analysis of variance was done using General Linear Model (GLM) procedures to detect differences between treatments. Variations in each dependent variable were partitioned into 2 components: variations attributable to known (experimental factors and their interactions) and unknown (random error) components based on a fixed

Table 1:
Mean differences in field emergence characteristics across hybrids, seed maturity and storage

Factor	Level	Overall mean		
		FFE (%)	EI (DAS)	ERI (DAS)
Seeds produced in 2000 (mean for 2 trial years)				
Hybrid	Ulla	94.18a	8.24a	8.89a
	Benicia	95.51a	7.82b	8.24b
Storage duration/	7 months	95.95a	7.57a	8.01a
Trial year	19 months	93.18b	8.72b	9.39b
Seeds produced in 2001				
Hybrid	Ulla	93.42a	8.67a	9.32a
	Benicia	92.00a	8.59b	9.39a

For each factor, values in a column with different letters are significantly different at $P<0.05$
DAS = Days after seeding

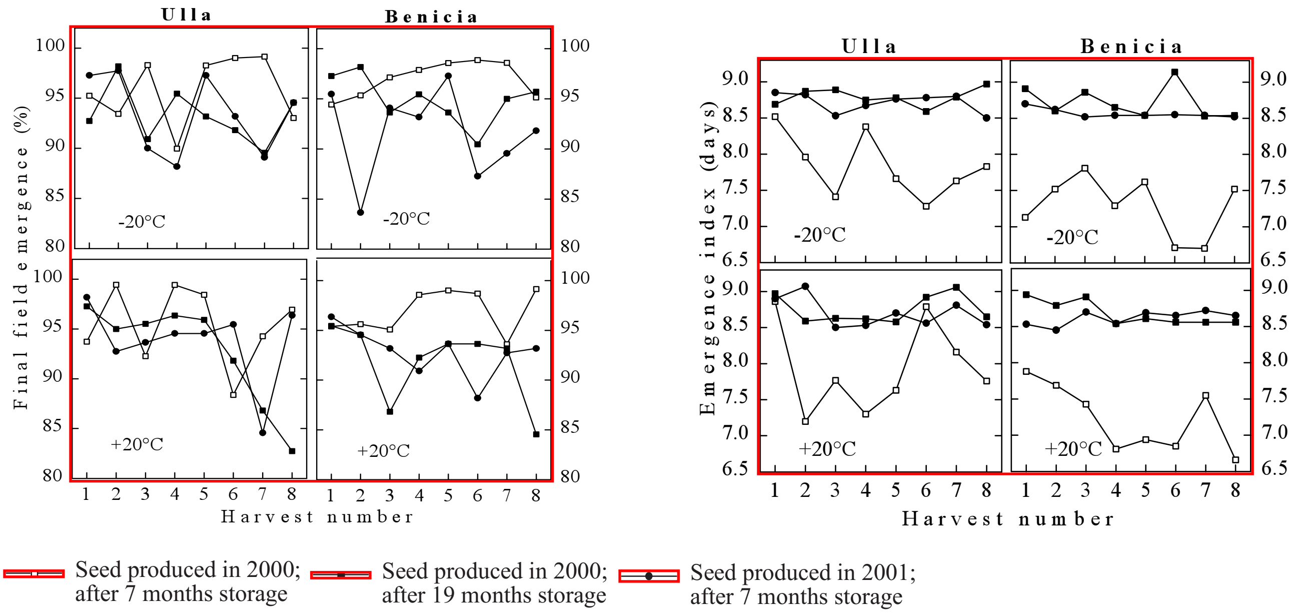


Figure 2:
Field emergence of seed harvested at different stages of maturity in two production years

