Oryza glaberrima Steud. の1年生系統とOryza sativa L. の多年生品種の出穂後の生育

誌名	日本作物學會紀事
ISSN	00111848
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発行元	日本作物學會
巻/号	63巻4号
掲載ページ	p. 632-637
発行年月	1994年12月

Jpn. J. Crop Sci. 63(4) : 632—637 (1994)

Growth of an Annual Strain of *Oryza glaberrima* Steud. and a Perennial Cultivar of *Oryza sativa* L. after Heading*

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Received October 26, 1993

Abstract: The growth of W492 (an annual strain of *Oryza glaberrima* Steud.) and Koshihikari (a perennial cultivar of *Oryza sativa* L.) after heading were compared to determine the growth characteristics of annual and perennial types in the genus *Oryza*. The plants were grown individually in 1/5000a pots. At heading and every week thereafter, 10 plants of each strain were sampled. The dry matter and the starch content of each plant part were determined. Greater differences were found between W492 and Koshihikari in : (1) the rate of dry matter accumulation in the panicle ; (2) the rate of decrease of leaf area ; (3) starch content of stem + leaf sheath and (4) new shoot emergence after heading. There was no marked difference in the harvest index between the two strains, which is typically a distinguishing characteristic between annuals and perennials. In the aforementioned differences, (3) and (4) have already been reported as differences between annuals and perennials but (1) and (2) have not. Based on these results, we assume that monocarpic annuality is closely associated with faster dry matter accumulation in the panicles and faster leaf area reduction. More extensive experiments using many annual and perennial strains are needed to confirm our assumption.
Key words: Annual, Food reserves, Harvest index, Monocarpic annual, *Oryza glaberrima* Steud., *Oryza sativa* L., Perennial, Shoot emergence.

***Oryza glaberrima* Steud.の1年生系統と*Oryza sativa* L.の多年生品種の出穂後の生育**：高崎康夫・関陽一・野島　博・礒田昭弘（千葉大学園芸学部）

要　旨：イネ属植物における1年生タイプと多年生タイプの生育の特性を知ろうとして，1年生の1系統W492（*Oryza glaberrima* Steud.）と多年生の1品種コシヒカリ（*Oryza sativa* L.）を供試して，出穂期以後の生育を比較した．両系統・品種とも1/5000アールポットに個体植えし生育を調査した．出穂期以降は1週間ごとに，両系統・品種とも10個体ずつを堀取り，植物体各部の乾物重とデンプン含有率を経時的に調査した．出穂期以降の生育で，両者の間で大きな違いがみられたのは，(1) 穂への乾物集積速度 (2) 葉面積の減少速度 (3) 茎＋葉鞘部分のデンプン含有率 (4) 登熟期前後からの新しい分げつの発生程度であった．イネ科植物の1年生と多年生の違いとしてよく指摘される収穫指数については大きな違いはみられなかった．(1)～(4) の中で (3) と (4) はイネ科植物の1年生と多年生の違いとしてこれまでにすでに報告されている．(1) の穂への乾物の集積速度と (2) の葉面積の減少速度の二つについては1年生と多年生の違いとしてこれまでに報告されていない．イネ属における1回結実性の1年生の性質は，穂への乾物の集積速度が速いこと，葉面積の減少速度が速いことと深く結びついていると推論した．
キーワード：1回結実性1年生，1年生，*Oryza glaberrima* Steud., *Oryza sativa* L., 収穫指数，多年生，貯蔵養分，分げつ発生．

When a crop reverses to the rank of genus, the genus has both annual and perennial species in most cases. In the genus *Oryza*, a cultivated species, *Oryza glaberrima* (African rice), and its ancestor, *Oryza barthii*, are considered to be annual[3,5,19,20,22]. Another cultivated species, *Oryza sativa* (Asian rice), is considered to be potentially a perennial and its ancestor, *Oryza rufipogon*, has been reported to include annual, perennial and intermediate types[6,9,11,19].

