Effects of Different Seeding Dates on Pattern of Internode Length in Sorghum Variety 'Kazetachi'

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Abstract

Sorghum (*Sorghum bicolor* Moench) stems, which have many internodes, are the main organs harvested for feed and biofuel materials. Sorghum reportedly has three types, characterized by individual internode length based on the internode position from base to top: 1) ever-increasing type, with internode length increasing from the base to the top internode; 2) unimodal type, with internode length in approximately the middle internode position that is longer than in lower or upper positions, except at the neck internode of the panicle; 3) bimodal type, for which the internode lengths alternately increases and decreases twice before reaching the peduncle. Sorghum variety 'Kazetachi', an ultralate-maturity variety in Japan with strong lodging tolerance, showed patterns with many peaks. It is a multimodal pattern in internode length. Furthermore, this variety shows large variation in the number of peaks per plant and the internode position with a peak among plants. This report describes internode length pattern analysis of 'Kazetachi' and the assessment of seeding date effects on the pattern. Seeds were sown on 20 May, and 3 and 18 June in 2009 in the northern part of Japan. Internode lengths were measured at harvest in early November. Peaks in the internode length pattern of each plant were 4–7, including both distinct and vague peaks. Pattern analysis using the internode position with a distinct peak contributed to the distinction among patterns on each seeding date. Although internode positions showing a distinct peak differed among patterns of different seeding dates, the period during which the internode with distinct peaks elongated rapidly appeared to be almost identical among them, suggesting that the internode length in 'Kazetachi' is characterized more by environmental factors than by genetic factors.

Keywords: internode length, *multimodal pattern*, *pattern of internode length*, Sorghum bicolor *Moench*

Introduction

Sorghum (*Sorghum bicolor* Moench) stems, consisting of many internodes, are the main organ harvested for feed and making syrup. Sweet sorghum has attracted attention recently as a biomass energy crop because its stems accumulate large amounts of sugars, which are convertible into ethanol: bioethanol. However, little information about development of cultivation techniques to increase stem yield in sweet sorghum exists because most research efforts have emphasized increasing of grain yields for grain sorghum. Stem size of sweet sorghum is the important factor that determines the stem yield including sugar yield (Tsuchihashi and Goto 2004; Sato *et al*., 2008; Nakamura et al., 2009).Increasing sweet sorghum stem yields necessitates research into internode formation in stems. Three types of sorghum can be characterized by individual internode length based on the internode position from the base to top (Ayyangar *et al*., 1938). 1) For the ever-increasing type, the internode length increases from the base to the top internode. 2) The unimodal type has internode length in approximately the middle internode position that is longer than in lower or upper positions, except at the neck internode of the panicle. 3) In the bimodal type, the internode lengths increase gradually, then decrease and increase slightly, and decrease again, with one more increase before reaching the peduncle. However, 'Kazetachi', ultralate-maturity variety, with strong tolerance of lodging in Japan, shows new patterns with many peaks: a multimodal pattern of internode length. This variety also shows large variation in the number of peaks per plant and the internode position, with the peak among plants (Figs. 1, 2) (Nakamura *et al*., 2011). This study assesses a method to analyze the internode length pattern in 'Kazetachi' and examines effects of the seeding date on the pattern.

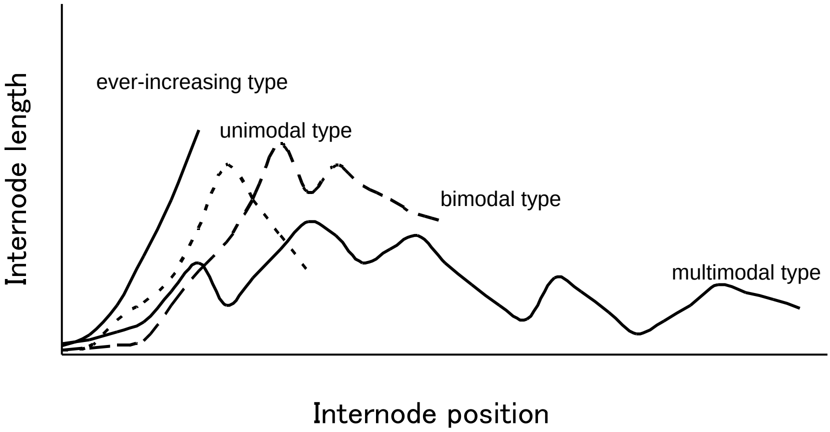

Figure 1. Schematic depiction of three internode length patterns—the ever-increasing, unimodal, and bimodal type—in sorghum, with the multimodal type shown for 'Kazetachi'.