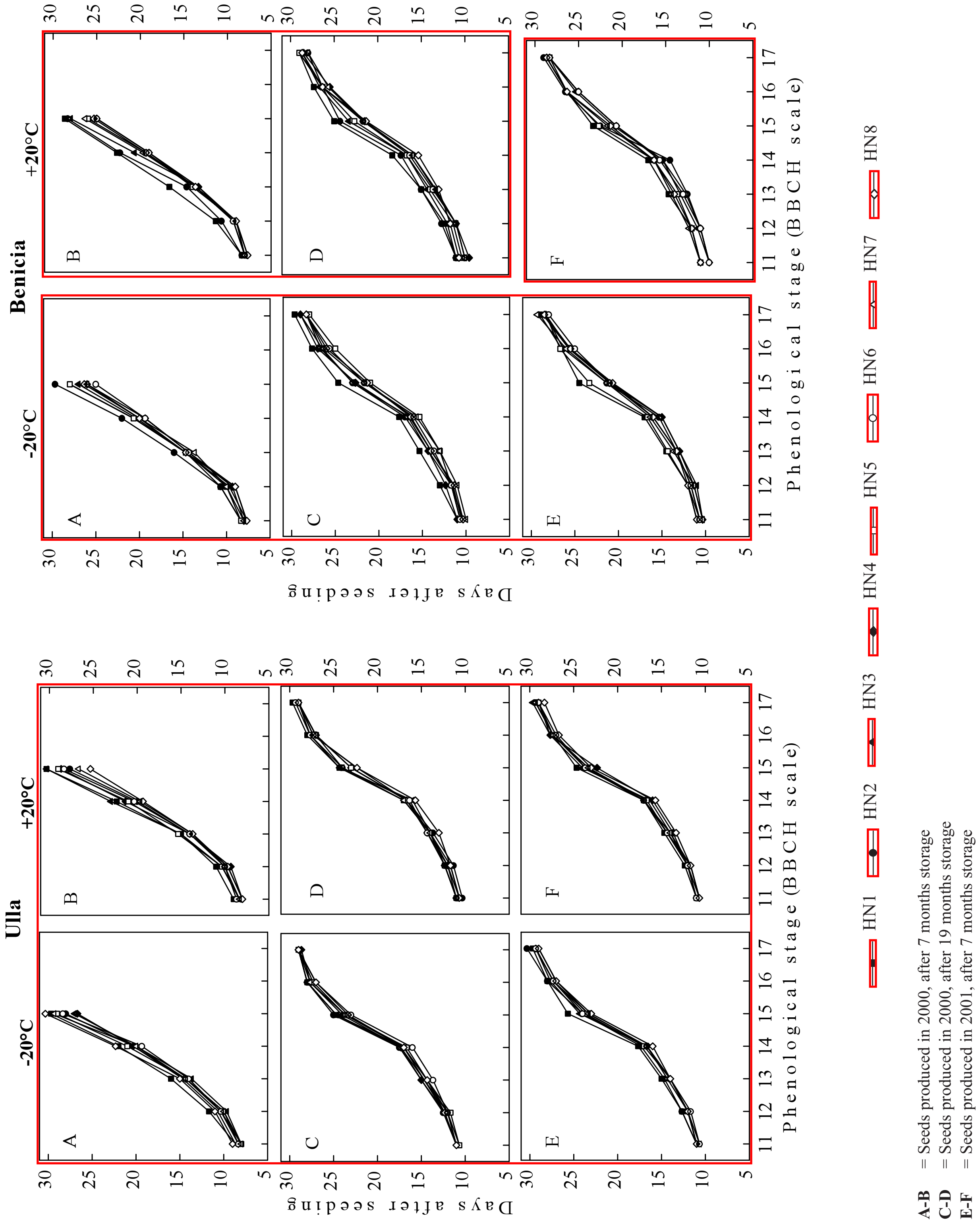


Figure 3:
Influence of seed maturity, storage condition and duration on phenological development of Ulla seedlings

effects model. The general linear model for each analysis of variance can be written as

$$y_i = \beta_0 x_{01} + b_1 x_{1i} + ... + \beta_k x_{ki} + e_i \qquad i = 1,2,\ldots,n$$

where

y_i is the response or dependent variable for the *i*th observation,
β_k are unknown parameters to be estimated, and
x_{ki} are treatment variables (SAS Institute, 1999).

