The Study on The Seed Storability of Black Soybean (*Glycine max* L. Merrill) Intercropped with Sweet Sorghum (*Sorghum bicolor* L. Moench)

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ABSTRACT

The experiment was aimed to know how to maintain seed quality during storage by planting black soybean and sweet sorghum in row using an intercropping system. This experiment was conducted in the Laboratory of Seed Technology, Faculty of Agriculture, Gadjah Mada University, Yogyakarta, Indonesia, from November 2013 until April 2014. This experiment was single factor experiment arranged in CRD (Completely Randomized Design) with four treatments and four replications. The treatments consisted of monoculture of black soybean, intercropping between black soybean and sweet sorghum with various row ratios, i.e. 3:1, 4:1, and 6:1. The seeds were stored as many as 250 g for each treatment in hermetic plastic at normal temperature (27-28 ºC) for five months. Seed quality testing was performed every month. Data collected included moisture content, germination, vigor index and vigor hypotetical of the seeds. The result of this experiment showed that the quality of black soybean seeds yielded from intercropping with sweet sorghum gave the same effect compared to the black soy bean seeds yielded from monoculture. Seed quality of black soybean planted in intercropping and monoculture system could be well maintained until the fourth months of storage.

Keywords: Black Soybean, Intercropping, Monoculture, Seed Quality, Storage

ABSTRAK

Percobaan ini bertujuan untuk mengetahui bagaimana menjaga kualitas benih selama penyimpanan dengan menanam kedelai hitam dan sorgum manis berturut-turut menggunakan sistem tumpangsari. Eksperimen ini dilakukan di Laboratorium Teknologi Benih, Fakultas Pertanian, Universitas Gadjah Mada, Yogyakarta, Indonesia, dari November 2013 hingga April 2014. Eksperimen ini adalah percobaan faktor tunggal yang diatur dalam RAL (Rancangan Acak Lengkap) dengan empat perlakuan dan empat ulangan. Perlakuan terdiri dari monokultur kedelai hitam, tumpangsari antara kedelai hitam dan sorgum manis dengan berbagai rasio baris, yaitu 3: 1, 4: 1, dan 6: 1. Benih disimpan sebanyak 250 g untuk setiap perlakuan dalam plastik kedap udara pada suhu normal (27-28 ºC) selama lima bulan. Pengujian kualitas benih dilakukan setiap bulan. Data yang dikumpulkan meliputi kadar air, perkecambahan, indeks vigor dan vigor hipotetis benih. Hasil penelitian ini menunjukkan bahwa kualitas biji kedelai hitam yang dihasilkan dari tumpangsari dengan sorgum manis memberikan efek yang sama dibandingkan dengan biji kedelai hitam yang dihasilkan dari monokultur. Kualitas benih kedelai hitam yang ditanam dalam sistem tumpangsari dan monokultur dapat dipertahankan dengan baik sampai penyimpanan bulan ke empat.

Kata Kunci: Kedelai hitam, Tumpang sari, Monokultur, Kualitas benih, Penyimpanan

INTRODUCTION

Soybean crops which are rich of protein become the source of vegetable protein to increase the nutrition. Soybean products as ingredients of processed food are potential and they have contribution to develop the small medium industries. Black soybean containing higher protein and lower fat is needed as the material of soy sauce industry that can result in healthier soy sauce with better color and taste due to the high content of glutamate and anthocyanin. The needs of black soybean as the material of soy sauce industry is increasing annually, therefore it is necessary to increase the production of high quality of black soybean. The use of qualified seed is the first success key. Most soybean farmers haven't planted the qualified seed. In small field, farmers have to provide food for livestock instead of planting soybean. Farmers usually plant soybean using intercropping system with sorghum as food for livestock. However, the farmers do not arrange the distance of planting which causes low yield of soybean and corn seeds.

Intercropping system is also a cultivation strategy for various plants in a field at the same period. The intercropping system could intensively increase

the yield per unit per time, decrease the failure of cropping, and increase the land productivity, sources and time. High land productivity in intercropping system compared to monoculture could be measured by LER (ATER) value, a number derived from comparison between yields of each plant in intercropping system to the crop yields in monoculture for the same area and time in different location. LER/ATER value which is more than 1 means the land productivity in the intercropping system is bigger than in the monoculture (Ashandi et al., 1987; Khalil, 2000 ; Vandermeer, 1989).