A plant type which is native to a certain area or acclimatized to a certain area, and continues to exist for more than one year is called a perennial. While a plant type that dies within one year is called an annual. Harper[2] has distinguished two categories of annuals. One is annuality, that is connected with death after flowering and ripening, which is called monocarpic annual, and the other is annuality that is related to environmental factors, especially temperature and dryness. The latter has some degree of ambiguity, because the death is linked to environmental factors. Takasaki et al.[18,19] reported that Koshihikari (*Oryza*

* The outline of this paper was presented at the 189th meeting of the Crop Science Society of Japan, Tokyo, 1990.

sativa) continued to exist even after ripening when it was given only a suitable temperature after heading, while W492 (*Oryza glaberrima*) died some period after ripening, even under a long-day and suitable temperature conditions. From these results so far we have concluded that W492 is a monocarpic annual strain or a strain characterized to be a monocarpic, while Koshihikari is essentially a perennial, though it does not survive the low temperature prevailing in Japan after ripening. A characteristic of perennial grasses is the ability to continue tillering even after heading. So the difference in growth characteristics between annuals and perennials is supposed to be manifested mainly during the period after heading. In this experiment, we compared the growth of W492 (annual type) and Koshihikari (perennial type) after heading, with special reference to changes of dry matter and starch content of each plant part after heading, in order to know the differences in growth characteristics between annual and perennial types in the genus *Oryza*.

Materials and Methods

The experiment was carried out in the Experimental field of the Faculty of Horticulture, Chiba University in 1989. The annual strain used was W492 (*O. glaberrima*) and the perennial cultivar was Koshihikari (*O. sativa*)[18,19]. (Herein referred to as strain.) The seeds used were harvested in the Experimental farm in 1988. The original seeds of W492 were offered by Dr. Yoshio Sano, National Institute of Genetics, in 1980. The seeds were sown in nursery boxes on 21st April 1989. At the 7th leaf stage the seedlings were transplanted into 1/5000a pots filled with paddy field soil on 17th May 1989, with 0.4 g of each N, P_2O_5, K_2O given. On the 5th and 25th of July ; 10th and 18th of August, 0.2 g of N/pot was used to top dress both W492 and Koshihikari ; and W492 was top dressed with 0.2 g of N/pot on 5th and 23rd of September. The plants were grown under flooding conditions. The pots were arranged at the spacing of 100×50 cm.

After transplanting, plant length, leaf number and tiller number were recorded every week. At heading time and thereafter, 10 plants of each strain were sampled every week. They were divided into five parts, panicle, leaf blade above 10 cm, stem + leaf sheath above 10 cm, leaf blade below 10 cm, and stem + leaf sheath below 10 cm. The leaf area of 2 average plants out of the ten was measured. These 2 plants were ground after drying at 80° C for 48 hours. Their starch contents were determined using Verringer-Mannheim starch kit.

Results

1. Tiller number (Fig. 1)

Heading date of Koshihikari was 9th August and that of W492 was 6th September, so the difference in heading date was almost one month. The rate of increase of tiller number was greater in Koshihikari than in W492. The tiller number was greater in Koshihikari than in W492 at any stage of growth. Both strains decreased their tiller number gradually, after attaining their maximum. In these decreasing trends of tiller numbers both strains headed and then ripened. Though tiller counting ceased 5 weeks after heading, it was observed that new tillers emerged in Koshihikari at ripening stage and thereafter. Its tiller number was 58 including the already headed tillers. While no tiller emerged in W492 after heading.

2. Total top dry weight after heading (Fig. 2)

Total top dry weight of Koshihikari increased gradually until 5 weeks after heading. While that of W492 increased until 3 weeks after heading and decreased gradually thereafter. The decrease of top dry weight in W492 was mainly due to the shedding of dead leaves. The total top dry weight of W492 was

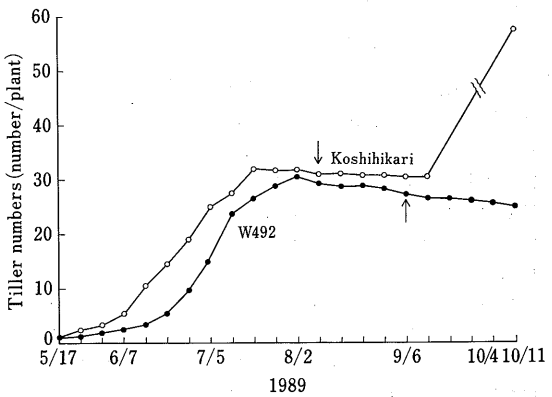

Fig. 1. Changes in tiller numbers. Arrows indicate heading time.

