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Yield Performance and Nutritional Quality of 'Agakong' Soybean Harvested in Drained-Paddy and Upland Fields

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Abstract - The study was conducted to evaluate the performance of the popular isoflavone-rich soybean 'agakong' in upland and in drained-paddy fields. Analysis revealed no significant variation in terms of plant height, number of seeds per pod, number of nodes, and 100-seed weight between the two cropping system. Number of pods was significantly higher in paddy field (234.2kg $10a^{-1}$) compared to those harvested in the upland field, which was later manifested on the yield where paddy soybeans obtained 278.1kg $10a^{-1}$ whereas upland only obtained 179.3kg $10a^{-1}$. This observed difference in yield was attributed to the observed higher amount of N in the paddy soil (0.907%) as compared to the upland soil (0.458%). In terms of nutritional content, protein and phytic acid contents were the only parameters that showed significant differences while oil, sugar, reducing power and fatty acids were all comparable in paddy and field condition. Protein content was higher in upland soil (47.4%) than that of the paddy (44.9%) soil. On the opposite, phytic acid was higher in paddy (2.90%) than in upland (1.09%). This study showed that the yield of soybean is generally a factor of soil N, drained-paddy field production of soybean is comparable to upland-field production with the benefit of increasing phytic acid content while maintaining its nutritional value.

Key words - Agakong, phytic acid, Protein, Soybean

Introduction

Soybean (*Gycine max* L. Merr.) is a crop valued for its high protein and oil contents. Its nutritional value depends on the relative abundance of proteins and fatty acids. In recent years, soybean breeding programs have been focused on improving quality such as increasing protein and (Sediyama *et al.,* 1996) isoflavone contents. Isoflavones are secondary metabolites abundantly found in soybean seeds that are becoming the main focus of soybean research because of its impact on human health. Studies have shown that isoflavones have positive potential role in preventing cancer, heart disease and even menopausal symptoms (Caragay, 1992; Messina, 1995) due to their function as anti-estrogens (Kitts *et al.,* 1980), antioxidants (Naim *et al.,* 1976) and tyrosine protein kinase inhibitors (Akiyama *et al.,* 1987). In Korea, a newly developed soybean variety popularly known as 'agakong' is rich in isoflavones.

Soybean cultivation is increasing in fields that have been converted from paddy field for rice called "drained-paddy field". In Korea, soybeans are traditionally grown in upland field but are now also grown in drained-paddy fields. In 2002, over 1,905ha of paddy fields have been converted for growing upland crops such as soybean, which had increased to about 7,000ha in 2004. Planting of soybean on drained-paddy rice field is being encouraged to make fallow lands more productive by alternating soybean to rice especially when rice income is low, and to improve paddy soil properties. The differences in the cultivation environments can affect several characteristic of soybean (Ishiguro *et al.,* 2006). Water-logging can occur when soybean plants are cultivated in a paddy field which can significantly affect grain yield of soybean (Scott *et al.,* 1989; Linkerman *et al.,* 1998), and the activity of symbiotic bacteria (Sallam and Scott, 1987; Puiatti and Sodek, 1999). The chemical components of soybean also vary in drained-paddy compared to upland field. Kim *et al.* (2004) reported that protein content is higher in drained-paddy field than in upland field.

The general objective of this study is to encourage cultivation of soybeans on drained-paddy field specifically the production of

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isoflavone-rich variety 'agakong'. In particular, it aims to investigate the yield performance of 'agakong' at different cultivation environment, i.e. in drained-paddy and upland fields, and to determine whether seed quality such as oil, protein, sugar, fatty-acids, reducing power and phytic acid contents will also be influenced by cultivation environment.

Materials and Methods

The experiment was conducted at the Kyungpook National University Agricultural Research Station in Gunwi on the summer season of 2005. Soil preparation was done mechanically. Fertilizer was applied before harrowing at the rate of 30-30-34 (N-P_2O_5-K_2Okg ha^{-1}) according to the standard recommendation. Seedbed, raised 25cm above the ground, was covered with black vinyl before transplanting.

The soybean cultivar used was 'agakong', a newly developed variety shown to have high contents of isoflavone. The seeds were germinated in the greenhouse and were transplanted in the field 25 days after germination. Two seedlings were transplanted per hill and thinning was done 25 days after transplanting.

