Productivity of the Soybean Seeds Stored for Various Periods

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Abstract: The growth characters and productivity of the soybean plants that developed from seeds stored for various periods at 5 °C and 40% relative humidity, but having 80% or higher germinability were examined in comparison with those of newly harvested seeds (new seeds). The seedlings at one month after sowing from the very old seeds (stored for 10 years and 7 months) showed morphological characters significantly different from those from the new seeds, but not those from the moderately old seeds (stored for 2 years and 7 months) or the old seeds (stored for 7 years and 7 months). In the plants from the old seeds, the mean emergence date, flowering date, maturing date, length of the main stem, yield components, seed yield, and inspection-grade or protein content of seed were not significantly different from those in the plants from the new seeds. On the other hand, in the plants from the very old seeds, the mean emergence date, length of main stem, yield components and seed yield were significantly different from those in the plants from the new seeds. We concluded that the seeds of soybean stored for 2 years and 7 months, or 7 years and 7 months having a germinability of higher than 80% are practically useful, and show normal growth characters and productivity. However, it should be noted that the seed storage for over 10 years had inferior grain yield.

Key words: Growth characters, Productivity, Soybean, Stored seed.

In the business of seed production, the seeds stored for two or more years are often used due to the limited demand for cultivation, unexpected meteorological disasters, and also to prevent a change in varietal characteristics. In such cases, the germination percentage is guaranteed to be higher than the standard value prescribed under the inspection law for agricultural products (over 90% for rice and over 80% for wheat, barley and soybean). However, farmers and seed producers sometimes hesitate to purchase the stored seeds, which they consider to be old seeds. They suspect inferior productivity of the stored seeds, and this is sometimes a problem in the business of seed production.

The stored seeds of soybean for sowing are usually inspected only for germinability and emergence rate (Kondo, 1933; Nakamura, 1985, Saito, 1990), and there is only a few reports on their productivity in the field. Hata et al. (1996) examined the productivity of soybean seed stored for 8 years in the field, and reported that the storage had effect on the yield in the conditions that the germination percentage was higher than 45%. However, in that experiment only the productivity of the seeds stored for 8 years was examined, and that of the seeds stored for various years was not. Furthermore, there are no reports on the growth characteristics and productivity of the stored seed having a germinability of higher than 80%.

Previously, we examined the productivity of the stored rice, wheat and barley seeds and the identity of the stored seeds with the new seeds at the DNA level to confirm the quality of the stored rice seeds (Matsue et al., 2000; Matsue et al., 2002). However, the stored seeds of soybean have not been examined.

In the present study, we examined the growth characteristics and productivity of the soybean seeds stored for various periods but showing a germination percentage of higher than 80%.

Materials and Methods

Soybean cultivar 'Fukuyutaka' was used in the experiments that were conducted on a sandy-loam paddy field at Fukuoka Agricultural Research Center in 2003. The seeds were stored for 2 years and 7 months (moderately old seeds), 7 years and 7 months (old seeds) or 10 years and 7 months (very old seeds) at 5 °C and 40% relative humidity. The seeds without storage (new seeds) were also used for comparison. Table 1 shows the year of harvest, storage period and germination percentage for each seed sample. All of the samples showed germination percentage of 80% or higher except for very old seeds (60%). The seeds moisture content for new seeds, moderately old seeds, old seeds and very old seeds was 9.2%, 8.8%, 8.9% and 8.9%, respectively. The emergence percentage was 100% for new seeds, moderately old seeds, and old seeds, but was 52% for the very old seeds in the field. Therefore, additional very old seeds were complementary planted within two weeks to make the number of seedlings the same as that of the seedlings form the other seedling samples.

Fifty grams of each seed sample (with a thickness...
of more than 5.5 mm for soybean) were counted for seed number three times, and then 100-seed weight was calculated using the average values. Those seeds (three seeds per hill) were sown at 20 cm spacing and 140 cm intra-row spacing between hills on 16 July. The seeding density was 7.1 plants per m$^2$ (20 × 70 cm$^2$). After seedling emergence, the plants were thinned to a plant per hill. Chemical fertilizer was applied by basal dressing at a rate of 0, 80 and 80 kg ha$^{-1}$ for N, P$_2$O$_5$, and K$_2$O, respectively. In this experiment, each seed sample was arranged in a randomized complete block design with three replications. The plot size for each seed sample size were 12 m$^2$.

