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Research paper

Seed-setting habit of a semidwarf common buckwheat line

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ABSTRACT

The seed-setting habit of a semidwarf common buckwheat (*Fagopyrum esculentum* Moench) line was evaluated in a field experiment under standard and high nitrogen levels. The ‘semidwarf line’ and ‘Kitawasesoba’ were used in the present study. The main stem length of the ‘semidwarf line’ was approximately two thirds of that of the ‘Kitawasesoba’. Minimal differences were observed in the numbers of nodes on the main stem and primary branches of the ‘semidwarf line’ and ‘Kitawasesoba’ among genotypes and nitrogen levels. No drastic decline of seed yield by the shortening of the main stem length along with the introduction of dwarfness was observed in the ‘semidwarf line’ compared with ‘Kitawasesoba’. The number of flower clusters per plant of the ‘semidwarf line’ in the high nitrogen plot tended to be greater than that of the ‘semidwarf line’ in the standard nitrogen plot and ‘Kitawasesoba’ in both nitrogen plots. This increase in flower clusters occurred on branches. The number of seeds of the ‘semidwarf line’ in the standard nitrogen plot was considerably lower than that of the ‘Kitawasesoba’ in both nitrogen plots. Similar tendencies were observed in the weights of seeds. The decline of seed number and weight of the ‘semidwarf line’ in the standard nitrogen plot was mainly observed in branches. From these results, it was found that the seed-set in the ‘semidwarf line’ can be improved by nitrogen fertilizer application. Furthermore, seed production on branches may play an important role in the high-yielding ability of semidwarf common buckwheat.

INTRODUCTION

Common buckwheat (*Fagopyrum esculentum* Moench) is widely cultivated, and its seeds are used in various food items, including cereal, noodles, tea, and bread. The yield of common buckwheat is generally affected by its seed-set, with a low seed-set resulting in a lower seed yield (Woo et al., 2016). Furthermore, lodging, i.e., the tendency of the stem to bend until the plant is lying horizontal, is one of the serious problems affecting buckwheat and resulting in a drastic decline of seed yield (Tetsuka and Morishita, 1999). Many typhoons occur during summer in Japan, leading to damage by lodging in common buckwheat cultivation. Shortening the plant height by developing a semidwarf cultivar can be useful in its improving the lodging resistance. In Tartary buckwheat (*F. tataricum* (L.) Gaertn.), the semidwarf cultivar 'Darumadattan' has already been developed by gamma ray-induced mutations (Ministry of Agriculture, Forestry and Fishers 2013). Darumadattan has been shown to have improved agronomic characteristics and strong lodging resistance (Morishita et al., 2010; Kasajima et al., 2012; 2013; 2014). On the other hand, few practical semidwarf cultivars of common buckwheat were available for a long time; however, dwarf and semidwarf genes in common buckwheat have been reported (Ohnishi and Nagakubo, 1982; Minami et al., 1999). Recently, Morishita et al. (2015) reported that novel semidwarf common buckwheat lines were developed from their breeding population in 2009. Compared with 'Kitawasesoba', a leading cultivar in Hokkaido, northern Japan, the semidwarf common buckwheat line has a plant height that is approximately 60% and a seed yield that is almost the same as or slightly lower than that of non-dwarf common buckwheat. (Morishita et al., 2015). Therefore, the dwarfness of common buckwheat is considered to be practical for cultivation in Japan.

The improved lodging resistance in common buckwheat is known to be observed for determinate cultivars as well as semidwarf cultivars (Ohsawa, 2011). The determinate cultivar shows shortened plant height based on a determinate inflorescence. It has been demonstrated that seeds that develop on branches constitute a larger proportion of the total seed number (Funatsuki et al., 2000). Kasajima et al. (2016) pointed out that seed production from flowers on branches arising from the lower order nodes on the main stem plays an important role in increased seed yield of determinate common buckwheat. These reports suggest that the seed-setting habit in a semidwarf common buckwheat plant may differ from that of the normal cultivars based on the difference in morphological characteristics between the cultivars. An investigation of the seed-set from the viewpoint of morphological characteristics in semidwarf common buckwheat line is required. However, to date, there are no reports on the yield-determining process of semidwarf common buckwheat. The objective of the present study was therefore to clarify the seed-setting habit of semidwarf common buckwheat.

