Development of soybean production technique by living mulch method with Rhodes grass in southwestern Japan

Y S Prasojo¹, G Ishigaki²*, K Fukuyama² and R Akashi³

¹Interdisciplinary Graduate School of Agriculture and Engineering, University of Miyazaki, Miyazaki 8892192, Japan
²Sumiyoshi Livestock Science Station, Field Science Education Research Center, Faculty of Agriculture, University of Miyazaki, Miyazaki 8800121, Japan
³Faculty of Agriculture, University of Miyazaki, Miyazaki 8892192, Japan

Corresponding author: gishigaki@cc.miyazaki-u.ac.jp

Abstract. Tropical grasses mainly utilized in southwestern Japan exhibited that the dry matter yield is increased as the growth stage. However, the nutritive value, such as crude protein (CP) and non-fibrous carbohydrate (NFC) decreased strikingly. Therefore, breeding for the new grass or crops with high potential as protein source is an urgent problem. The aim of the study were to investigate the dry matter yield of two soybean cultivars (‘Miyakonojo’ and ‘Williams82’) with Rhodes grass as living mulch plant after 1st cutting and to investigate the nutritive value of the silage. The growth of the Rhodes grass hampered the growth of soybean at the initial and the subsequent growth stages. Hence, the dry matter yield of soybean ranged from 9.8 kg/10a to 26.6 kg/10a, correspond to about 3 to 10% of total dry matter yield. The nutritive value of EE, CA and CP in Rhodes grass with soybean silage higher than those of Rhodes grass silage. These results suggest that the addition of soybean biomass could be useful for increasing the nutrition value of silage. Moreover, it is necessary to choose an appropriate sowing date to increase dry matter yield of soybean biomass in southwestern of Japan.

1. Introduction

Kyushu is the primary livestock production area in Japan and accounts for around 24% of the total livestock production. South Kyushu (Miyazaki Prefecture, Kumamoto Prefecture, and Kagoshima Prefecture) as a center for livestock breeding accounts for more than 50% of total livestock production in Kyushu and largely depends on imports for feed materials. The cost of feed mixed have increased every year, to increase the self-produced roughage is one urgent issue.

Tropical grasses which mainly utilized in southwestern Japan have exhibited that the dry matter yield increase as the growth stage developed. However, the nutritive value such as crude protein and non-fibrous carbohydrate tends to be decreased as the growth stage developed. Therefore, the introduction or breeding the new grass or crops that have high potential as high protein source will be an urgent problem. Recently, in a cold area of northern Japan, interest has mounted in using soybean as a high-protein source in silage. There has been a report that cultivated soybean under Italian ryegrass sod as living mulch plant [1]. However, practical success cases have not been reported in the southern-western region of Japan. There is some problem of pasture production in the southwestern temperate zone, 1) low nitrogen availability to soil nitrogen for warm-season grass; 2) nutrient value
of grass dramatically decreased as growth stage developed. If such problems can be solved and high-protein feed production can be developed in a warm region of southwestern area, it will be possible to significantly reduce the production cost of livestock production (such as beef cattle production and milk production).

We cultivated two soybean cultivars (‘Miyakonojo’ and ‘Williams 82’) after first cutting of warm season grass, Rhodes grass (*Chloris gayana* kunth.), as living mulch plant. Rhodes grass is often used for forage feed in Kyushu area. Furthermore, the silage was prepared from Rhodes grass and mixed with soybean. The aim of this study was to determine the dry matter yield of two soybean cultivars (‘Miyakonojo’ and ‘Williams 82’) under Rhodes grass sod as living mulch plant and investigate the nutritive value of the silage.

2. Materials and methods

The study was conducted in Sumiyoshi Livestock Science Station (39°59′N, 131° 28′E, elevation of 12 m above sea level), Faculty of Agriculture, University of Miyazaki, Southern Kyushu, Japan. The soil type characterized as sandy soil with relatively poor in organic matter. The climate of Miyazaki according to the Köppen classification, is Cfa that is humid subtropical climate, relatively high temperature and evenly distributed precipitation throughout the year. Two typical grain-type cultivars, ‘Miyakonojo’ and ‘Williams 82’, were used in this study.

The experiment was used two system, tillage and non-tillage. In with tillage, Rhodes grass as a living mulch was sown on May 2016 at a rate of 3.0 kg/10a, and was harvested at a mowing height of 15 cm above the ground on August 2016, followed by tillage with rotary cultivator (Kubota) at 40 cm width and soybean seeds were sown directly after tillage. In without tillage, soybean seeds were sown directly into Rhodes grass sod without tillage. We applied 1 L/10a of fermented cow feces as basic fertilizer (N 2.5%, P$_2$O$_5$ 4.0%, K$_2$O 2.1%). Followed by application of 4 kg chemical fertilizer (N, 3.4 kg of P$_2$O$_5$, 2.9 kg of K$_2$O).

Rhodes grass and soybean were harvested on November 2016, plant height (cm) was investigated before harvested. The dry weight was recorded after drying at 60 °C for > 72 h. Rhodes grass and soybean growth stage was recorded during cultivation time. After drying, harvested Rhodes grass and soybeans were chopped into approximately 5 cm in length using a forage cutter and packed into a sealed plastic. Silage bag was sealed by using vacuum to reduce air inside. Statistical analysis was performed using R statistic version 3.1.1. Differences between treatments were tested by the Tukey-Kramer method when ANOVA F-test was significant.