Figure 2. Short internodes among upper internodes of a stem of sorghum variety' Kazetachi'.

Materials and Methods

This study was conducted at the experimental field of the School of Food, Agricultural and Environmental Sciences, Miyagi University, Japan. Seeds were sown on 20 May (S1), 3 June (S2), and 18 June (S3) in 2009 with three replications. Seedlings were thinned to one per hill at 0.85 m distance between the lines and to 15.0 cm between the plants. A basal fertilizer of 16–14–16 g NPK per m^{-1} was applied. The internode length was measured for each of the 18 plants at harvest in the beginning of November.

The (*n*)-th internode (IN n) was defined that between the (*n*+1)-th node and the (*n*)-th node where the (*n*)-th leaf is attached. The internode position of the peak in the internode length pattern was defined as the internode position that was longer than just upper and lower internodes.

Results and Discussion

The average of the total leaf number on the main stem was 30.7 ± 0.1 (S1), 29.8 ± 0.2 (S2), 29.1 ± 0.2 (S3). Figure 3 shows the internode length of each internode position through IN8–IN28 at each seeding date. The peaks per plant in the internode length patterns shown in S1, S2, and S3 were 3–5, from 3–6, and from 3–5, respectively. The average numbers of peaks were 3.6 ± 0.2 (S1), 4.4 ± 0.2 (S2), and 3.8 ± 0.2 (S3) (Fig. 4). Distinct and vague peaks existin the internode length patterns of all plants, but the average patterns had very similar shapes. Three distinct peaks were observed in the average pattern, irrespective of the seeding date (Fig. 3). According to this result, these peaks were designated acropetally as peak I, peak II, and peak III. The respective internode positions with peak I in S1, S2, and S3 were IN12–IN14 (13.1 avg.), IN14–IN17 (14.7 avg.), and IN11–IN13 (12.0 avg.) (Fig. 5 and Table 1). The respective internode positions with peak II in S1, S2, and S3 were IN20–IN21 (20.4 avg.), IN18–IN21 (19.4 avg.) and IN16–IN20 (17.7 avg.). The respective internode positions with peak III in S1, S2, and S3 were IN25–IN27 (26.1 avg.), IN23–IN26 (24.8 avg.), and IN21–IN26 (23.4 avg.). These results show that the average internode positions of peak II and peak III shifted lower with a later seeding date, excepting peak I.