Beets (1982) mentioned that the determination of the components, both in types and varieties which are combined, is very important. Each individual will influence each other so that there will be interference. This interference could occur between plants of different species (interspecies and between the parts of the plant (interplant).

Osborne et al. (2014) noted that planting the seeds of green beans resulted from the intercropping system between green bean and sweet corn in small land could be recommended. Because based on the results of their research, quality of seeds produced from intercropping system was acceptable based on standard ISTA. In addition, they also noted that the infection of *Xanthomonascamprestris* pv. *Phaseoli* even relatively attack seeds produced from monoculture plantations compared to intercropping. Bean seeds produced from intercropping system have the same germination rate with the seeds produced from the cultivation of monoculture (Hilli and Kulkani 1988).

Thiagarajan (1994) mentioned that the soybean and pea seeds which were produced from intercropping system with sweet corn could perform lower quality in weight of 100 seeds and vigor of seed compared to those from monoculture farming system. From the intercropping between peanut and sweet corn, it was known that the germination rate and vigor were significantly affected by the cropping system. In the cropping system of 1: 1 could yield seeds with low germination of 68%. Th quality of peanut seeds decreased significantly, while the quality of sweet corn seeds was not deteriorated. Cervantes (1997) cit. Ogata et al. (2012 stated that modified intercropping system between green beans and sweet corn called Mbili with spacing 2: 2 in the Western region of Kenya could increase vigor of green beans and dry weight of seedling up to 42% compared to seeds produced from monoculture system.

Generally, the farmers plant the soybean after rice in dry season. After harvesting the soybean, the farmers will plant the rice in the next six months in dry season. Therefore, the soybean seeds need to be stored for six months to re-plant. The stored seeds will experience natural aging and lose the vigor faster than the viability. The lost on seed vigor shows the lost on its viability. For the seed, it is showed by the decrease of the germination rate under the non-optimal condition. Seeds with high vigor will have better ability to be stored and to produce normal seedling in large amount in large area. Therefore, the soybean seeds that will be planted have to be stored in good environment (Schmidt, 2000; Egli dan Krony, 1996 cit. Viera et al., 2001).

The temperature in the storage room takes part in maintaining the viability of the seeds during the storage. It is influenced by the moisture content of the seeds, temperature and the relative humidity in the storage room. At low temperature, the respiration runs slowly compared to the condition at high temperature. In that condition, the seeds viability can last longer. The safe moisture content to store the soybean seeds in room temperature for 6 – 10 months is no more than 11% (Yaya, et al., 2003). The research of Purwanti (2004) conducted

the storage of black soybean and yellow soybean in plastic with 9% of moisture content at room temperature (27°C) and low temperature (20°C) in 6 months. The result of the research showed that black soybean seeds which stored at low temperature resulted in 92% growth rate and 86% growth rate at room temperature. The yellow soybean seeds stored at low temperature resulted in 88% growth rate and 65% growth at room temperature.

MATERIALS AND METHODS

This experiment was conducted from November 2013 until April 2014 in the Laboratory of Seed Technology, Faculty of Agriculture, Gadjah Mada University, Yogyakarta, Indonesia. The tools and materials used in this experiment were the black soybean seed cv. Mallika planted using intercropping system with sweet sorghum cv. Unpad 1, petridish, germinator, hand counter, seed moisture tester, oven, hermetic plastic bags, analytical balance, oven, and leaf area meter. This experiment used a single factor design treatment arranged in CRD (Completely Randomized Design) with four treatments and four replications The treatments were: T1 = black soybean 3 rows + sweet sorghum 1 row, T2 = black soybean 4 rows + sweet sorghum 1 row, T3 = black soybean 6 rows + sweet sorghum 1 row, T5 = black soybean monoculture. Seeds were stored as many as 250 g for each treatment in hermetic plastic bag and stored at normal temperature (27-28 °C) for five months. Seed quality testing was performed every month. Data collected were moisture content, germination of seed, vigor index and hypothetical vigor. The data were analysed using Analysis of variance at 5 %. Should there were significant differents between, means separation was performed using Duncan Multiple Range Test at 5%.