3. Result and discussions

3.1. Yield characteristics of Rhodes grass and soybean cultivars

The soybean cultivars ‘Miyakonojo’ and ‘Williams 82’ both emerged from the 5th day after sowing and grew vigorously, but the regeneration after 1st grass cutting of Rhodes grass was more vigorous than soybean growth, so that after 21 days of sowing, the height of Rhodes grass was higher than soybean (Fig 1a). Before harvest, though it was not significant, the plant height of soybean in non-tillage treatment tended to be higher than tillage treatment in all cultivars (Table 1).

![Figure 1](image_url). Experimental field (Fig 1a) of Rhodes grass and two soybean plants (‘Miyakonojo’, Fig 1b; ‘Williams 82’, Fig 1c) at pre-harvest time (23th November 2016).
Furthermore, since the plant height of Rhodes grass was significantly higher than the plant height of soybean in tillage or no tillage treatment, means that tillage treatment was done before soybean was sown also had no effect on growth of soybean. The dry matter yield of Rhodes grass in tillage and non-tillage was significantly higher ($P < 0.05$) than both soybean cultivars. However, there was no significant difference between tillage and non-tillage system for both Rhodes grass and soybean. The dry matter yield of Rhodes grass was about 300 kg/10a in both treatments, while the soybean dry matter yield ranged from 9.8 kg/10a to 26.8 kg/10a (Table 1).

**Table 1.** Plant length and dry matter yield of Rhodes grass and two soybean cultivars (Miyakonojo and Williams 82)

| Parameter          | ‘Miyakonojo’ | ‘Williams 82’ |
|--------------------|--------------|---------------|
|                    | Non-tillage  | Tillage       | $P$  | Non-tillage | Tillage | $P$  |
| Plant length (cm)  |              |               |      |             |         |      |
| Rhodes grass       | 156.1$^a$    | 137.3$^a$     | 0.011| 156.2$^a$   | 131.7$^a$| 0.001|
| Soybean            | 57.3$^b$     | 54.7$^b$      | 0.227| 52.0$^b$    | 47.7$^b$| 0.055|
| Dry matter yield (kg/10a) | | | | | | |
| Rhodes grass       | 318.1$^a$    | 337.0$^a$     | 0.784| 318.6$^a$   | 266.5$^a$| 0.358|
| Soybean            | 9.8$^b$      | 15.2$^b$      | 0.343| 16.8$^b$    | 26.8$^b$| 0.254|
| Soybean mixing (%) | 3.1          | 4.5           | 0.496| 5.3         | 10.1    | 0.240|

Values followed by different letters between Rhodes grass and soybean differ significantly ($P < 0.05$) by t-test.

The result showed that Rhodes grass developed through autumn was growth vigorously after first cutting and started to generate the heading. Rhodes grass served as a living mulch suppressed soybean growth at the initial growth stage and the subsequent stages. Means that autumn was not best season to begin a living mulch system between Rhodes grass and soybean, appropriate sowing date of soybean using a living mulch need to consider in the warm southwest area.

In many areas in the southwestern warm region including southern Kyushu, cold-season grass such as Italian ryegrass is being harvest in the beginning of May and followed by cultivating of corn and warm-season grass such as Rhodes grass. However, it is necessary to examine of living much system by using Italian ryegrass in southwestern area.

### 3.2. Investigation of *Spodoptera litura*

In this experiment, we were also investigated the number of insect that infect soybean during cultivation period. The most insect to infect was *Spodoptera litura*. *Spodoptera litura* is broad-spreading insect that belongs to the Lepidoptera and had been reported making damage for many crops including soybean [2]. During the test period, adults (males) were detected from the beginning of the survey. The number of confirmed individuals became highest on August 2nd (about 160 animals) and then dropped sharply (Fig 2). On September 7, seven days after sowing, no worms were identified.
Previously on this site, there was no report about pest infected because of no cultivating of leguminous crops such as soybean. Therefore, it is important to considering the behaviour of pest infected the crops.

3.3. Nutrient value of silage

Table 2 shows silage nutritive value of Rhodes grass only (RG) and Rhodes grass with soybean cultivar ‘Miyakonojo’. Even though there was no significant difference, RG+Soybean silage had higher extract ether (EE), crude ash (CA), and crude protein (CP) than RG silage. Means that addition of soybean effective to increased nutritive value especially CP in silage. However, low CP value of RG+Soybean silage in this study probably cause by small addition of soybean biomass compare to Rhodes grass. Another report on intercropping between soybean and grass millet showed that CP was increased as proportion ratio of soybean also increased [3].

|                  | Moisture | Extract Ether | Crude Ash | Crude Protein |
|------------------|----------|---------------|-----------|--------------|
| Rhodes grass (RG)| 60.5     | 2.2           | 10.2      | 10.5         |
| RG+Soybean       | 61.9     | 2.5           | 10.5      | 12.0         |

4. Conclusions

The result of this study concludes that despite soybean growth being hampered by high development growth of Rhodes grass, the intercrops system had the potential to make good quality silage. It is necessary to examine another soybean cultivars by choosing an appropriate sowing date to increase dry matter yield and effectiveness by using living mulch system with Rhodes grass or Italian ryegrass in southwestern area for further study.

Acknowledgment

The authors gratefully acknowledge the financial support of research grant project by The Ito Foundation.

References

[1] Uchino H, Uozomi J, Touno E, Kawamoto H and Deguchi S 2016 F. Crop Res. 193 143–53
[2] Endo N, Hirakawa, Wada T and Tojo S 2007 Appl. Entomol. Zool. 42 199–204
[3] Jahanzad E, Sadeghpour A, Hashemi M, Afshar R K, Hosseini M B and Barker A V 2015 Grass Forage Sci. 71 584–94