When the primary leaves were developed fully, the length, width and dry weight of cotyledon per plant were measured, and the mean values of 10 plants were calculated. A month after sowing, the leaf age, plant height, the number of nodes on the main stem and dry weight of tops were measured for each plant and the mean values for 10 plants were calculated. On 26 September, at the maximum in stage vegetative growth, the dry weight of tops was measured for 10 plants in each plot and averaged. The flowering date was determined as the date with 50% of the plants flowered. The maturing date was done shown by the date when 90% of the pods were tawny-colored. For examining yield component and seed yield, 5 and 30 plants, respectively, were harvested from each plot by hand at maturity, and the plants were dried naturally in a glasshouse.

Protein content of seed was determined by near-infrared spectroscopic analysis (Infratec 1241, Foss Japan Ltd.). The inspection grade of soybean was judged by the Fukuoka Local Food Agency Office under the Ministry of Agriculture, Forestry and Fisheries.

**Results and Discussion**

1. **Growth characters at a month after sowing**

Table 2 shows the 100-seed weight of each seed sample (stored for various periods), and the leaf age, plant height, the number of nodes on the main stem and dry weight of tops at a month after sowing on the plants developed from the very old, old, moderately old and new seeds. There were no significant differences in the leaf age, plant height and dry weight of top among the plants from moderately old, old and new seeds, although the older the seed samples, the lower the number of nodes on the main stem. However, the vegetative growth in the plants from the very old seeds was significantly inferior to that of the plants from the other seed samples (Table 2). Although the difference in dry weight was not significant, the plants from the new seeds, whose 100-seed weight (36.0 g) was heavier than that of other seed samples, tended to show greater vegetative growth during a month after sowing than others. These results are in agreement with the previous report (Matsue et al., 2000; Matsue et al., 2002), that the heavier the seeds of rice, wheat and barley, the more vigorous the growth of the plants at an early growth stage.

Table 3 shows the size and weight of cotyledons developed from the seeds stored for various periods, measured when the primary leaves were fully developed. The cotyledon from very old seeds had characters significantly inferior to that from the other seed samples. In addition, much cracks, wounds and deformity were recognized in the cotyledon from very old seeds (observation). Asanuma (1987) suggested that the damage of cotyledons at an early emergence stage has severe effects on the plant growth because the photosynthetic loss is not compensated until the expansion of succeeding leaves. The seedling emergence date was three days later in the very old seed sample than in other seed samples (Table 4).

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**Table 1.** The year of harvest, storage period and germination percentage of each plant.

| Seed samples            | Year of harvest | Storage period           | Germination percentage (%) |
|-------------------------|-----------------|--------------------------|----------------------------|
| Short storage (Moderately old seeds) | 2000            | 2 years and 7 months     | 98.7                       |
| Long storage (Old seeds)  | 1995            | 7 years and 7 months     | 97.0                       |
| Very long storage (Very old seeds) | 1992           | 10 years and 7 months    | 60.0                       |
| Newly harvested seeds (New seeds) | 2002           | 7 months                 | 100.0                      |

**Table 2.** Weight of seeds stored for various periods and growth characters of the plants developed from those seeds at a month after sowing.

| Seed samples              | 100-seed weight of seed sample (g) | Leaf age (L) | Plant height (cm) | Number of nodes on main stem | Dry weight of tops (g plant$^{-1}$) |
|---------------------------|------------------------------------|--------------|------------------|-----------------------------|-----------------------------------|
| Moderately old seeds      | 29.7a                              | 6.4b         | 46b              | 10.4bc                      | 6.3b                              |
| Old seeds                 | 30.0a                              | 5.9b         | 42b              | 9.9b                        | 5.6b                              |
| Very old seeds            | 30.1a                              | 4.6a         | 27a              | 8.1a                        | 2.5a                              |
| New seeds                 | 36.0b                              | 6.8b         | 48b              | 11.3d                       | 7.4b                              |

Means followed by the same letter are not significantly different by Fisher’s protected LSD values (p<0.05).
Therefore, the inferior growth of the plants (tops) from the very old seeds might be caused by the reduced photosynthetic ability of cotyledons, and delay of emergence. The reason for the damage of cotyledons from the very old seeds is not clear at present.

