STRESS CRACKING IN MAIZE (*Zea mays* L.) SEEDS

Alfredo B. Escasinas and Murray J. Hill·

Instructor, Department of Agronomy and Soil Science, Visayas State College of Agriculture, Baybay, Leyte, Philippines and Director, Seed Technology Centre, Massey University, Palmerston North, New Zealand.

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ABSTRACT

Maize hybrid D54 seeds were used to determine the effect of processing on stress cracking and the relationship between stress cracking in artificially dried seeds and loss of seed viability after storage. Considerable stress cracking occurred during the seed drying stage of processing. Some cracks significantly reduced seed germination after storage for 12 months. Cracks in the endosperm alongside or extending into the middle portion of the embryo as shown by x-ray analysis significantly decreased seed germination after storage. However, stress cracking did not reduce germination of seeds prior to storage. Visual cracks not detected by x-ray radiography and cracks outside the embryo did significantly decrease seed germination even after storage.

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KEY WORDS: Maize. *Zea mays* L. Seed cracking. X-ray radiography. Seed processing. Viability.

INTRODUCTION

Artificial drying is considered an essential part of the production system in commercial maize seed production. Newly harvested seeds are generally too wet for ordinary storage without reduction in seed moisture content to safe storage levels. As a result, the use of heated air in drying maize seeds has become a common practice by seed producers.

The use of heat, especially high temperatures results in rapid seed drying but this causes fissures in the endosperm termed as stress cracks by Thompson and Foster (1963). Stress cracking is brought about either by rapid shrinking of outer seed parts while the inner parts are still undried (Harrington, 1972) or by creation of a moisture gradient stress in the seeds during drying (Ekstrom et al., 1966).

Several investigators have shown the deleterious effects of seed damage on viability and storage performance of maize seeds (Wortman and Rinke, 1951; Livingston, 1952; Waelti and Buchele, 1969; Moore, 1972; Justice and Bass, 1978; Nikilov and Kirilov, 1983) and reported it to be a major cause of reduced seed germination (Pana, 1977).

Moore (1972) stated that seed damage may not cause immediate loss of seed viability but it becomes critical with seed age. Hence, seed germination reduction due to injury is often noticed only after seed aging.

This study presents the effect of processing on stress cracking in maize seeds and the relationship between stress cracking in artificially dried seeds and loss of seed viability after storage.

MATERIALS AND METHODS

Seeds of maize hybrid D54 which passed through different points of processing were examined for cracking either visually or by x- ray radiography using a Faxitron x-ray machine. The different processing points where seed samples were obtained include the following:

A - Hand harvested samples from the field

B - Intake to the processing plant

C - After husking

D - After ear drying

E - After shelling

F - After seed drying

Samples from B to F were machine harvested. The seeds (sample F) were artificially dried to about 12% moisture content at 30°C. Seed samples A to E were air-dried to the same moisture level. The original moisture content at harvest was about 27%.

To determine seed cracking, 50 sample seeds per treatment were set on the x-ray film. The same seeds were visually examined for cracking using a tungsten bulb filament.

To assess the independent effects of stress cracking levels on seed viability following storage, samples were taken from artificially dried seeds stored at about 20°C and 65% RH for 12 months. The seeds were x-rayed and examined for stress cracks. Subsamples of 4 x 50 seeds each with different stress cracking levels (0-70%) were tested for germination. Correlation analysis was done to determine the relationship between seed germination after storage and cracking levels.

Separate seed samples exhibiting different cracking positions were tested for germination. The artificially dried seeds stored for 12 months were examined to determine the precise location of internal cracks as revealed by x-ray photographs. Samples of 25 x 3 seeds of each type or position of cracks were compared to determine their effect on seed viability after storage. The different types or positions of cracks are as follows:

A - No cracks (control)

B - Visual - Crack seen visually but not detected by x-ray

C - Position 1 - Crack with its length situated outside the embryo as detected by x-ray.