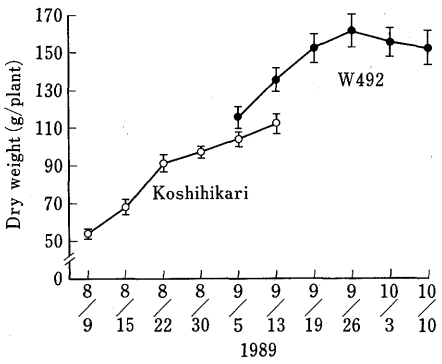

Fig. 2. Changes of total top dry weight per plant after heading. Vertical short lines indicate 95% confidence interval.

160 g, and that of Koshihikari was 110 g at the maximum. Top dry weight of W492 was always greater than that of Koshihikari at any time after heading.

3. Dry weight of each part of plant after heading (Fig. 3)

Fig. 3 shows the dry weight of the plant parts after heading. The figure shows as if heading dates were the same in both strains. Panicle weight of Koshihikari increased until 5 weeks after heading, while that of W492 increased up to 4 weeks and decreased slightly thereafter. But the sharp increase of panicle weight was until 4 weeks after heading in Koshihikari and 2 weeks after heading in W492. Panicle weight of W492 2 weeks after heading was 85% of its maximum weight, while that of Koshihikari 2 weeks after heading was 40% of its maximum weight. It seems W492 had faster accumulation of photosynthates in the panicle, as compared with Koshihikari. Green leaf weight of 10 cm and above in Koshihikari remained almost constant until 2 weeks after heading, followed by a gradual decline. Whereas that of W492 was higher at heading time. However, it decreased sharply from heading till 5 weeks after heading when the value was very small. Stem + leaf sheath weight above 10 cm was higher in W492 than in Koshihikari at any growth stage after heading. W492 increased from heading to one week after heading, then decreased gradually until 5 weeks after heading, while Koshihikari increased slightly until 2 weeks after heading and remained constant until 5 weeks after heading. Stem + leaf sheath weight below 10

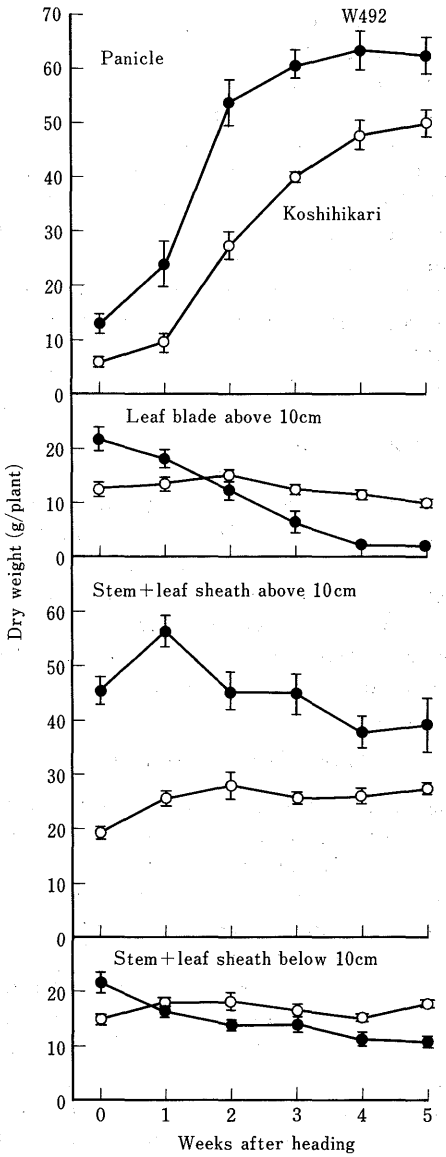

Fig. 3. Dry weight of plant parts after heading. Vertical short lines indicate 95% confidence interval.

cm was higher in Koshihikari than in W492 at any time except at heading time. W492 decreased gradually from heading to 5 weeks after heading, while Koshihikari had flat trends until 5 weeks after heading, though it showed some small fluctuations.