3 Results

3.1 Effect of seed maturity

Averaged over the other factors, differences between the hybrids in final field emergence (FFE) of seeds produced in 2000 were negligible but Benicia consistently emerged faster than Ulla by a significant margin ($P<0.05$), irrespective of seed production year (table 1). Differences due to storage temperature were negligible ($P>0.05$) (data not shown). Irrespective of seed maturity, hybrid and storage temperature, differences between field emergence characteristics in both trial years were significant ($P<0.05$). When compared with data after 7 months storage, FFE after 19 months storage was reduced by 2.32 %, and speed

Table 2:
Mean differences for field emergence characteristics of seeds produced in 2000

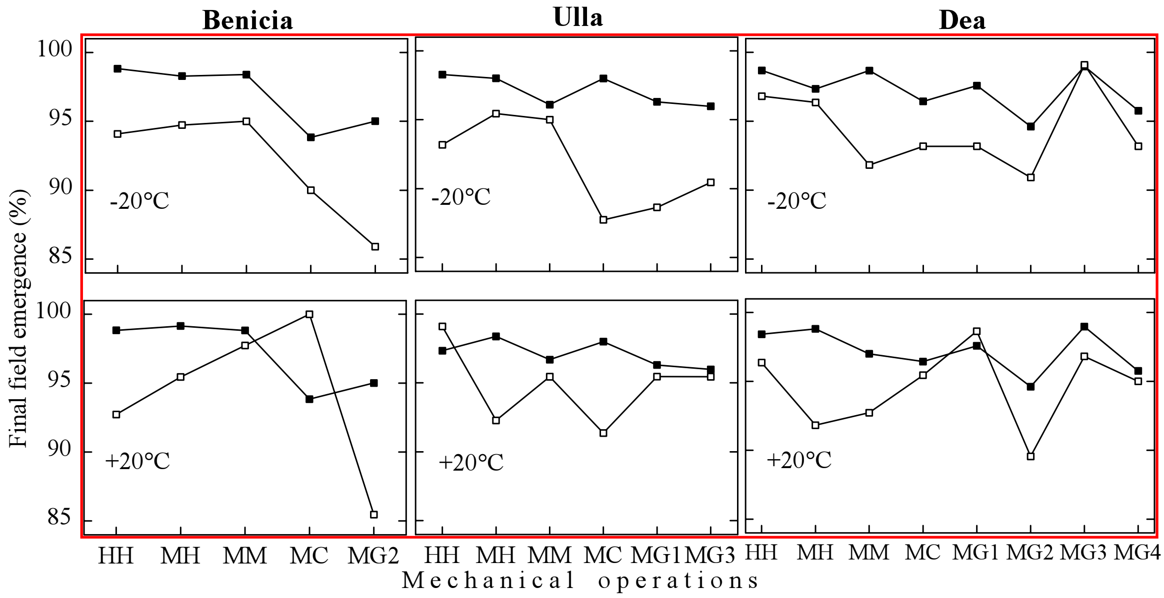
Hybrid	Factor	Level	Mean FFE	Mean EI	Mean ERI
Ulla	Stage	No significant differences between means (data not shown)			
	Storage Temperature	-20 °C	94.80a	8.22a	8.75a
		+20 °C	93.56a	8.26a	9.03a
	Storage Duration	7 months	94.95a	7.88a	8.50a
		19 months	93.01a	8.77b	9.47b
Benicia	Stage	No significant differences between means (data not shown)			
	Storage Temperature	-20 °C	96.18a	7.83a	8.18a
		+20 °C	94.84a	7.81a	8.30b
	Storage Duration	7 months	96.95a	7.26a	7.52a
		19 months	93.35b	8.66b	9.32b

For each factor, values in a column with different letters are significantly different at $P<0.05$

Table 3:
Mean differences for phenological development across hybrids, seed maturity and storage

Factor	Level	Overall mean (days after seeding) 11	12	13	14	15	16	17
Seeds produced in 2000								
Hybrid	Ulla	9.57a	11.16a	14.27a	18.67a	25.93a	27.48a	29.04a
	Benicia	9.23b	10.69b	14.18a	18.43a	24.71b	26.38b	28.62b
Storage duration	7 months	8.16a	9.96a	14.36a	20.43a	27.46a	-	-
	19 months	10.69a	11.88b	14.09b	16.61b	23.12b	26.93	28.84
Seeds produced in 2001								
Hybrid	Ulla	10.88a	12.02a	14.17a	16.71a	23.71a	27.38a	29.27a
	Benicia	10.59b	11.61b	13.54b	15.89b	21.65b	25.89b	28.53b