D - Position 2 - Crack along the side of the embryo as detected by x-ray

E - Position 3 - Crack along the middle portion of the embryo as detected by x-ray

RESULTS AND DISCUSSION

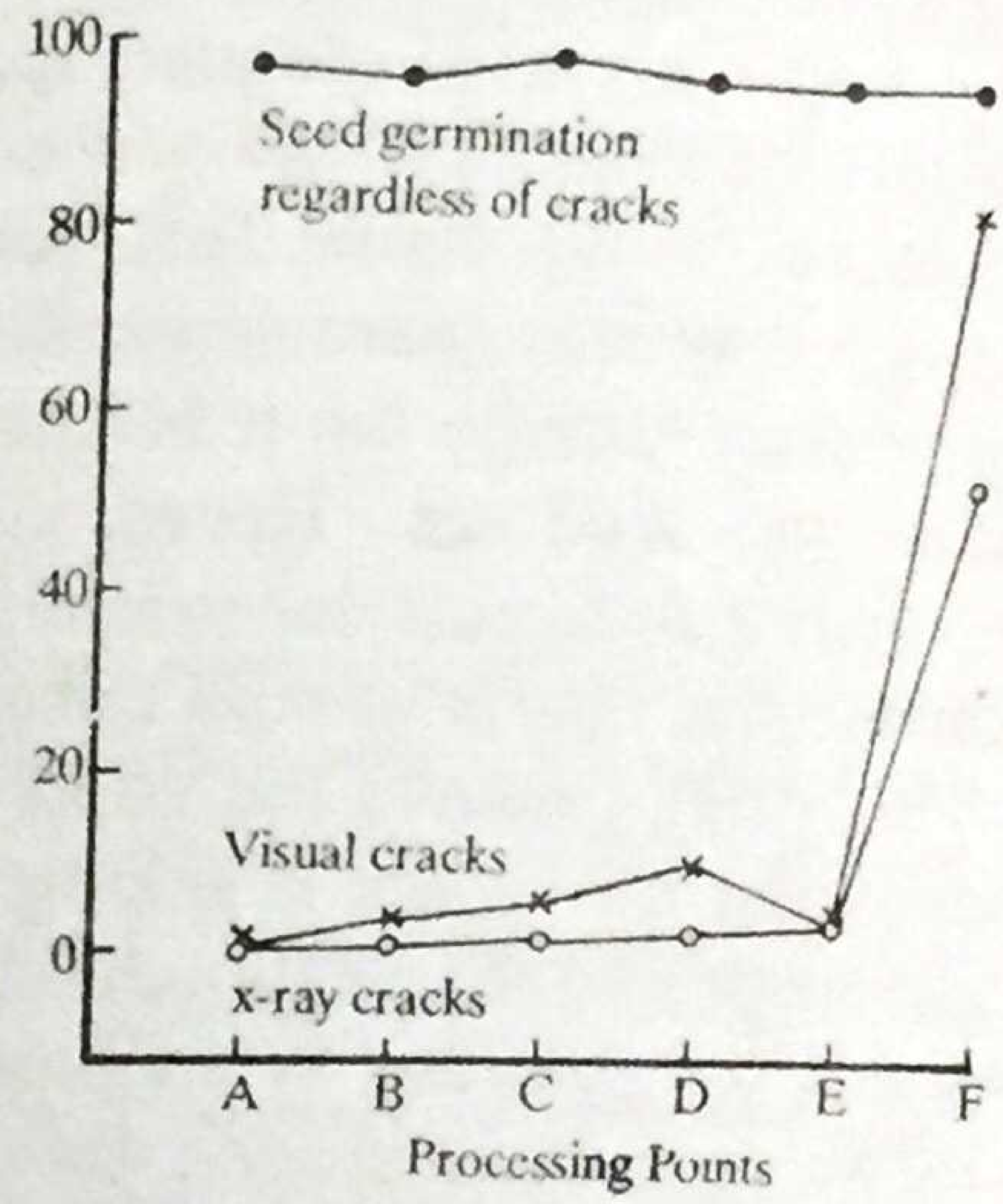
Occurrence of Stress Cracking

Large amounts of stress cracks were associated with the seed drying stage of processing (Fig. 1). Stress cracks were not detected after x-ray analysis of sample seeds obtained prior to drying. Internal stress cracking in maize seeds has been reported to occur due to the stress created by moisture gradient during seed drying (Thompson and Foster, 1963; Ekstrom et al., 1966).

Results of the visual examination of stress cracks were very variable. Although a few cracks were observed in seeds from some parts of the processing system before seed drying, sample seeds obtained after artificial drying showed more cracks.

The percentage of visual cracks was higher than that detected by x-ray radiography. Since some visual cracks were not visible using x-ray radiography (Figs. 3 and 4), they were considered unlikely to affect seed germination after storage as observed in this experiment.