4. Harvest index (Fig. 4)

Harvest index was lower in Koshihikari than in W492 up to 2 weeks after heading, thereafter Koshihikari became higher than W492. Harvest index 5 weeks after heading

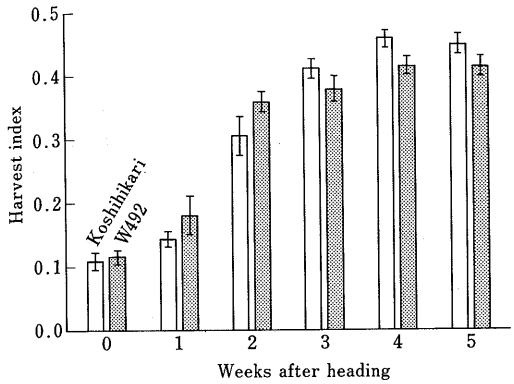

Fig. 4. Changes in the harvest index (panicle dry weight/total top dry weight) after heading. Vertical short lines indicate 95% confidence interval.

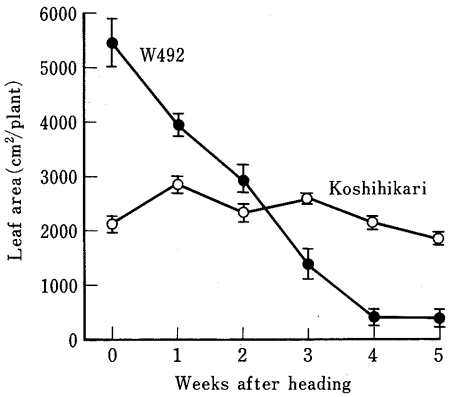

Fig. 5. Changes in the leaf area after heading. Vertical short lines indicate 95% confidence interval.

was 0.45 for Koshihikari and 0.41 for W492. The difference in harvest index between the two strains was not so great as it had been expected.

5. Changes in leaf area (Fig. 5)

The leaf area per plant at heading stage was much greater in W492 than in Koshihikari. W492, however, had a fast leaf area decrease up to 4 weeks after heading and showed very low values. Koshihikari increased its leaf area until 1 week after heading, followed by a gradual decrease. The leaf area of W492 5 weeks after heading was reduced to less than 10% of that at heading time, while Koshihikari showed 60% of that at heading time. The leaf area 5 weeks after heading was 1800 cm²/plant for Koshihikari, and 400 cm²/plant for W492. The leaf area of Koshihikari was 4.5

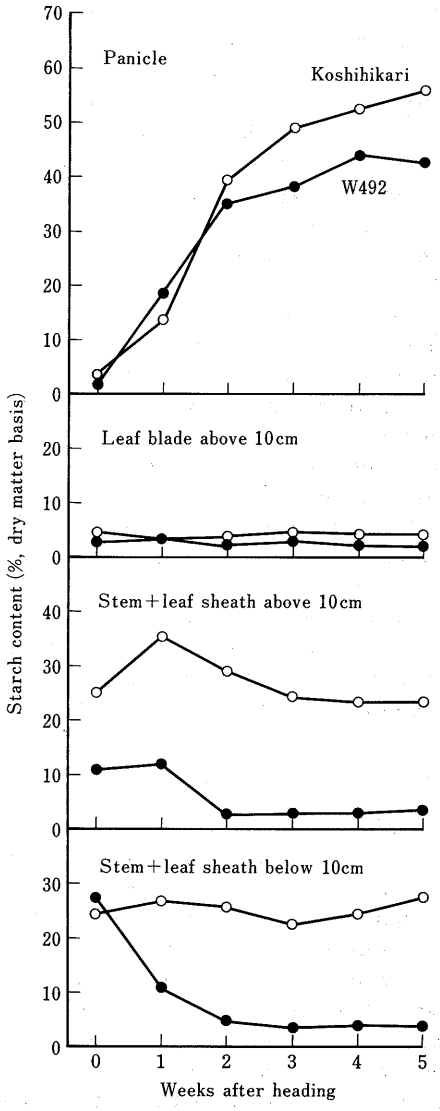

Fig. 6. Starch content of each plant part after heading.

times greater than that of W492 5 weeks after heading.