2. The dates of emergence, flowering and maturing

Table 4 shows the date of emergence (50% emergence), flowering (50% flowering) and maturing (90% tawny-colored pods) of the plants. The plants from very old seeds, old seeds and moderately old seeds had the same flowering and maturing dates as like the new seeds. Matsue et. al. (2002) reported that the heading date of wheat and barley varied with the seed-storage period. In vegetable seeds, weak vitality due to seed aging has also been reported to hasten (Yoon et al., 1983) or delay (Hoshino, 1936) the heading and flowering dates. The heading and maturing dates of the soybean plants, however, were uninfluenced by seed storage for seven years (old seeds).

The length of the main stem, the numbers of nodes on the main stem, and pods per plant, and dry weight of tops were not significantly influenced by short (moderately old seeds) or long (old seeds) storage, but was significantly decreased by the very long storage (Table 5). Thus, the vegetative growth of soybean plants varies with the storage period of the seed. This is in agreement with the result reported previously by Matsue et al., (2002), that the growth characters of wheat and barley were deteriorated by a long storage. However, the growth character of the plants from the very old seeds, though the germination percentage was higher than 80%, was somewhat different from that of the plants from the new seeds. The very old seeds of soybean should be used carefully.

3. Yield components, inspection grade, protein content and seed yield

Table 6 shows the yield components, inspection grade, protein content and seed yield of the plants developed from the seeds stored for various periods. The length of the main stem was not affected by the short and long seed storage, but significantly shortened by the very long storage. The number of nodes on the main stem, the number of branches per m², the number of ripening pods per m² and the number of plum seeds per m² were not affected by the short and long storage, but significantly decreased by the very long storage. On the other hand, the 100-seed weight, inspection grade and protein content of seeds were not affected by the short and long seed storage, but significantly decreased by the very long storage.

As mentioned above, the very long storage of the seeds retarded the seedling emergence and reduced the photosynthetic ability of cotyledons. TeKrony (1980) reported that the vigor of soybean seed was dependent on the field environments during development. Therefore, the decrease in seed yield of the plants from very old seeds may be attributable to the reduced photosynthetic ability of cotyledons, delayed seedling emergence and diminished vigor of soybean seed.

In the present study, no significant difference in the yield was observed between new seeds with a heavy seed weight and old and moderately old seeds with lighter seed weight. This is in contrast to the findings reported by Matsuda (1951) that, the productivity and protein content of soybean seeds were influenced by the seed-storage period. In vegetable seeds, weak vitality due to seed aging has also been reported to hasten (Yoon et al., 1983) or delay (Hoshino, 1936) the heading and flowering dates. The heading and maturing dates of the plants developed from the seeds stored for various periods measured when the primary leaves fully developed.

| Seed samples         | Length (mm) | Width (mm) | Dry weight (mg plant⁻¹) |
|----------------------|-------------|------------|-------------------------|
| Moderately old seeds | 22.2c       | 16.6c      | 121.0b                  |
| Old seeds            | 20.6b       | 15.7b      | 114.1b                  |
| Very old seeds       | 15.0a       | 11.9a      | 79.4a                   |
| New seeds            | 20.5b       | 15.0b      | 156.0c                  |

Means followed by the same letter are not significantly different by Fisher’s protected LSD values (p<0.05).

Table 3. Size and weight of cotyledons from the seeds stored for various periods measured when the primary leaves fully developed.

| Seed samples         | Length of main stem (cm) | Number of nodes on main stem | Number of pods per plant (plant⁻¹) | Dry weight of top (g plant⁻¹) |
|----------------------|--------------------------|------------------------------|-----------------------------------|------------------------------|
| Moderately old seeds | 37.2b                    | 13.6ab                       | 87.7b                             | 56.9b                        |
| Old seeds            | 36.9b                    | 13.1ab                       | 89.3b                             | 57.1b                        |
| Very old seeds       | 29.0a                    | 12.3a                        | 51.1a                             | 28.1a                        |
| New seeds            | 42.9b                    | 14.3b                        | 93.6b                             | 62.9b                        |

Means followed by the same letter are not significantly different by Fisher’s protected LSD values (p<0.05).

Table 4. The emergence date, flowering date and maturing date of the plants developed from the seeds stored for various periods.

Table 5. Growth characteristics of the plants developed from the seeds stored for various periods at the maximum vegetative growth stage.
by seed size. This is probably because the difference in seed size among the various old seeds for soybean in the present experiment was smaller than that of materials used by Matsuda (1951).

As mentioned above, the growth characteristics of the plants from very old seeds except for the 100-seeds weight, inspection grade and protein content of seeds, were inferior to those in the plants from the new seed.