Some visually observed seed cracks could not be seen when seeds were x-rayed longitudinally (Fig. 5). However when x-ray photographs were taken on the seeds in a transverse position, visual cracks appeared in the x-ray pictures as very tiny white lines (Fig. 6). This suggests that visual cracks not detected by x-ray radiography are small and superficial. Milner and Shellenberg (1953) reported that detection of internal flaws in solid bodies by x-ray radiography is limited by the ratio of the void to the total body diameter. In wheat, x-ray radiography apparently permitted visualization of fissures greater than approximately 2% of the kernel diameter. Smaller internal cracks did not impart a radiographic shadow.



Legend:

A - Harvested samples from the field

B - Intake to the processing plant

C - After husking

D - After ear drying

E - After shelling

F - After seed drying

Note: Samples B to F were machine-harvested

Figure 1. Differences in levels of seed cracking and germination of maize hybrid D54 as affected by processing.

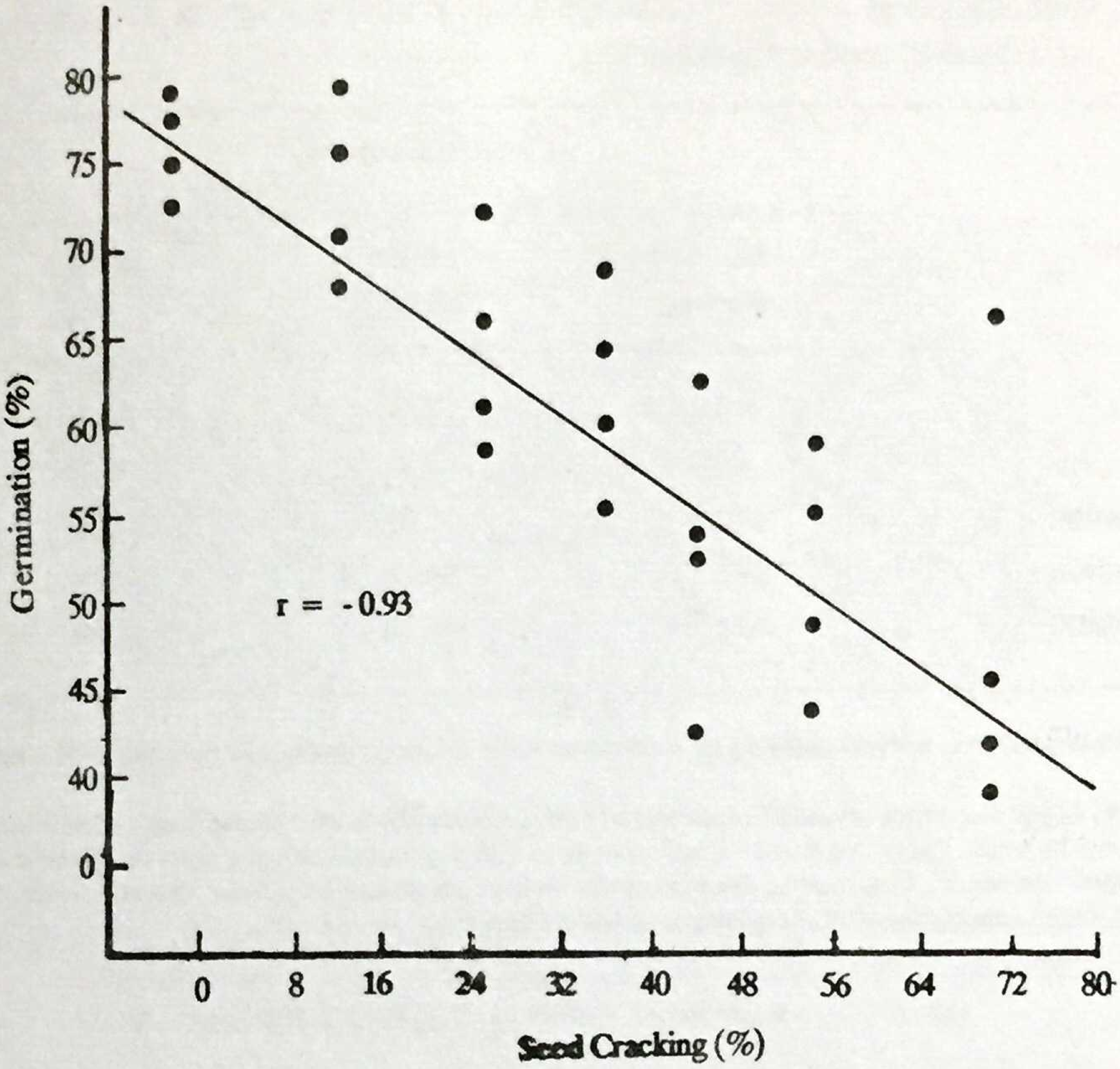


Figure 2. Correlation between germination percentages after seed storage and levels of cracking in artificially dried maize seeds.

