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Reserve Carbohydrates Changes in *Imperata cylindrica var. koenigii* Following Defoliation

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The changes in reserve carbohydrates (TNC) in *Imperata cylindrica* var. *koenigii* following the cuttings in September and in October, respectively, were investigated.

One rhizome cutting per pot was planted in June and grown under field conditions and cutting was conducted at 5 cm above soil surface on September 13 and October 17, respectively. Samples were taken at 0, 4, 8, 12, 16, 20, 24 and 28 days after cutting and separated into foliage (leaves above cutting height), stubble and rhizome.

Comparing the two cutting times, September cutting was higher in foliage regrowth and October cutting was higher in the recovery of rhizome+stubble dry weight. The maximum decrease in rhizome+stubble weight after cutting occurred at 12 days after cutting in September and at 16 days in October. Although TNC contents of rhizome and of stubble at cutting in October were higher than in September cutting, they decreased following cutting and could not recover to the levels at cutting. The changes in dry weight and TNC content following September cutting suggest that *Imperata* has such a characteristics that TNC is used preferentially to form rhizomes.

INTRODUCTION

An increase in productivity of animals on *Imperata cylindrica* which is an important component of natural grassland in the tropics and subtropics (Falvey, 1981) can be attained by the improvement of grazing or cutting management by regulating interval of utilization.

In Papua New Guinea, Chadhokar (1977) found that total dry matter yield in *Imperata* increased until 8 weeks of cutting interval then decreased. Holmes et *al.* *(1976)* reported that every four weeks cutting of *Imperata* depressed regrowth ability. In comparing cutting intervals of between 25 and 75 days, Rusdy et *al.* (1995) reported higher dry matter yield but lower protein and digestible dry matter contents in 75 days cutting than 25 days cutting. Thus, proper defoliation is a key to good pasture management. If defoliation is too frequent and severe, total dry matter production and reserve carbohydrates generally reduces (Youngner, 1972 ; Humphreys, 1981; Jones, 1985 ; Butterworth, 1985).

Imperata produces many rhizomes ; the roots plus rhizomes may be double of those above ground plant parts (Crowder and Chedda, 1982). Rhizome, being a reserve carbohydrates storage organ and possessing a high regenerative capability, is very important in the propagation and persistence of *Imperata* (Seth, 1970). Therefore, studies on the effects of defoliation on the growth of rhizome and the reserve carbo-

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hydrates content of ***Imperata*** in relation to the time of the year and physiological state of plants are needed.

This experiment was conducted to investigate the effect of time of defoliation in the growing season of *Imperata* on the regrowth and its reserve carbohydrates level and variation.

MATERIALS AND METHODS

The experiment was conducted in the field from June until October, 1990, at Kyushu University experimental field, Fukuoka, Japan. One rhizome cutting of *Imperata cylindrica* var. *koenigii* previously had been grown for one month in the growth cabinet, was planted into 48 pots each, containing 3.5 littres of clay soil. When the grass was established, 1 g each of N, P_2O_5 and K_2O was supplied as compound fertilizer. The plants were watered daily and volunteer weeds were removed periodically.

Defoliation was conducted at different two times ; a half of the pots were defoliated on September 13 and the rest were cut on October 17. Cutting was conducted using pruning scissors at a height of 5 cm above the surface of soil. The plants from three pots selected at random were separated from soil. The stubble (stem bases below cutting height) and rhizome were sampled and dry weight determinations were conducted immediately after cutting.

Samples were taken again from 3 pots at 4, 8, 12, 16, 20, 24 and 28 days after cutting, respectively. On each day the new leaves produced were defoliated and their dry weights were determined. These new leaves, collectively were termed as foliage. Samples were collected at sunrise to minimize the effects of diurnal variation in carbohydrates content.

Dry weight determination was conducted by placing the samples in an air draft oven at 70°C for 48 hours. For determination of reserve carbohydrates (total non-structural carbohydrates : TNC), the procedure of analysis based on that of Weinmann (1947) was used. In short, starch was hydrolyzed to reducing sugar by Takadiastase and reducing power of the solution was determined by the method of Somogyi (1952) using glucose as standard.

RESULTS AND DISCUSSION

Change in dry weight following cutting

The dry weight of foliage, dry weight of rhizome+stubble and foliage/rhizome ratio in ***Imperata*** *cylindrica* following respective defoliation on September 13 and October 17 are shown in Table 1.

Rhizome+stubble dry weights at and following cutting in ***Imperata*** were higher in October 17 cutting than in September 13 cutting and foliage regrowth following September cutting was higher than that following October cutting. These resulted in the higher foliage/rhizome ratios following September cutting than those following October cutting. With respect to total dry weights (foliage +rhizome+ stubble),

Table 1. Regrowth of *Imperata cylindrica* following cutting on September *13* and October 17, respectively.