For each factor, values in a column with different letters are significantly different at $P<0.05$



HH: Manually harvested, shelled and cleaned seeds
MH: Mechanically harvested but manually shelled and cleaned seeds
MM: Mechanically harvested and shelled but manually cleaned seeds
MC: Mechanically harvested, shelled, cleaned but ungraded seeds
MG: Mechanically harvested, shelled, cleaned and graded seeds
MG1-Medium, flat seeds MG2-Medium, round seeds, MG3- Large, flat seeds, MG4- Large, round seeds

Figure 4:
Influence of seed processing operations and storage on field emergence

of emergence delayed by 1.15. But EIs after 19 months storage of seeds produced in 2000 were of the same magnitude as EIs for seeds produced in 2001 stored only for 7 months before field trial (figure 2). There was a strong interaction for final field emergence between hybrids, maturity stages and storage temperature. The differences in FFE between the different maturity stages were not statistically significant (data not shown) but the range was more than 5 %. There were more significant differences in seedling establishment of Benicia than that of Ulla seeds. Both hybrids did not shown any response to storage temperature but showed response to duration of storage with EI after 19 months being greater than after 7 months (table 2). Additionally, final field emergence of Benicia was significantly reduced by duration of seed storage before seeding. All treatment differences were not significant for seeds produced in 2001 (data not presented). Hybrid differences observed in speed of emergence earlier noted above were carried on to phenological development with Benicia consistently attaining some of the phenological stages earlier than Ulla. (table 3). Phenological development was slower and intervals between the stages were wider after 19 months storage compared to after 7 months storage. Stage 11 was reached earlier during the trial conducted after 7 months compared to after 19 months storage but stages 14 and 15 were reached much earlier after 19 than after 7 months storage.

Across all treatments, stage 14 to 15 took the longest time, 5.75-7.25 days (figure 3). With the exception of the persistent significant hybrid differences, treatment differences began to disappear after stage 15. A flush of leaves were formed and all treatments reached stages 16 and 17 within 4 days and 3 days, respectively. Plant appearance also changed from light to deep green after stage 15. In general, differences between the harvest numbers within a hybrid were wider and significant (P<0.05) for Benicia than for Ulla. Irrespective of seed production year, differences between the different maturity stages at which seeds were harvested were not significant.

3.2 Effect of mechanical seed processing operations:

Differences between FFE and ERI of the two hybrids were not significant but all the hybrids were significantly different (P<0.05) in EI (table 4). EI for Benicia was the lower than the corresponding value for Ulla. Seeds stored at +20 °C had a marginal but significantly higher emergence than those stored at -20 °C. Overall FFE average after 19 months storage was about 4.64 % lower than after 7 months storage, EI prolonged by 1.50 days and ERI by

2.06 days compared to 2.77 %, 1.15 days and 1.38 days, respectively, for seed maturity lots. Differences due to mechanical seed processing operations were largely non-significant (P>0.05). But compared to manually processed and ungraded seeds (HH), round (MG2) seeds had the significantly least emergence percentage and EI. Emergence

Table 4:
Mean differences in field emergence characteristics across hybrids, storage and mechanical operations

Factor	Level	FFE (%)	EI (DAS)	ERI (DAS)
Hybrid	Ulla	95.58a	7.94a	8.33a
	Benicia	94.85a	7.70b	8.20a
Storage Temperature	-20 °C	94.32a	7.86a	8.42a
	+20 °C	96.24b	7.80a	8.12b
Storage duration	7 months	97.06a	7.25a	7.47a
	19 months	92.42b	8.75b	9.53b
Mechanical Operation	HH	96.90a	7.88a	8.16a
	MH	96.81ab	7.85a	8.41a
	MM	95.16a	7.87a	8.15a
	MC	94.17ab	7.79a	8.31a
	MG1	94.60ab	7.79a	8.28a
	MG2	91.93b	7.54b	8.26a
	MG3	94.77ab	7.99a	8.45a