RESULTS AND DISCUSSION

The result of the analysis showed that there was no significant difference of moisture content in the seeds for three months of storage. The moisture content increased in the fourth and fifth month of the treatment. In the treatment 6:1 the moisture content of the seeds was in the highest condition compared to other monthly treatment. The highest increase of the moisture content occurred in the monoculture treatment which was from 9.08% to 10.46% in the fifth month of storage (Table 1). Meanwhile, intercropping treatment 4:1 in the fourth and fifth month resulted to lower moisture content which was significantly different from other treatments. It was because the hermetic plastic bags used to store the seeds which were airtight had high protection to water vapor without extreme change in the room temperature. The moisture content was not affected by the cropping pattern system, but by the relative humidity of the storage room and its room temperature (Soemardi and Karama, 1996).

Based on the result of the seeds growth test,

Table 1. The Average of Moisture Content of Black Soybean Seeds Yielded from Intercropping with Sweet Sorghum During Five Months of Storage

Treatment	Moisture content (%)					
	Month 0	Month 1	Month 2	Month 3	Month 4	Month 5
BSB Monoculture	9.08 a	9.15 a	9.42 a	10.02 a	10.13 ab	10.46 a
3 rows BSB+1 SS	8.97 a	9.11 a	9.62 a	10.10 a	10.24 ab	10.45 a
4 rows BSB +1 SS	9.03 a	9.08 a	9.35 a	9.80 a	9.90 b	10.19 b
6 rows BSB+ 1 SS	9.10 a	9.36 a	9.79 a	10.06 a	10.44 a	10.40 a
CV (%)	1.34	1.65	1.23	1.84	1.96	1.13

Note: Means followed by the same letters in the same column are not significantly different based on DMRT at 5 %;
BSB = Black Soybean; SS = Sweet Sorghum

there was no significant difference observed between treatments at month 0 to the 3rd month. However, in the fourth month, the seeds growth of monoculture and intercropping treatment of 4: 1 was significantly different from that of intercropping treatment of 3:1 and 6:1. (Table 2.). Overall, the result did not show significant differences on the seed growth. Treatment of row combination only affected the growth and yield of black soybean. The growth rate indicates the seed viability which is the ability of the seeds to normally grow in the optimal condition in the field. The longer the storage life, the lower the growth rate. It is because the seed can absorb water vapor that increase the moisture content. The moisture content increase leads to the activation of enzymes involved in the metabolism of seed. Active enzymes trigger the respiration which uses substrate of the reserved food in the seed causing the reserved food for the growth of the embryo germination reduced. The requirements for high quality of soybean seed are fulfilled if the growth rate reaches 80% in laboratory testing. The growth of black soybean in this treatment still met the standard of quality seed after storage for 5 months.

In the observation of black soybean seed vigor index, the analysis result indicated that there was no significant difference on vigor index at the beginning to the second month of storage. In the third month of storage, there was significant difference observed on the treatment of 4: 1. In the fourth month of treatment there was a significant difference observed on the treatment of 3: 1, while for the fifth month there was significant difference observed on each treatment (Table 3.). Vigor index of the seeds in the early month up to fifth month of storage showed simultaneous and rapid growth on day 4. The vigor index simultaneously decreased on the day 7 for intercropping plantation of 3:1 after 4-5 months of seed storage. Each plant either of intercrop or monoculture plantation was able to show good growth and development. The

Table 2. The Average of Germination Rate of Black Soybean Seeds Yielded from Intercropping with Sweet Sorghum During Five Months of Storage

Treatment	Germination rate (%)					
	Month 0	Month 1	Month 2	Month 3	Month 4	Month 5
BSB Monoculture	78.08 a	99.50 a	98.50 a	94.00 a	83.50 a	80.00 a
3 rows BSB+1 SS	84.25 a	97.50 a	97.50 a	86.00 b	80.00 b	80.00 b
4 rows BSB +1 SS	80.50 a	99.00 a	98.00 a	92.50 a	86.50 a	81.50 a
6 rows BSB+ 1 SS	80.00 a	100.00 a	90.50 b	91.00 ab	84.00 a	80.50 a
CV (%)	8.7	1.83	2.83	3.58	4.17	4.03