Stress Cracks and Seed Viability

Despite the high percentage of seed cracking after artificial seed drying, seed viability before storage was not reduced (Fig. 1). After seed drying, the percentage seed germination was comparable to all air-dried samples from the other processing points. Storage under ambient conditions for 12 months with an associated increase in seed cracking resulted in reduced germina tion (Fig. 2).

A high negative correlation was noted between stress cracking and seed germination. However, the extent of this effect depended on the position of the seed crack (Table 1). Cracks extending down the side (Position 2) and the middle (Position 3) of the germ area (Fig. 7) significantly reduced seed germination after storage for 12 months. On the other hand, cracks which were visually seen on the longitudinal seed position (Fig. 7) did not decrease germination. Similarly, cracks with their length situ ated outside the germ area (Position 1) did not decrease seed germination after storage although the tip of the crack probably touched the margin of the plumule. These suggest that cracks must im-

Table 1. Germination of artificially dried maize seeds after storage for 12 months as influenced by seed crack position.

Crack Position[2]	Germination (%)[1]		
	Normal Seedlings	Abnormal Seedlings	Dead Seeds
No Cracks	73.3a	13.3b	13.3b
Visual Cracks	68.0a	17.3b	14.7b
Crack Position 1	69.3a	17.3b	13.3b
Crack Position 2	45.3b	34.7a	20.0a
Crack Position 3	42.7b	33.3a	24.0a

[1]Means within a column followed by a common letter are not significantly different at 5% level, L.S.D.

[2]No Crack - No crack on seeds observed both visually and by x- ray; Visual Crack - Crack seen visually but not by x-ray; Crack Position 1 - Crack with its length situated outside the embryo as detected by x-ray; Crack Position 2 - Crack along the side of the embryo as detected by x-ray; Crack Position 3 - Crack along the middle portion of the embryo as detected by x-ray.

