Effect of Source or Sink Restriction on Flowering, Podding, and Yield Performance in Field-Grown Adzuki Bean

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Abstract

The effect of source or sink restriction on flowering, podding, and yield performance in field-grown adzuki bean cv. 'Erimo-shozu' was investigated. Defoliation and defloration treatments were performed as source and sink restriction during the flowering period. Defoliation treatment reduced the flower and pod numbers and shortened the period of flowering and podding. Defloration increased the flower and pod numbers. Defoliation treatment was shown to reduce the seed yield and yield components. The 100-grain weight in defoliation treatment was significantly the lowest among all treatments. These results suggest that the seed yield of adzuki bean depends on dry matter production during the flowering period. Furthermore, a compensatory effect in sink restriction indicated by an increase in flower number was also noted.

Keywords: adzuki bean, defloration, defoliation, flowering, podding, yield component

Introduction

Adzuki bean (*Vigna angularis* (Willd.) Ohwi et Ohashi) is the second most important leguminous crop in Japan after soybean (*Glycine max* (L.) Merr.). It is widely used for the production of a sweet bean paste called Ann, which is a major component in traditional Japanese sweets (Murata, 1999). It has been commercially produced in Hokkaido, Northern Japan, where crop breeding program is mainly carried out in that area (Shimada, 2006). In recent years, improvement of yield stability is an important issue to be considered since the production efficiency of adzuki bean grown in Hokkaido varies drastically each year because of higher rates of damage due to cold weather (Shimada, 2006). However, up-to-date information with regard to the yield-determining process of adzuki bean has been limited because of its minor role worldwide.

In adzuki bean, as in many other leguminous crops, knowing the habit of flowering and podding is considered to be important for analyzing the yield-determining process. Compared to the soybean, the adzuki bean has a long flowering period and a low podding efficiency (Takahashi, 1958). In general, source-sink relationships play an important role in the yield-determining process. For example, defoliation or defloration treatments of soybean plants accelerated the development of flower buds and podding (Saitoh *et al*., 2001). However, there is limited information about the effect of source or sink restriction on flowering, podding, and yield performance of adzuki bean. In order to evaluate the relative importance of source or sink on yield-determining process, we examined the changes in flower and pod numbers and yield components in field-grown adzuki bean plants as affected by defoliation or defloration treatments.

Materials and Methods

The field experiment was conducted in the Tokyo University of Agriculture farm at Abashiri, Hokkaido, Japan (43°53′44″N, 144°21′45″E). The soil type was andosol, and the preceding crop was barley (*Hordeum vulgare* L.). Adzuki bean cv. 'Erimo-shozu', which is a most famous leading variety of adzuki bean in Hokkaido, was used in this study. Four seeds per hill were seeded on June 2, 2010, at 16.6-cm spacing in approximately 3.5-m-long rows with 72-cm row spacing. The seedlings were thinned to two seedlings per hill three weeks after seeding. Compound fertilizer ($N:P_2O_5:K_2O$ = 5:25:14%) at 80 g m^{-2} was applied as the basal application. Although the summer air temperature in 2010 was higher than that in the average year, this experiment was performed under normal climatic conditions.

Source or sink restriction treatment was initiated on July 26, after flowering began. Source restriction treatment consisted of removing two lateral leaflets of every trifoliate leaf when flowering began. Sink restriction treatment consisted of removing every flower on each branch. After initiation, defoliation and defloration were continued until flowering ceased. Six experimental plots including a control were set up according to a randomized block design with two replications.

The change in flower and pod numbers was investigated for 5 plant samples in each plot. The flowering date was recorded on a small label (9 mm in width and 22 mm in length) for each plant, and then the label was wrapped around the pedicel of the flower. The labels were attached on all flowers that had formed pods by the time of maturity. The podding rate was calculated from the flower and pod numbers during the entire flowering period based on the label data. At maturity, 20 standard plants from 10 hills in each plot were sampled except for the plant with attached labels. After air-drying, the seed yield and yield components—namely, pod number, seed number per pod, and 100-seed weight—were examined.

Results and Discussion

The average temperatures during the vegetative and reproductive stages were 17.5°C and 19.6°C, respectively. The growth and yield of adzuki bean are known to be susceptible to cold weather damage (Shimada, 2006), e.g., the low temperature during vegetative growth induced abortion of main stem elongation, and low temperature before flowering induced podding injury in a previous study (Aoyama *et al*., 2009). In the present experiment, air temperature during every growth phase tended to be higher than that in the average year. The main stem length and top dry weight at maturity in control treatment condition were 83.4 cm and 640 g m^{-2}, respectively. It was confirmed that in the normal plant type, flowering and podding were not affected by low temperatures.