MATERIALS AND METHODS

Two common buckwheat genotypes were used in the present study. The 'semidwarf line' was discovered in 2009 after obtaining F_3 progeny through crossing between 'Horominori' and 'Mekei 20', and its semidwarf trait is controlled by one recessive gene (Morishita et al., 2015). 'Kitawasesoba' is the leading cultivar in Hokkaido, Japan (Inuyama et al., 1994). The cultivation of the materials used in the field experiment of the present study was conducted in the experimental field at the Memuro Upland Farming Research Station of the National Agriculture and Food Research Organization (NARO) Hokkaido Agricultural Research Center (Shinsei, Memuro, Kasai-Gun; longitude, 143° 03′ E; latitude, 42° 55′ N) from June to August, 2016. To evaluate the seed-setting habit, we designed standard and high nitrogen plots. In the standard nitrogen plot, a compound fertilizer, which comprised 1.8 g m^{-2} of N, 7.2 g m^{-2} of P_2O_5, and 4.2 g m^{-2} of K_2O, was applied to the plots. In the high nitrogen fertilizer plot, ammonium sulfate containing 7.2 g m^{-2} of N, equivalent to 5-fold that of N for the standard nitrogen plot, was applied in addition to the fertilizers used in the standard nitrogen plot. In both plots, fertilizer applications were performed only as a basal dressing. The seeds were sown in rows on June 3, 2016, with 60-cm row spacing and seeding density of 150 seeds m^{-2}. The experimental plot area was 7.2 m^2 (3 × 2.4 m). The plants of each plot were grown in a completely randomized design with two replications.

Ten plants in each plot were sampled on August 24, 2016 (maturity stage). The main stem length, number of nodes on the main stem, and number of primary branches of the plants were investigated after the sampling. Subsequently, plant samples were air-dried over a period of two weeks. The number of flower clusters on main stem and each primary branch were then collected and counted. We investigated the seed number and weight on the main stem and branches after hand-threshing. In addition, the seed yield in each plot was investigated by unit area sampling.

RESULTS AND DISCUSSION

Table 1 shows the morphological characteristics and seed yield of the 'semidwarf line' and 'Kitawasesoba' grown under different nitrogen levels. The main stem length of the 'semidwarf line' was approximately two thirds of that of 'Kitawasesoba'. In both genotypes, the main stem length in the high nitrogen plot tended to be longer than that in the standard nitrogen plot. The difference in main stem length between the standard and high nitrogen levels was larger in the 'semidwarf line' than in 'Kitawasesoba'. However, minimal differences were observed in the number of nodes on the main stem and the number of primary branches of the 'semidwarf line' and 'Kitawasesoba' among genotypes and nitrogen levels. These results indicated that the decrease in the main stem length of the 'semidwarf line' can be dependent on the shortening of internode length, which was consistent with previous reports on semidwarf common buckwheat (Morishita et al., 2015) and Tartary buckwheat (Kasajima et al., 2012; 2013). No drastic decline in seed yield of the 'semidwarf line' by the shortening of the main stem length along with the introduction of dwarfness was observed as compared with ‘Kitawasesoba’. The seed yields of the ‘semidwarf line’ and ‘Kitawasesoba’ in the high nitrogen plot tended to be higher than those of the standard nitrogen plot. Morishita et al. (2015) reported that the seed yield of the ‘semidwarf line’ was almost the same or approximately 80% of that of ‘Kitawasesoba’. Similarly, in the present experiment, the usefulness of the ‘semidwarf line’ was confirmed, and it was shown that its yield may be improved by nitrogen fertilizer application.

Fig. 1 shows the number of flower clusters on the main stem and on each branch (branches 1–4) of the ‘semidwarf line’ and ‘Kitawasesoba’ grown under different nitrogen levels. The number of flower clusters per plant of the ‘semidwarf line’ in the high nitrogen plot tended to be greater than that of the ‘semidwarf line’ in the standard nitrogen plot and ‘Kitawasesoba’ in both nitrogen plots. This increase in the number of flower clusters was dependent on the increased number of flower clusters on branches, particularly branches 2 and 3. The results of the present study indicated that the application of nitrogen fertilizer promotes the development of flower clusters that develop on branches rather than on the main stem. Based on the present results, it is considered that the seed-set of the ‘semidwarf line’ used in the present study was susceptible to nitrogen fertilizer application.