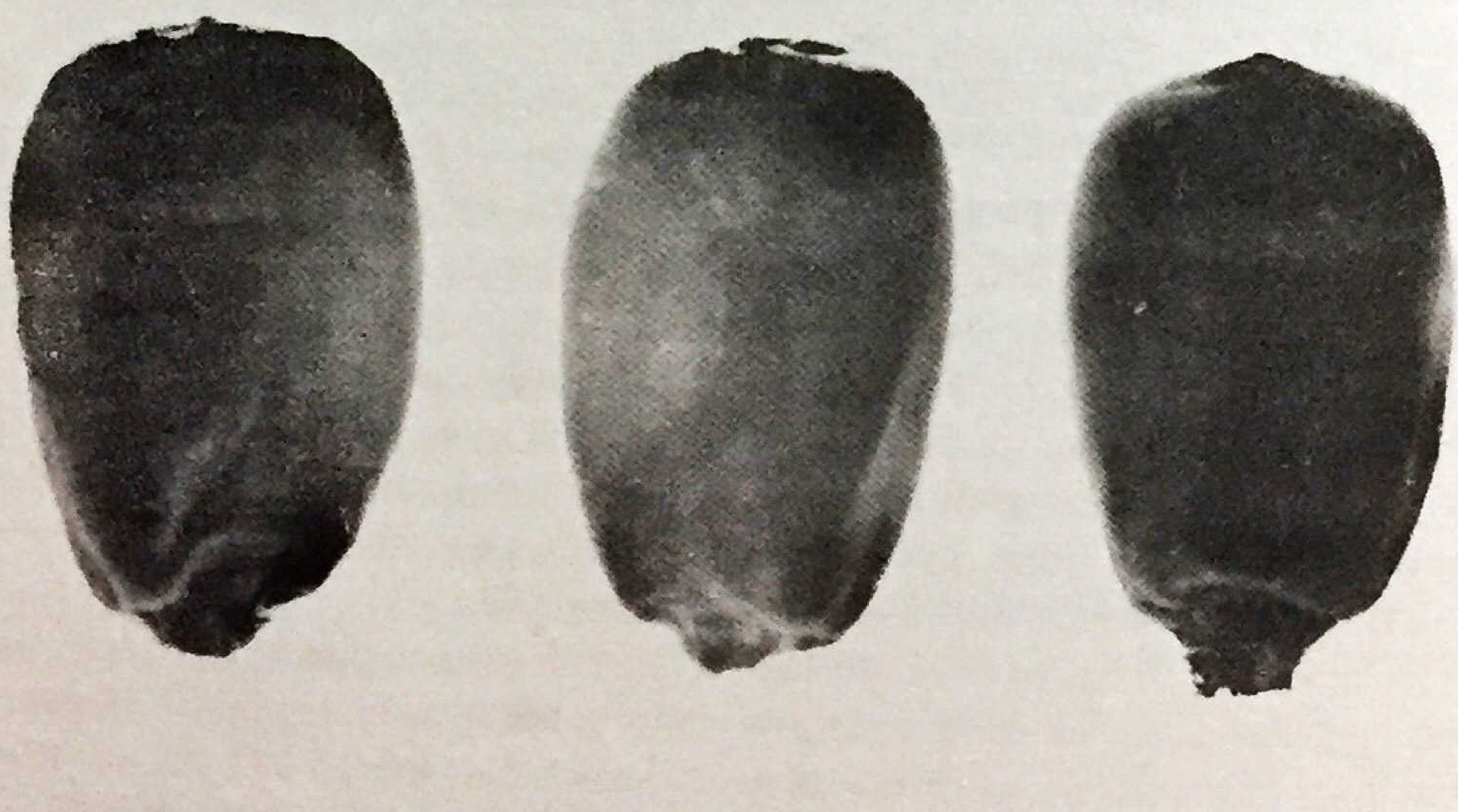


Figure 3. Maize seeds showing visual cracking in the endosperm. Left and Middle: Seeds with cracks both seen visually. Right: A sound seed without sign of visual cracking.

Figure 4. X-ray photograph of the same maize seeds in Figure 3. Left: Seed with visual crack also seen by x-ray. Middle: Seed with visual crack but not seen by x-ray. Right: Sound seed without evidence of cracking under x-ray.

Figure 5. Photograph of maize seeds x-rayed in the longitudinal position. Top: Seeds with cracks seen by both x-ray and visual examination. Bottom: Seeds showing no cracks under x-ray but hairline cracks detected visually.