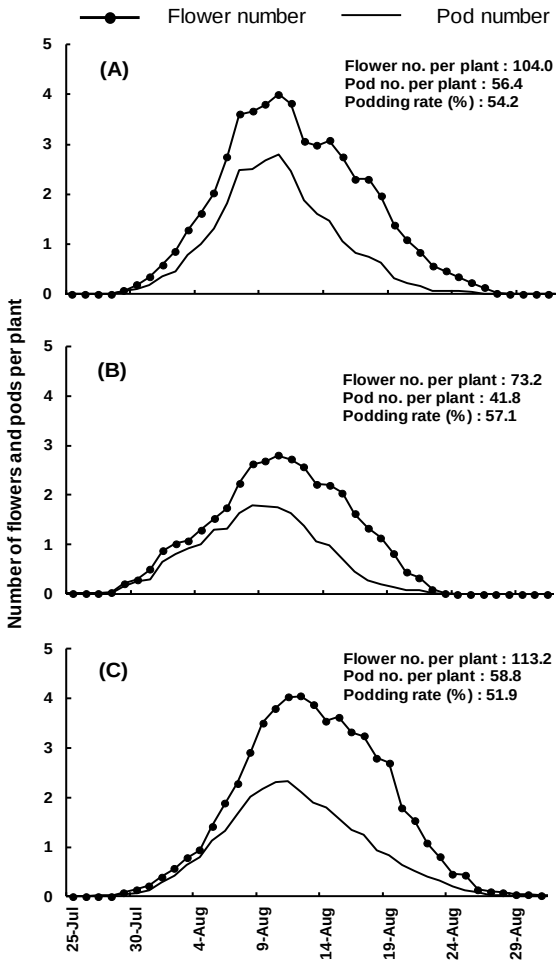
The change in flower and pod numbers per plant differed among treatments (Fig. 1). In control treatment, the cumulative flower and pod numbers per plant were 104.0 and 56.4, respectively (Fig. 1A). In source restriction treatment, however, the flower and pod numbers were reduced and the period of flowering and podding was shortened compared to control (Fig. 1B). Data indicated that dry matter production after flowering affects the flower and pod numbers. Furthermore, this study clarified that the reduction in dry matter production also affects the flowering and podding periods. Conversely, the flower and pod numbers in sink restriction treatment were higher than those in the control but the podding rate was lowest among all treatments (Fig. 1C). These results suggested that sink restriction treatment was compensated by a drastic increase in the flower number. In this study, sink restriction treatment consisted of removing all flowers from all branches. The effects of source and sink manipulations on the flower numbers of soybean varied with flower position between the main stem and branches (Saitoh *et al*., 2001). Thus, further studies are required to clarify the source-sink relationship between the main stem and branches of adzuki bean.

Table 1 showed the effect of source or sink restriction on the seed yield and yield components of adzuki bean. The seed yield tended to be lower in source restriction treatment than in control and sink restriction treatments, although no significant difference was observed. Similar tendencies were observed in yield components. The 100-seed weight in source restriction treatment was significantly lower than the weights in other treatments. The decline in 100-seed weight by defoliation suggested that the seed yield of adzuki bean might be limited by source size, which was consistent with previous reports on soybeans (Egli & Leggett, 1976; Saitoh *et al*., 2001).

Table 1. Effect of source or sink restriction on the seed yield and yield components of adzuki bean

Treatment	Seed Yield (g m^{-2})	Pod no. (no. m^{-2})	Seed no. per Pod	100-seed weight (g)
Control	358 a	487 a	5.52 a	12.9 a
Source restriction	305 a	438 a	5.42 a	12.1 b
Sink restriction	338 a	463 a	5.48 a	13.0 a

Values with different letters in a single column are significantly different at the 5% significance level by Tukey–Kramer's test.



Data shows 5-days moving average with 10 plants of 2 replicates. The flower number, pod number, and podding rate in each figure show the values of entire examination periods.

Figure 1. The change in flower and pod numbers per plant in control (A), source restriction (B), and sink restriction (C).

In conclusion, this study suggested that the seed yield of adzuki bean depends on dry matter production during the flowering period. A compensatory effect in sink restriction treatment indicated by an increase in flower number was also observed. Moreover, defoliation treatment shortened the flowering and podding periods. This result may be related to early maturity. In the future, we plan to conduct additional experiments using early maturing varieties.

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*In Japanese.
** In Japanese with English summary.
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