6. Starch content of the plant parts (Fig. 6)

Fig. 6 shows the starch content of each plant part every week after heading. The starch contents of panicle of both strains increased sharply until 2 weeks after heading, then increased gradually thereafter. The starch contents of panicle were almost the same in both strains until 2 weeks after heading and thereafter Koshihikari was higher. The starch content of leaves was less than 5%

in both strains. Although the difference was small, Koshihikari was higher in its starch content at any time after heading. Stem + leaf sheath above 10 cm in Koshihikari was higher in starch content than that of W492 at any time after heading. It increased up to one week after heading and then decreased gradually. W492 was lower in starch content than Koshihikari at heading time and decreased further up to 2 weeks after heading, which remained at a low level until 5 weeks after heading. The starch content of stem + leaf sheath below 10 cm showed almost the same value in both strains at heading time. W492 decreased rather sharply until 2 weeks after heading and kept at a lower level in the process of time until 5 weeks after heading, while those of Koshihikari increased slightly until one week after heading. It decreased thereafter and showed the minimum value 3 weeks after heading, then increased a little until 5 weeks after heading. The difference in starch content between Koshihikari and W492 was considerably greater 5 weeks after heading.

Discussion

The differences in growth after heading between W492 (annual type) and Koshihikari (perennial type) were manifested in : 1) rate of dry matter accumulation in the panicle ; 2) rate of decrease of leaf area ; 3) starch content of stem + leaf sheath ; 4) new shoot emergence after heading. There were no great difference in harvest index between the two strains, which is often pointed out as the difference between annuals and perennials[12,19]. The difference in harvest index ought to be greater between cultivated and wild types than between annuals and perennials. The difference in harvest index in this experiment was not so great, as the comparison was made between an annual and a perennial[12]. Among the differences from (1) to (4), (3) and (4) have already been reported as the differences between annuals and perennials by many workers. Generally speaking, perennial plants tend to accumulate some food reserves in some parts of plant[1,15,19]. In the genus *Oryza*, it is known that perennial types have the tendency to save some food reserves in stem + leaf sheath[17,18]. As the continual existence in the gramineae is dependent on the emergence of new shoots after heading, it is quite natural that perennial types have the ability to emerge new shoot after heading[4,14,19].

The difference in rate of dry matter accumulation in the panicles between annual and perennial types has not been so far reported. In this experiment, dry matter accumulation in the panicles of W492 was 85% of maximum panicle weight 2 weeks after heading, while that of Koshihikari was 40% of maximum panicle weight 2 weeks after heading. Furthermore, ripening indices were calculated by ((panicle dry weight each week − panicle dry weight at heading) / (maximum panicle dry weight − panicle dry weight at heading)) × 100. The ripening indices were 12, 49, 77, 96 and 100% for Koshihikari, in the order from 1 to 5 weeks after heading, and 22, 81, 95, 100 and 97% for W492 respectively. It is quite clear that starch accumulation in the panicles was much faster in W492 than in Koshihikari. The leaf area per plant 5 weeks after heading was 9% of its maximum value in W492, while 60% in Koshihikari. W492 was faster than Koshihikari in leaf area reduction. Sumi et al.[16] reported that the leaf area reduction of a strain of *O. glaberrima* after heading was faster than that of a strain of *O. sativa*. But they did not refer to annuality and perenniality of these species. These results make us assume that monocarpic annuality is closely associated to faster dry matter accumulation in the panicles and faster leaf area reduction. Although this experiment did not show which preceded the other, both characteristics seem to associate closely to monocarpic annuality.

However, it was reported that Indica accumulated dry matter in the panicles much faster than Japonica and the rate of leaf area reduction of Indica was much faster than that of Japonica[7,10,13]. It was also reported that considerable variation existed in ripening period both in Indica and in Japonica[8,10,13,21]. The fact that there is variation in rate of dry matter accumulation and in ripening period in both subspecies and among varieties suggests that our assumption should be tentative. Thus our assumption was drawn from the comparison of only two strains. Furthermore, the two strains were different in heading time about one month, so climatic conditions of ripening stages of both strains might affect the ripening

processes of the two strains. More extensive experiments using many annual and perennial strains will be needed to confirm our assumption that monocarpic annuality is closely associated to faster dry matter accumulation in the panicles and faster leaf area reduction.

Acknowledgement

We wish to express our thanks to Dr. Yoshio Sano, National Institute of Genetics, for offering the seeds of W492 in 1980.

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* In Japanese with English summary.
** In Japanese with English abstract.
*** Translated from Japanese by the present authors.
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