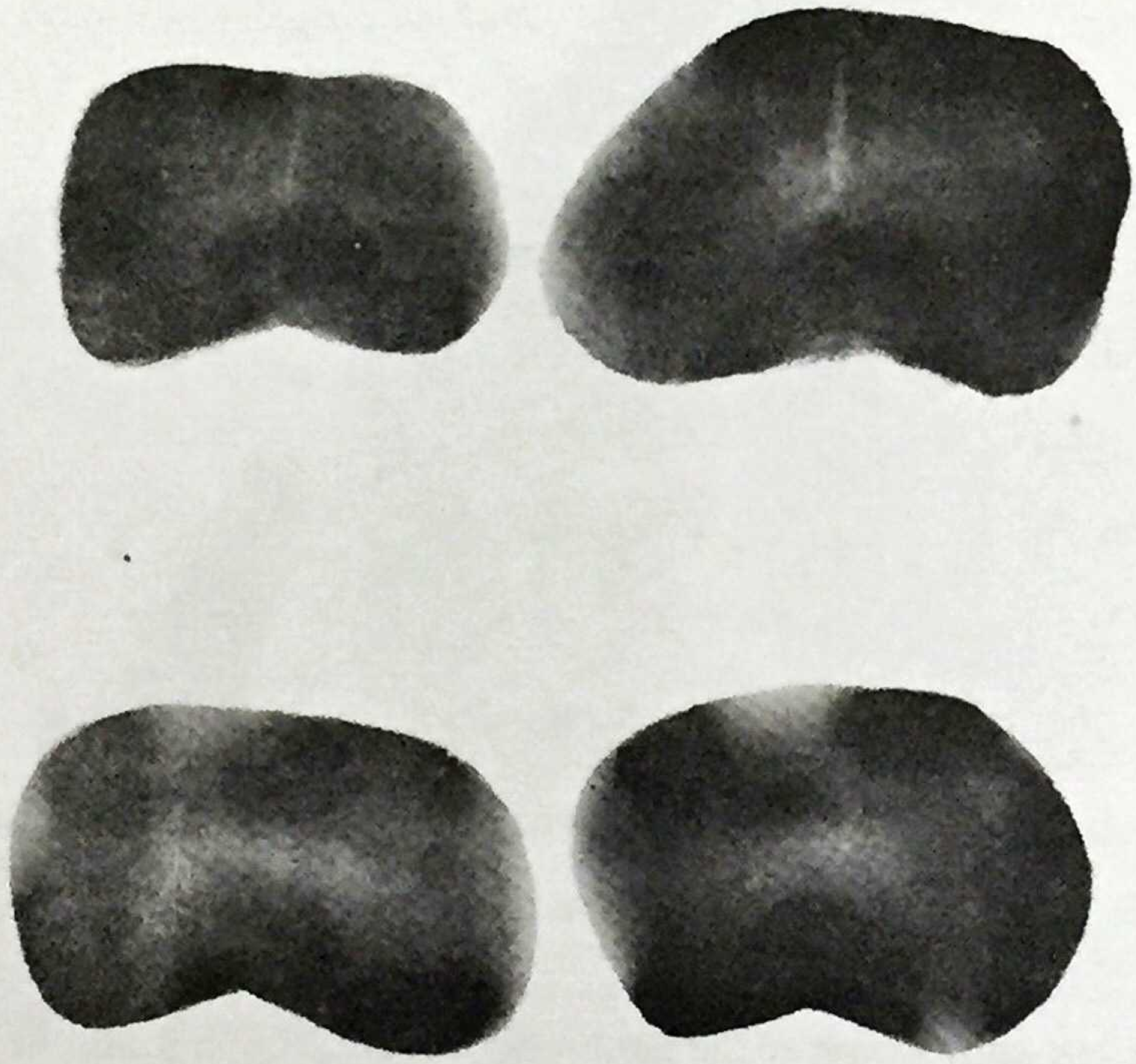


Figure 6. Photograph of the same maize seeds in Figure 5 x-rayed in the transverse position. The visual cracks not seen by x-ray in the longitudinal position may be seen as tiny cracks in the transverse position.

Figure 7. X-ray photograph showing different positions of the cracks in maize seeds. Left to right: No crack, crack outside the embryo, crack along the side of the embryo, crack along the middle portion of the embryo.

Figure 8. Maize seeds displaying seed cracks in the germ area as seen by x-ray photograph.

Table 2. Types of abnormal seedlings observed in seeds with different types or positions of crack.

Crack Type/Position	Seedling abnormalities
No cracks	Stunted or no primary roots No roots Stunted or no plumule Weak seedlings Split coleoptile
Visual cracks	Stunted or no primary roots No roots Stunted or no plumule Weak seedlings Split coleoptile
Cracks with their length situated outside the embryo as detected by x-ray (Position 1)	Stunted or no primary roots No roots Weak seedlings Stunted plumule
Cracks situated along the side of the embryo as detected by x-ray (Position 2)	Stunted or no primary roots No roots Weak seedlings Split coleoptile
Cracks along the middle portion of the embryo as detected by x-ray (Position 3)	Stunted or no primary roots No roots Weak seedlings Split coleoptile

pinge on the germ area before they can reduce seed ger minability after storage. Moreover, visual cracks observed in some stages of processing prior to seed drying not detected by x- ray do not affect seed viability even after storage.

The number of abnormal seedlings and dead seeds after storage was significantly higher in seeds with cracks along the side of the germ area or extending into the middle portion of the embryo (Positions 2 and 3) (Table 1). The types of seedling abnormalities were generally similar regardless of the position of the cracks (Table 2). This indicates that the degree of cracking hastened deterioration or death of seeds which was preceded by the production of abnormal seedlings. The types of seedling abnormalities consisted mainly of stunting or absence of roots and development of weak seedlings. Minor splitting of coleoptiles was observed not only in cracked but also in undamaged seeds.

When seeds exhibiting cracking in the germ tube (Fig. 8) were germinated, normal seedlings were usually produced although abnormal seedlings were also noted (Table 2).

Therefore, the amount of seed cracking did not directly damage the embryo but it drastically enhanced the aging process. Furthermore, some cracks detected by x-ray were probably very slight such that they did not severely damage the seeds during storage for 12 months. Abnormalities due to this type of cracking may appear after a much longer storage period. As shown by x-ray photograph of seeds in transverse position (Fig. 5), the cracks did not extend into any essential part of the embryo although they probably reached the scutellum area. Hence, direct embryo damage can not be expected. However, larger cracks extending into the scutellum of the seed might cause faster deterioration during storage. Moore (1972) stated that a non- critical injury with no immediate effect on seed viability, and located on or near an essential part of the embryo can readily cause non-viability of a seed. During storage, these injured areas promote rapid weakening and early death of surrounding normal tissue. Large and deep-seated injured areas are more destructive to seed germination than small injuries located in less important areas of the seed.

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