Soil nitrogen was determined following the method described by Bremmer and Mulvaney (1982) using samples taken from 0 to 15cm depth. Soil samples were air-dried and ground to pass through a 2mm sieve. The sieved soil (1g) sample was digested following the Kjeldahl procedure and then total nitrogen determined by an automatic system (Kjeltec Auto1035/38 Sampler System, Tecator AB, Sweden) as specified in Tecator Application Notes. Soybean protein, oil and fatty acid was analyzed by using a NIR system Model 6500 near grain analyzer (Near Infrared Reflectance Spectrophotometer; NIRD).

The determination of reducing power was done as described by Yen and Chen (1995). Extracts (20, 50, and 100mg mL^{-1}) were mixed with phosphate buffer (0.5mL, 0.05M, pH 6.6) and 1% potassium ferricyanide (5mL), and incubated at 50°C for 20 minutes. After addition of 0.5mL of 10% trichloroacetic acid, the mixture was centrifuged at 5,000rpm for 10 minutes. The supernatant (0.5mL) was mixed with distilled water (0.5mL) and 0.1% of ferric chloride (0.1mL). Absorbance reading at 700nm was recorded.

Phytic acid was determined according to the method of Huang and Lantzsch (1983) and Antonio *et al.* (1991). Extraction was done by mixing 2.5g sample and 50mL of 1.2% HCl - 10% Na_2SO_4 solution in a shaker for 2hr. A 10-mL filtrate was added with 12mL of $FeCl_3$ solution and then placed in a 100oC water bath for 75min. The sample was cooled for 1hr in room temperature and then centrifuged for 15mins at 3,500rpm. Four milliliters of filtered solution was added with 1mL of Wade reagent (0.03% $FeCl_3 \cdot 6H_2O$ - 0.3% sulfosalicylic acid) and after 10mins, absorbance at 500nm was measured using a spectrophotometer. The results were then expressed as mg Fe bound per gram of sample extracted.

Data were analyzed using an analysis of variance (ANOVA) procedure (SAS Institute, Inc., Cary, NC, USA). Least significant differences between treatment means were obtained using Duncan's Multiple Range Test.

Results and Discussion

Effects on growth of soybeans

Table 2 shows the growth performance of 'agakong' soybeans cultivated in the upland and drained-paddy fields. The growth parameters of soybean planted in the drained-paddy field were generally higher compared with those in the upland field. However, significant difference between the two was only recorded in the number of pods. The number of pods in drained-paddy field (234.2kg $10a^{-1}$) was significantly higher than that of the upland field (220.4kg $10a^{-1}$). Cho *et al.* (2006) reported that soybean cultivars planted in paddy soil produced higher 100-seed weight than those in

Table 1. Soil nitrogen content in upland and drained-paddy fields

Types of Field	Nitrogen (%)
Drained-paddy	0.907a
Upland	0.458b

The same letters (a or b) in each column are not significantly different at 5% level by DMRT.

Table 2. Growth and yield of 'agakong' soybean in upland and drained-paddy fields

Types of Field	Plant height (cm)	No. of seeds per pod	No. of nodes	No. of pods	100-seed weight (g)
Drained-paddy	151.8a	3.1a	17.8a	234.2a	6.8a
Upland	146.7a	2.8a	16.8a	220.4b	6.8a

The same letters (a or b) in each column are not significantly different at 5% level by DMRT.

the upland field though no significant difference was recorded between them.

The relatively good performance in terms of growth parameters of soybeans planted in the drained-paddy field is in agreement with the higher soil nitrogen content (Table 1) of drained-paddy field. Soil nitrogen in drained-paddy field (0.907%) was almost twice than that of the upland field (0.458%).

Effects on yield of soybeans

Fig. 1 depicts the yield of soybean planted in the upland and drained-paddy field. Drained-paddy field (278.1kg $10a^{-1}$) produced significantly higher yield than the upland field (179.3kg $10a^{-1}$). This observation can be thought as a direct effect of significantly higher number of pods and the generally better growth performance of plants planted in the drained-paddy field. However, this result was not in agreement with that observed by Cho *et al.* (2006) wherein soybean cultivars taegwangkong, daewonkong and hwanggumkong cultivated in the upland obtained higher grain yield than that of the drained-paddy.