Table 1. Morphological characteristics and seed yield of a ‘semidwarf line’ and ‘Kitawasesoba’ grown under different nitrogen levels.

		Main stem length (cm)	Number of nodes on main stem	Number of primary branches	Seed yield (kg a^{-1})
Semidwarf line	Standard nitrogen	70.5 ± 3.4	13.7 ± 0.4	3.0 ± 0.1	16.3 ± 0.6
	High nitrogen	86.6 ± 4.1	14.9 ± 0.6	3.2 ± 0.2	20.0 ± 1.2
Kitawasesoba	Standard nitrogen	111.4 ± 2.7	12.4 ± 0.4	3.2 ± 0.2	19.4 ± 0.9
	High nitrogen	118.7 ± 2.9	12.9 ± 0.4	3.3 ± 0.2	22.3 ± 1.8

Data are shown as mean ± standard error of two replicates.

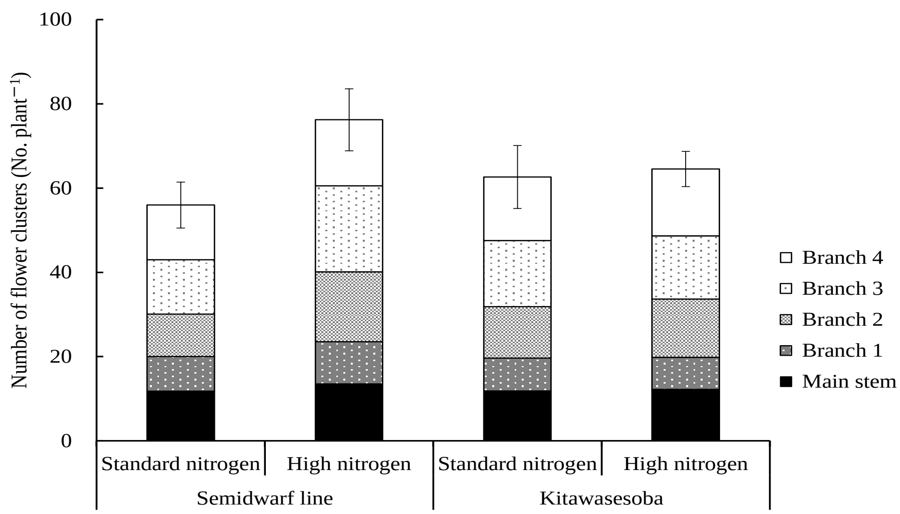

Fig. 1. Number of flower clusters in each part of a ‘semidwarf line’ and ‘Kitawasesoba’ grown under different nitrogen levels. Vertical bars represent standard errors of total flower clusters based on two replicates. The branches were numbered from the soil surface (branch 1) to the terminal part of the plant (branch 4).

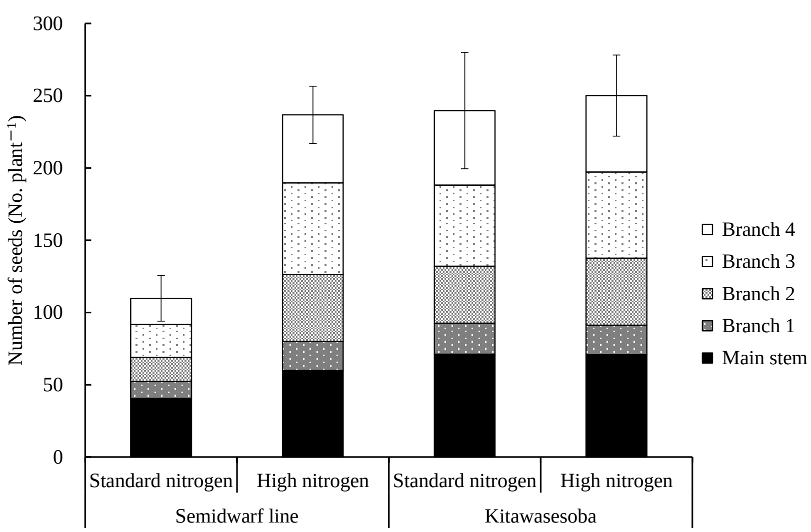

Fig. 2. Number of seeds on the main stem and on each branch (branches 1–4) of a ‘semidwarf line’ and ‘Kitawasesoba’ grown under different nitrogen levels. Vertical bars represent standard errors of total seed number based on two replicates. The branches were numbered from the soil surface (branch 1) to terminal part of the plant (branch 4).