We conclude that soybean seeds stored for 2 years and 7 months (moderately old seeds), and 7 years and 7 months (old seeds) having higher than 80% germinability are practically useful, and show normal growth and productivity. However, the seeds of soybean stored for longer than 10 years should be used with caution, because their productivity in the field is inferior to that of the new seeds.

### References

Asanuma, K. 1987. Relationships between the CO₂ exchange and the growth and chemical contents in soybean seedlings. Kagawa Univ. Tec. Bull. Fac. Agr. 38 (Issue 2) : 1-6***.

Hata, K., Arai, N., Watanabe, K., Nomura, T., Ueno, T. and Otsuka, K. 1996. Technique for the long term storage of soybean seeds. II Effect of long term preserved seeds on the growth in soybean. Jpn. J. Crop Sci. 65(Extra issue 1) : 142-145*.

Hoshino, Y. 1936. Relationships between aged seed and viability, bolting and flowering. Hokkaido Univ. Farm Extra Bull. 6 : 1-93****.

Kondo, M. 1933. Studies on Seeds in Japanese Agriculture and Forestry Seed Study. Yokendo Co., Tokyo. 185-194****.

Matsuda, I. 1951. On the seed weight effect on the growth and the yield in soybean cultivation. Jpn. J. Crop Sci. 20 : 53-54***.

Matsue, Y., Uchimura, Y. and Sato, H. 2000. Comparison of productivity and growth habit between stored and newly harvested rice seeds, and identification of the cultivars of stored rice seed by RAPD method. Jpn. J. Crop Sci. 69 : 38-42***.

Matsue, Y., Uchimura, Y. and Sato, H. 2002. Confirmation of the productivity of the stored seeds of wheat and two-rowed barley. Plant Prod. Sci. 5 : 187-193.

Nakamura, S. 1985. Seed Science. Youkendo, Tokyo. 227-228****.

Saito, S. 1990. Influence of storage on the viability of several crops seeds. Kyushu Agric. Res. 52 : 36*.

TeKrony, D. M., Egli, D. B. and Phillips, A.D. 1980. Effect of field weathering on the viability and vigor of soybean seed. Agron. J. 72 : 749-753.

Yoon, W.M., Lee, S.S. and Pyo, H.K. 1983. Studies on bolting of stored seeds of radish (Raphanus sativus L.). (1) Effects of seed storage temperature, relative humidity and period on bolting of radish and changes of bolting rate as influenced by sowing time. J. Korean Soc. Hort. Sci. 24 : 101-106**.

† : Inspection grade consists of 9 grades of quality; i.e, First grade-upper(1), -middle(2), -lower(3), Second grade-upper(4), -middle(5), -lower(6), Third grade-upper(7), -middle (8), -lower(9).

Means followed by the same letter are not significantly different by Fisher’s protected LSD values (p<0.05).

### Table 6. Yield components, inspection grade and protein content of seeds produced on the plants developed from the seeds stored for various periods.

| Seed samples         | Length of main stem (cm) | Number of nodes on main stem | Number of branches | Number of ripening pods (m⁻²) | Number of plum seeds (m⁻²) | 100-seed weight (g) | Inspection grade † | Protein content of seeds (%) | Seed yield (gm⁻²) |
|----------------------|--------------------------|------------------------------|--------------------|-------------------------------|---------------------------|-------------------|-------------------|-----------------------------|-----------------|
| Moderately old seeds | 42.9b                    | 15.3c                         | 44.0bc             | 405b                          | 1001b                     | 28.9a             | 3.0a              | 44.8a                      | 265b            |
| Old seeds            | 40.4b                    | 14.0b                         | 40.2b              | 370b                          | 898b                      | 25.5a             | 3.3a              | 45.5a                      | 262b            |
| Very old seeds       | 28.4a                    | 12.6a                         | 28.4a              | 130a                          | 510a                      | 29.3a             | 3.0a              | 45.3a                      | 179a            |
| New seeds            | 43.5b                    | 14.8bc                        | 49.7c              | 398b                          | 942b                      | 29.9a             | 1.6a              | 45.1a                      | 299b            |

† : Inspection grade consists of 9 grades of quality; i.e, First grade-upper(1), -middle(2), -lower(3), Second grade-upper(4), -middle(5), -lower(6), Third grade-upper(7), -middle (8), -lower(9).

Means followed by the same letter are not significantly different by Fisher’s protected LSD values (p<0.05).