Generally, all factors being equal, yield is a factor of soil nutrients. Considering that the other agronomic characters like branch length and number of seeds and nodes did not show significant differences, the higher number of pods and yield in the drained-paddy field suggested a high dependence of yield performance of 'agakong' on the type of soil. Relating the yield to the soil nitrogen content, there was a significantly higher nitrogen content in the drained-paddy soil (Table 2) than in the upland soil which probably brought about the higher number of pods and yield in the drained-paddy field.

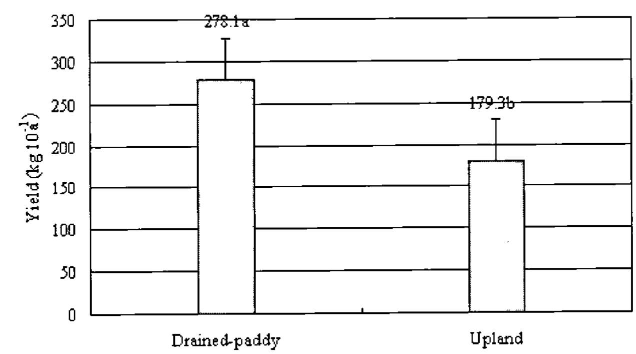

Fig. 1. Yield of 'agakong' soybean at different field conditions. The same letters (a or b) in each bar are not significantly different at 5% level by DMRT.

Effects on seed nutritional quality

Table 3 shows the seed quality of 'agakong' soybean. Results showed that the soybean produced in the upland field obtained significantly higher protein content than that produced in the drained-paddy field. Results further showed that aside from protein content there was no significant difference in all other nutrient contents analyzed namely: oil, fat, oleic, linoleic and sugar content. Except for protein content, result of this study is similar to the report of Park *et al.* (2006). Protein content of soybean produced in upland field (47.4%) was significantly higher than that in drained-paddy field (44.9%). Protein content in plants is primarily affected by the amount of nitrogen in the soil available for root absorption of the plant. Considering this, there was a discrepancy between the observed low soil nitrogen in upland field and the high protein content in soybean planted in this particular field. Timmerman and Brolley (2002) concluded in their study that high soil nitrogen resulted to lower yield and protein content in soybean. The negative correlation between yield and protein content is a common observation in soybean production (Filho *et al.,* 2004) that many breeding programs for soybean focused on producing varieties that would produce both high yield and protein content. Ishiguro *et al.* (2006) also found out that environmental factor had little effect on the protein contents of soybean.

Effects on seed antioxidant property

The antioxidant properties of soybean seeds were analyzed and presented in Table 4 for reducing power and Table 5 for phytic acid content. The values obtained for the reducing power of soybeans

Table 3. Seed quality of 'agakong' soybean in upland and drained-paddy fields (%)

Types of Field	Protein	Oil	Carbohydrate	Sucrose	Oleic	Linoleic	Linolenic
Drained-paddy	44.9b	13.6a	6.3a	3.8a	24.5a	52.9a	9.8a
Upland	47.4a	13.5a	6.3a	3.7a	24.3a	53.2a	9.8a

The same letters (a or b) in each column are not significantly different at 5% level by DMRT.

Table 4. Reducing power of 'agakong' soybean in upland and drained-paddy fields

	Optical density (700nm)		
	100mg mL^{-1}	50mg mL^{-1}	10mg mL^{-1}
Vitamin C	1.04	0.92	0.90
Drained-paddy	0.64a	0.54a	0.17a
Upland	0.66a	0.62a	0.20a

The same letters (a or b) in each column are not significantly different at 5% level by DMRT.

Table 5. Phytic acid content of 'agakong' soybean in upland and drained-paddy fields

Types of Field	Phytic acid (mg g^{-1})
Drained-paddy	2.90a
Upland	1.09b

The same letters (a or b) in each column are not significantly different at 5% level by DMRT.

produced in the upland field was generally higher than those obtained for the drained-paddy field though no significant difference was observed between them. Furthermore, their values were much lower compared than that of Vitamin C. In the case of phytic acid content, drained-paddy soybeans gave significantly higher value than that of the upland produced soybeans. Drained-paddy soybeans obtained a phytic acid content of 2.90mg g^{-1} that is more than twice than that of upland produced soybeans which is 1.09mg g^{-1}. This result was in agreement with that reported by Ishiguro *et al.* (2006) wherein the phytic acid of 12 varieties tested was high in the drained-paddy field than in the upland field.

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