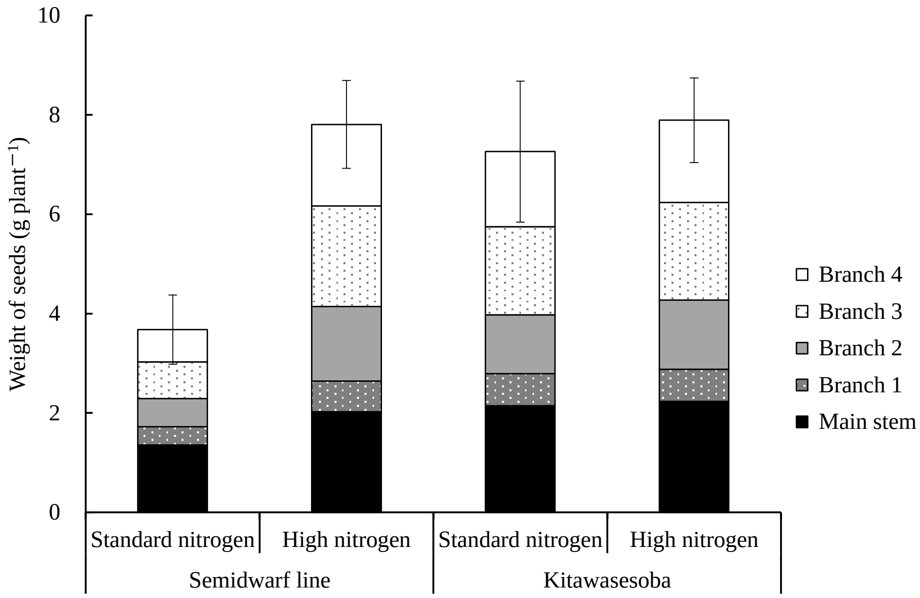

Fig. 3. Weight of seeds on the main stem and on each branch (branches 1–4) of a ‘semidwarf line’ and ‘Kitawasesoba’ grown under different nitrogen levels. Vertical bars represent standard errors of total seed weight based on two replicates. The branches were numbered from the soil surface (branch 1) to terminal part of the plant (branch 4).

Fig. 2 shows the number of seeds on the main stem and on each branch (branches 1–4) of the ‘semidwarf line’ and ‘Kitawasesoba’ grown under different nitrogen levels. The number of seeds of the ‘semidwarf line’ in the standard nitrogen plot was considerably lower than that of ‘Kitawasesoba’ in both nitrogen plots. On the other hand, the seed number of the ‘semidwarf line’ in the high nitrogen plot was almost the same as that of ‘Kitawasesoba’ in both nitrogen plots. Similar tendencies in regards to the weights of seeds were observed in the ‘semidwarf line’ (Fig. 3). The decline of seed number and weight of the ‘semidwarf line’ in the standard nitrogen plot was mainly observed in branches, particularly branches 2–4, rather than in the main stem. These results indicated that the application of nitrogen fertilizer may improve the seed-set on branches of the ‘semidwarf line’ used in the present study. Furthermore, we clarified that the seeds that developed on branches play an important role in the yield-determining process of semidwarf common buckwheat.

In conclusion, it was found that the seed-set in a ‘semidwarf line’ can be improved by application of nitrogen fertilizer. Furthermore, the seed production on branches may play an important role in the high-yielding ability of semidwarf common buckwheat. In the future, we plan to carefully examine the responses of lodging in the ‘semidwarf line’ to heavy fertilizer application. The semidwarf cultivar of Tartary buckwheat was found to have a higher rooting ability compared with the cultivar of standard height (Kasajima et al., 2015). Further studies will be required to examine the lodging resistance of semidwarf common buckwheat from the viewpoint of rooting ability.

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