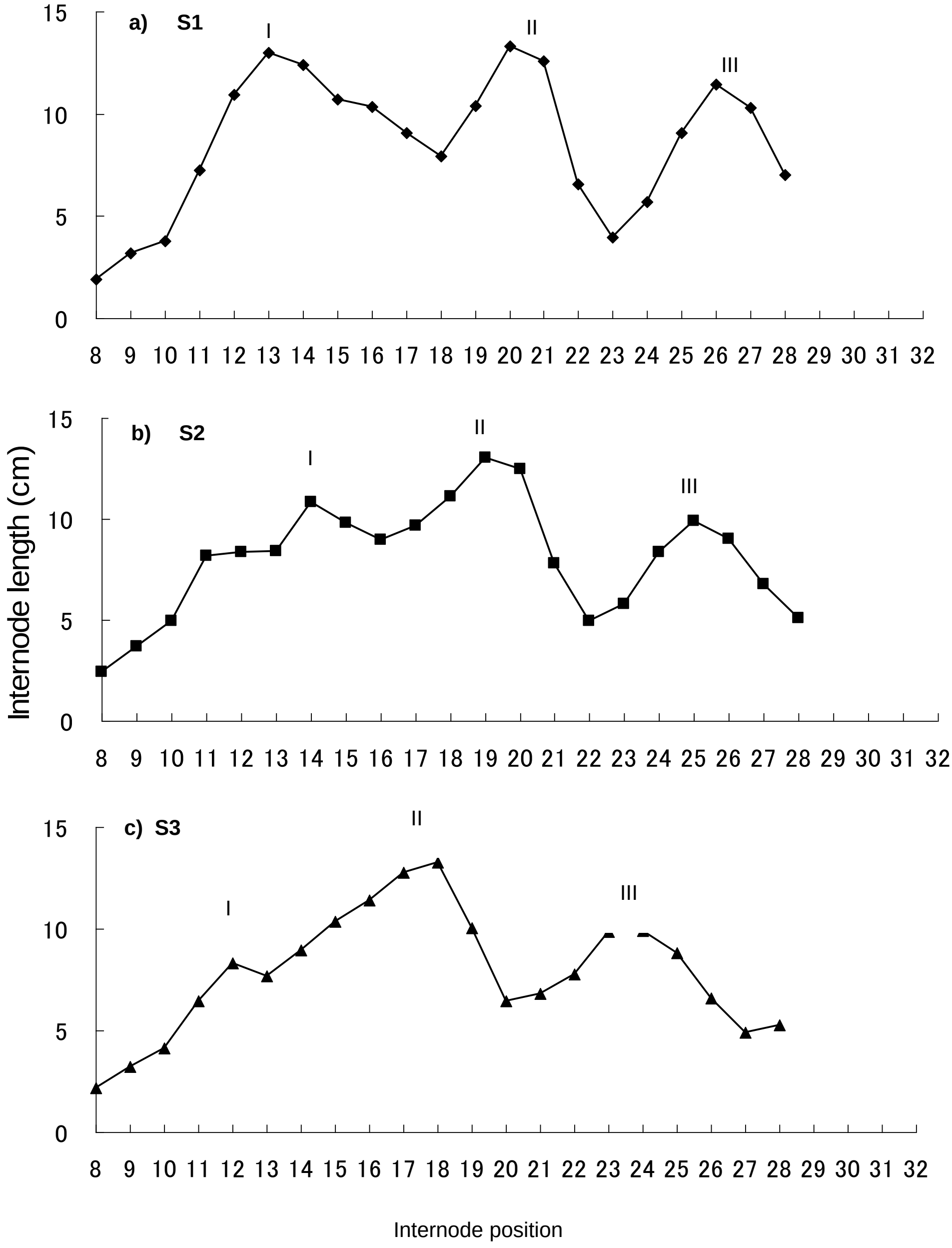

Figure 3. Internode lengths through IN8–IN28 in S1 (a), S2 (b) and S3 (c).

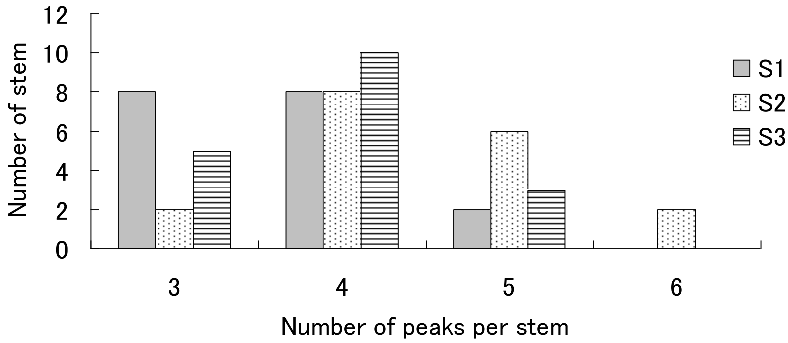

Figure 4. Number of internode length pattern peaks on each seeding date.