HH: Manually harvested, shelled and cleaned seeds
MH: Mechanically harvested but manually shelled and cleaned seeds
MM: Mechanically harvested and shelled but manually cleaned seeds
MC: Mechanically harvested, shelled, cleaned but ungraded seeds
MG: Mechanically harvested, shelled, cleaned and graded seeds
MG1-Medium, flat seeds MG2-Medium, round seeds, MG3- Large, flat seeds

Table 5:
Mean differences in phenological development combined for all factors

		Phenological stages (days after seeding)						
Factor	Level	11	12	13	14	15	16	17
Hybrid	Ulla	9.42a	10.92a	14.21a	19.04a	26.29a	27.72a	29.44a
	Benicia	8.98b	10.20b	13.65b	18.12b	24.40b	26.10b	28.57b
Storage temperature	-20 °C	9.27a	10.64a	13.92a	18.71a	25.41a	29.97a	29.09a
	+20 °C	9.17a	10.55b	13.98a	18.53a	25.45a	27.00a	29.00a
Storage duration	7 months	7.58a	9.20a	13.97a	20.77a	27.88a	-	-
	19 months	10.86b	11.98b	13.94a	16.47b	22.98b	26.98	29.11
Mechanical operations	HH	9.29a	10.75a	14.21a	18.96a	25.96ab	27.00a	29.25a
	MH	9.17ab	10.54a	13.83a	18.38ab	25.13b	26.67ab	28.58a
	MM	9.21ab	10.54a	14.00a	18.71a	25.14ab	26.75a	28.92a
	MC	9.21ab	10.50a	13.75a	18.42ab	25.13b	27.25ac	29.25a
	MG1	9.33a	10.75a	14.00a	19.08a	26.33a	27.67c	29.33a
	MG2	9.00b	10.00b	13.83a	17.83b	23.83c	26.17b	28.83a
	MG3	9.33a	11.08c	14.08a	19.00a	26.08ab	27.67c	29.33a

For each factor, values in a column with different letters are significantly different at $P<0.05$
HH: Manually harvested, shelled and cleaned seeds
MH: Mechanically harvested but manually shelled and cleaned seeds
MM: Mechanically harvested and shelled but manually cleaned seeds
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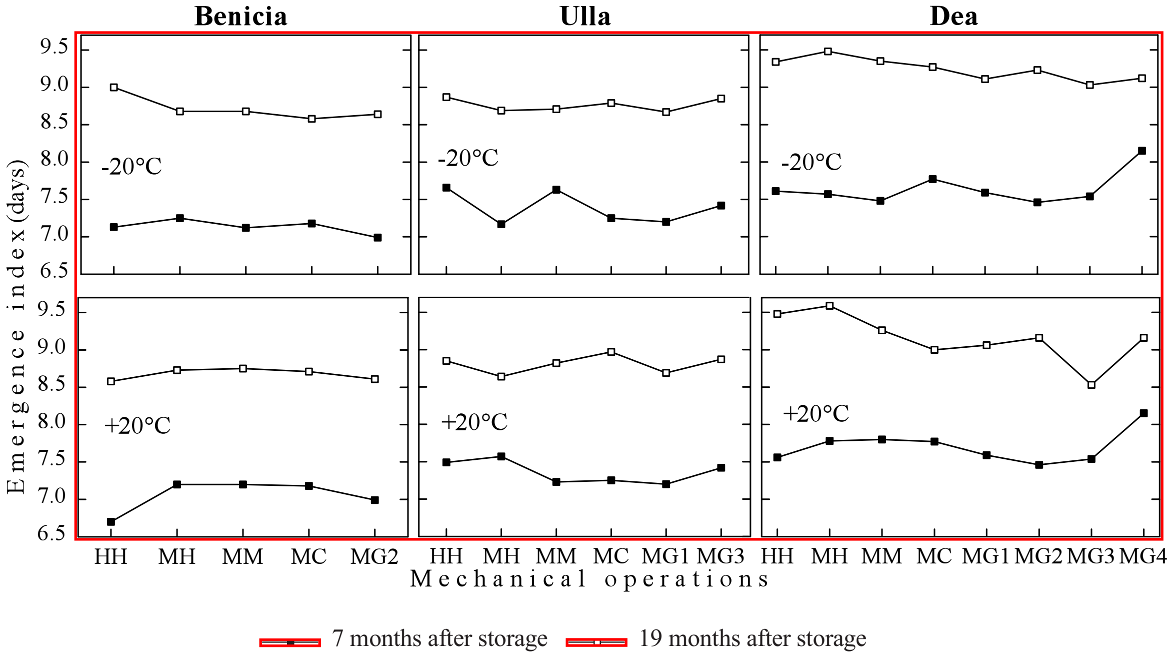