Note: Means followed by the same letters in the same column are not significantly different based on DMRT at 5 %;
BSB = Black Soybean; SS = Sweet Sorghum

Table 3. The Average of Vigor Index of Black Soybean Seeds Yielded from Intercropping with Sweet Sorghum During Five Months of Storage

Treatment	Vigor Index					
	Month 0	Month 1	Month 2	Month 3	Month 4	Month 5
BSB Monoculture	27.99 a	24.67 a	29.18 a	19.68 b	25.05 a	18.50 b
3 rows BSB+1 SS	18.89 a	23.21 a	24.90 a	19.80 b	14.75 b	17.18 b
4 rows BSB +1 SS	16.90 a	27.27 a	23.37 a	23.90 a	22.78 a	24.05 a
6 rows BSB+ 1 SS	19.97 a	21.28 a	22.45 a	17.13 b	25.43 a	22.44 ab
CV (%)	26.49	11.97	17.01	10.62	13.30	16.41

Note: Means followed by the same letters in the same column are not significantly different based on DMRT at 5 %;
BSB = Black Soybean; SS = Sweet Sorghum

Table 3. The Average of Hypothetical Vigor of Black Soybean Seeds Yielded from Intercropping with Sweet Sorghum During Five Months of Storage

Treatment	Hypothetical Vigor					
	Month 0	Month 1	Month 2	Month 3	Month 4	Month 5
BSB Monoculture	8.35 a	8.16 a	7.56 a	7.61 a	7.60 a	7.38 a
3 rows BSB+1 SS	8.22 a	8.11 a	7.70 a	7.81 a	7.74 a	7.37 a
4 rows BSB +1 SS	8.71 a	8.45 a	8.43 a	7.93 a	7.93 a	7.56 a
6 rows BSB+ 1 SS	8.27 a	7.98 a	7.91 a	7.75 a	7.86 a	7.84 a
CV (%)	1.90	2.64	3.37	2.30	2.38	1.96

Note: Means followed by the same letters in the same column are not significantly different based on DMRT at 5 %;
BSB = Black Soybean; SS = Sweet Sorghum

absorption process of nutrients, water and sunlight of each plant could optimally support the photosynthesis process. It resulted in the same height of the seeds since there was no competition between individual plants (sunlight, nutrients and water). The photosynthesis ran well affecting the pod filling and physiological maturity (Tuaeli and Friesen, 2003). This encourages the plant to maintain vigor remained high for up to 5 months of storage. According Yudono (1992), seed vigor is positively correlated with protein content. Therefore, the seeds with high value of vigor index have a high protein content as well. Vigor is defined as the ability of seeds to normally and quickly grow at suboptimal conditions. Vigor seeds should be relevant to the production level, which means that the seed with high vigor will be able to achieve high production rates. Seed vigor is also the foundation for the ability of plants to grow and compete with plant pests or other crops in intercropping plantation (Sutopo, 2002).

Hypothetical vigor illustrates the growth of seedlings for all components of growth including the height of seeds, leaf area, leaf number, stem diameter, fresh weight and dry weight of seedlings. In observation of hypothetical vigor, the analysis showed that there was no significant difference between the seeds of the monoculture and intercrop plantation in the first five months of storage (Table 4). This was caused by the high growth rate of the seeds in all treatments for the first five months of storage. All treatments enabled the seed to grow at least 80% higher so that they meet high standards of quality seed. This was supported also by the high seed vigor index and the fast growth in the fourth day although the seeds had been stored for 5 months.

CONCLUSIONS

The treatment of intercropping and monoculture system have the same effect on the quality of the seed after being stored for five months. Seed viability resulted from all treatments was 80% during 5 months of storage. High vigor in all treatment could be maintained for up to five months of storage (fast grow and uniformity).

Intercropping system with four rows of black soybean with one row of sweet sorghum produced higher quality of black soybean seed compared to other treatments, i.e. 83.75% viability and high vigor after being stored for five months.

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