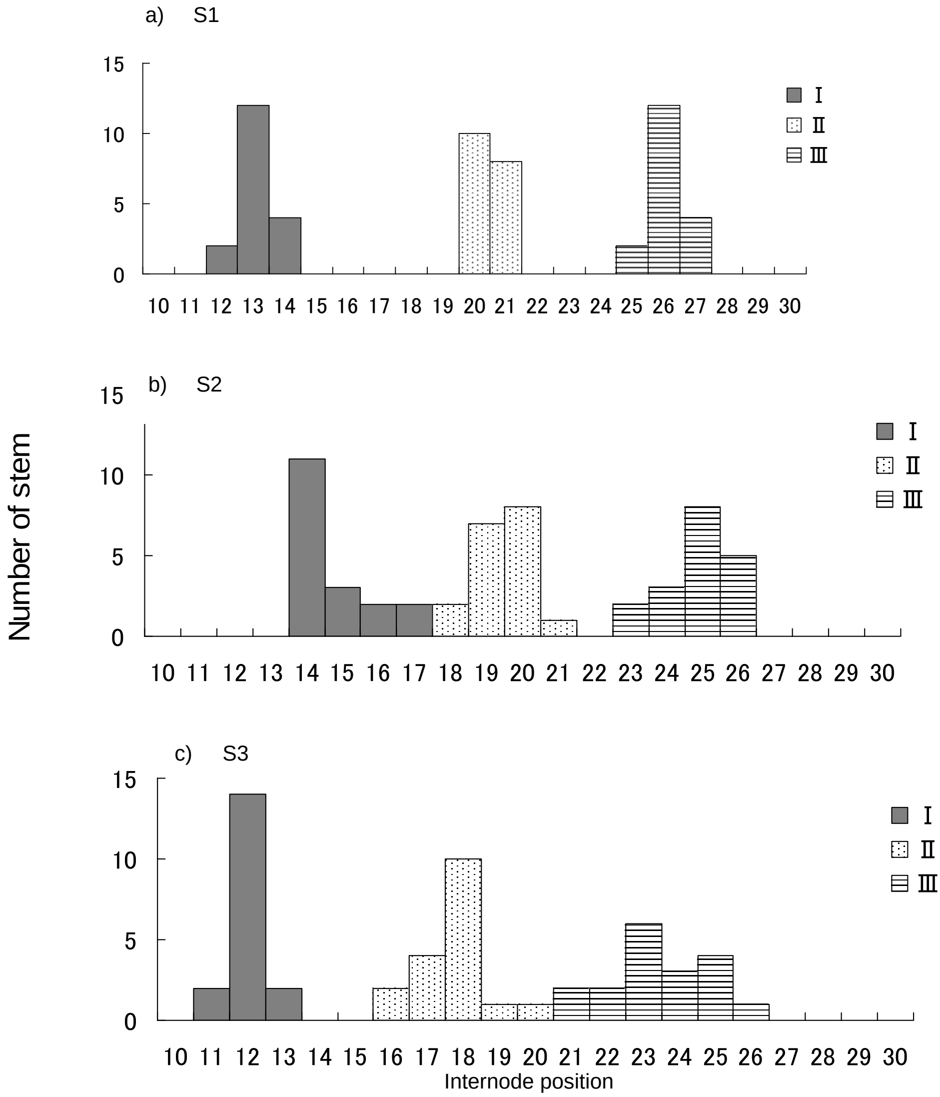

Figure 5. Internode positions with peak I – peak III in S1 (a), S2 (b), and S3 (c).

Table 1. Internode position and average internode position for peak I – peak III for S1, S2, and S3

plot	Range of internode position			Average of internode position		
	I	II	III	I	II	III
S1	12 – 14	20 – 21	25 - 27	13.1± 0.1	20.4± 0.3	26.1± 0.2
S2	14 – 17	18 – 21	23 – 26	14.7± 0.1	19.4± 0.2	24.8± 0.3
S3	11 - 13	16 - 20	21 – 26	12.0± 0.1	17.7± 0.2	23.4± 0.4

According to an investigation of the internodes as they increased rapidly in each plot on 5 September 2009, the positions of the internode in S1, S2 and S3 were estimated respectively as IN20, IN19, and IN18. These internode positions correspond to internodes with peak II in each plot, indicating that the internodes with peak II in S1, S2 and S3 were elongating at almost the same period. These results suggest that the internode length in sorghum variety 'Kazetachi' is characterized more strongly by environmental factors than by genetic factors.

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