Figure 5:
Influence of seed processing operations and storage on speed of emergence

of MG2 seeds after 19 months storage fell sharply compared to after 7 months storage (figure 4) but its EI was comparable to those of others (figure 5). Even in Dea that had all seed sizes and shapes, reduction in the FFE of MG2 seeds was conspicuous. In all hybrids, there were differences in pattern of emergence between the storage temperatures. But variabilities in EI between the different operations were minimal though graded seeds tended to have lower EI.

Phenological development of Benicia was consistently faster than those of Ulla (table 5) and a significant difference between the two storage conditions was observed at stage 12, the stage at which emerging seedlings were producing the first leaf after emergence from the soil, with seeds stored at +20 °C attaining only stage 12 significantly earlier than seeds stored at -20 °C. Despite the delay of over 3 days in the commencement of phenological growth in 2002 (after 19 months storage) compared to 2001 (after 7 months storage), intervals between successive stages were shorter in 2002 such that the average duration to stages 14 and 15 was more than 3 days faster in 2002 compared to 2001 field trial. Differences between mechanical operations prior to grading were negligible (P>0.05). Though MG2 seeds had the lowest emergence potential (P<0.05), their rate of phenological development was significantly faster than the rate of phenological development of seeds manually processed and ungraded (HH). Generally, differences in phenological development between hybrids, seed processing operations and storage temperature and the intervals between stages were minimal (figure 6).

4 Discussion

Crop productivity depends on the availability of seeds with necessary quality traits that ensure speedy germination and emergence through the soil and successful establishment of a vigourous seedling capable of further growth into a productive mature plant. Seed maturity and level of mechanical damage are prominent among factors that influence the quality of a seed or seed lot. Mechanical damage accelerated the loss of seed quality during storage than seed maturity. The effect of mechanical damage is more visible as reduction in FFE and slower rate of development compared to seed maturity lots. The field trials of all seed maturity lots revealed minor and statistically negligible maturity differences in final field emergence. The differences in climatic conditions of both trial years was responsible for the large variations in EIs. Emergence commenced earlier in 2001 than in 2002 but continued over a longer time, 17 versus 12, days after seeding in 2001 compared to 2002. But variability in speed of emergence was not as dependent on storage temperature prior to seeding as it was on seed maturity. The two hybrids showed differences in sensitivities to storage temperature and duration before seeding- Benicia was more sensitive to storage duration before seeding than Ulla.

Ulla and Benicia seeds were uniform in shape, flat and round, respectively. But while Benicia seeds were graded into only one size (medium), Ulla seeds were graded into two sizes (medium and large). There was a distinct advantage of fast seedling establishment of medium round seeds over other graded and ungraded seeds. This advantage

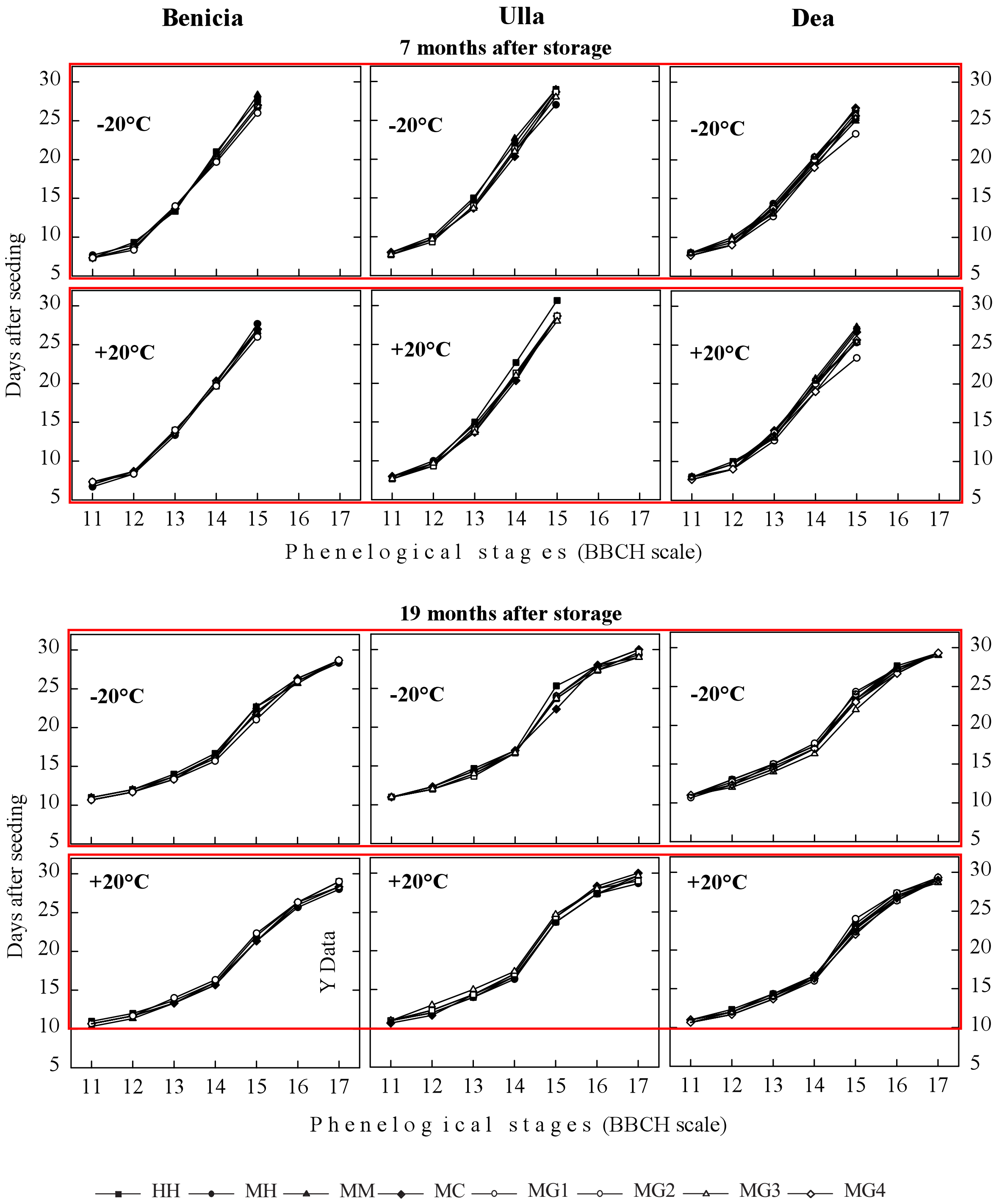

Figure 6:
Influence of seed processing operations and storage on phenological development

was not just a genotypic attribute because in Dea that had all the seed shapes and sizes, a similar trend was observed. But for all practical purposes, the advantage was negated by the reduction in the number of successfully emerged and established seedlings. Therefore, there was no practical advantage of mechanically processed and graded seeds over manually processed and ungraded seeds as Shieh and McDonald (1982) earlier reported. Martinelli and Carvalho (1999) reported that large hybrid seeds emerged more rapidly than small seeds. But in this study only medium and large seeds were used and by comparing size means, medium seeds emerged faster than large seeds. Our results suggest that speed of emergence was more hybrid dependent because despite differences in seed maturity and level of mechanical damage, Benicia seeds emerged faster than Ulla and Ulla was faster than Dea, and these differences were significant. This conclusion is in accord with that of Begna et al. (2001) that rates of seedling emergence and leaf appearance are strongly influenced by genotypic differences. Martinelli and Carvalho (1999) also reported that three-way hybrid crosses were less sensitive to differences in seed size than double cross hybrids.

The most persisting effect on phenological development and establishment of maize seedlings was hybrid differences. Though statistically negligible a difference of up to 2 days between the different maturity stages in reaching a given phenological stage, has practical significance for escape strategies, survival and successful establishment of seedlings under adverse seed bed and climatic conditions. But differences between manually and mechanically processed seeds, even when significant, were less than one day. These differences between seed maturity and mechanically processed seed lots can be attributed to the large variability in amount of reserves in maturity seed lots while each seed within mechanically processed lots were well filled before harvesting. Seed emergence and early seedling growth is dependent on these reserves (Deleens et al., 1984). Averaged over the three hybrids, speed of phenological development of round, medium seeds was also significantly faster than the speed for ungraded seeds on the one hand and than the speed for flat, large seeds (MG3) on the other. The pattern of phenological development agrees with Tollenaar and Dwyer (1999) that maize seedlings begin active photosynthesis after formation of the fourth leaf (stage 14).

Differences in weather and seedbed conditions exerted a significant effect on the interval between phenological stages, the most critical being the transition from the fourth to the fifth leaf stage. This relatively long intervening period was termed “growth arrest or crisis” by Deleens et al. (1984), a time when growth is temporarily suspended for about a week before the fifth leaf (stage 15) was formed. In all treatments and irrespective of speed of growth, this long period was conspicuous. Deleens et al. (1984) carefully demonstrated that this growth arrest affects both leaf and root developments and that even when active photosynthetic activities have commenced, there is still a preferential use of carbon from seed reserves for leaf development and molecules provided by photosynthesis for respiration. They suggested that the growth crisis period was for the setting up of translocative function of products from the leaves to the roots. Tollenaar and Dwyer (1999) termed this stage as the transition from heterotrophic to autotrophic growth. The conspicuous ‘growth arrest’ as we observed it agrees with these conclusions. Rate of leaf production after stage 15 was very fast, stem elongation also commenced and this was the time when differences due to maturity and to mechanical seed processing operations began to disappear. This implies that neither seed maturity nor mechanical damage altered pattern of phenological development in maize and their effects was only visible in intervals between the stages. Nafziger (1992) also did not observe any ‘visible’ differences in size at about the 4^{th} leaf stage among plants grown from different seed sizes and their mixtures. Similarly, Bockstaller and Girardin (1994) reported that differences in initial seedling growth as a result of seed size effect decreased during stem elongation and had disappeared before silking.

The lack of large, practically significant effect of mechanical operations and of seed sizes and shapes on maize seed emergence and seedling establishment under field conditions imply that damage to commercial, mechanically processed seeds can be avoided or at least minimized by eliminating grading, the operations causing the most damage (Ajayi 2003). Indeed, Nafziger (1992) proved that seed size is of no importance as a factor in maize production because it had no effect on the yield of maize hybrids, regardless of whether plantings were of uniform seed size or mixtures of seed sizes. Therefore, given the large contributions of grading to mechanical damage and the fact that grading only serves to make seed lots fit mechanical planter specifications, it will serve farmers’ and marketers’ carry over interests to avoid mechanical grading of commercial seed lots. In agreements with other workers cited above, this study showed that grading has significant negative influence on field emergence, speed of emergence and these effects would be magnified under unpredictable and harsh field conditions.

Summary

These results suggest that under favourable field conditions, maize seeds have in-built physiological mechanisms to partly compensate for differences in physiological status. Thus, the relative genotypic differences play a greater role in seedling establishment and phenological interval than the seed-to-seed differences in maturity and level of mechanical damage. Breeders need to be aware of the response of maize genotypes to inevitable factors such as duration and condition of storage that have an influence of quality of seeds. Every seed used in crop production passes through a period of storage because there is always an intervening period between seed production and seeding in the following season when field conditions are unsuitable for planting and seed must be stored.

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