Days after defoliation	0	4	8	12	16	20	24	28
				September 13 cutting				
Foliage dry weight (g/pot)	0.00	0.24	0.40	0.54	0.97	2.09	2.46	2.73
Rhizome + stubble dry weight (g/pot)	17.50	16.48	12.94	11.06	13.22	15.08	16.60	21.50
Total dry weight (g/pot)	17.50	16.72	13.34	11.60	14.19	17.17	19.06	24.23
Foliage/rhizome ratio	0.000	0.016	0.031	0.049	0.073	0.139	0.148	0.127
				October 17 cutting				
Foliage dry weight (g/pot)	0.00	0.24	0.39	0.49	0.52	0.67	0.92	0.95
Rhizome + stubble dry weight (g/pot)	27.00	24.58	23.42	22.82	20.60	27.64	27.72	28.20
Total dry weight (g/pot)	27.00	24.82	23.81	23.31	21.12	28.31	28.64	29.15
Foliage/rhizome ratio	0.000	0.010	0.017	0.021	0.025	0.024	0.033	0.034

however, higher values were obtained in October cutting than in September cutting.

Rhizome+stubble dry weight dropped sharply after both cutting times, reached a minimum at 12 days after September 13 cutting and at 16 days after October 17 cutting and then showed a period of recovery until dry weight increased above the original weight at cutting. The maximum decrease in rhizome+stubble dry weight after cutting on September 13 was larger (36.8%) than that on October 17 (23.7%).

TNC content at cutting

As shown in Fig. 1, there were large differences in TNC contents in stubble and in rhizome at the cutting between on September 13 and on October 17. TNC contents in stubble and in rhizome on September 13 were 3.2% and 6.3%, respectively, while those on October 17 were 8.7% and 20.0%, respectively. Undoubtedly, the growth stage and air temperature are the main factors that influence the difference in TNC at defoliation conducted at different time. *Imperata cylindrica* is a tropical origin grass that has a higher optimum temperature for growth and photosynthesis than temperate origin grasses. The optimum temperature for growth is in the region of 21 -32°C (Ayeni and Duke, 1985). Although the day temperature for growth of *Imperata* at September cutting may be in optimum range, because of high day temperature followed by high night temperature, respiration rates of plant parts including a large amount of rhizome also increase, causing the lower percentage of TNC. Differently, the lower temperature in October might be favourable for TNC accumulation and plants might actively accumulate TNC for over wintering under decreasing temperature. This suggestion is in agreement with Jones (1985) who stated that plants tend to

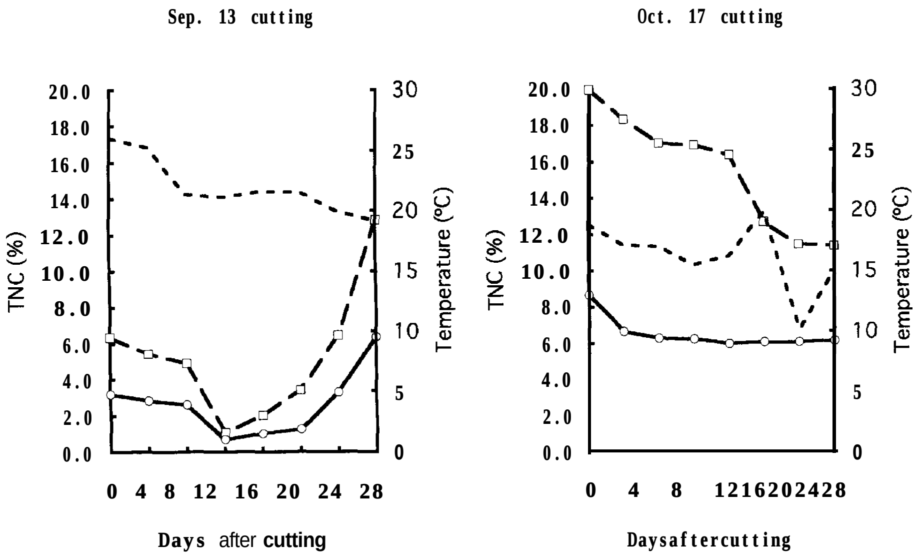

Fig. 1. Changes in TNC contents in stubble (—o—) and rhizome (– –□– –) and air temperature (-----) following September 13 cutting and October 17 cutting.

accumulate TNC at suboptimal temperature. A similar response has also been reported by Brown and Blaser (1963) who found that reserve carbohydrates do not accumulate during the early growth when conditions are favourable for rapid growth.

Dependence on reserves at cutting for regrowth in this experiment was influenced by the time of defoliation. The difference in dependence on the content of reserve carbohydrates appeared in the difference in the maximum decrease in rhizome + stubble dry weight after cutting as previously mentioned and earlier recovery in rhizome+stubble dry weight to the initial level at cutting in October cutting (Table 1).

TNC change following cutting

Figure 1 represents the changes taking place in the stubble and in rhizome with respect to TNC content following each cutting time.

TNC contents in stubble were always lower and showed less fluctuation than those in the rhizome in both cutting times. This suggests that rhizome is the main reserve organ in *Imperata* plant.

After cutting, as with the change in dry weight of rhizome +stubble, TNC contents were higher in October 17 cutting than those in September 13 cutting. TNC content dropped sharply after cutting on September 13 until it reached the lowest level at 12 days after cutting followed by a rapid recovery. But in October cutting TNC contents in both plant parts could not recover to the levels at cutting ; after cutting they decreased more slowly and beginning at the 8th day TNC in stubble tended to level off and that in rhizome decreased continuously.

The decreases in TNC content and in dry weights of stubble and underground parts after cutting have also been reported in other plants as orchard grass (Davidson and Milthorpe, 1965) and alfalfa (Pearce *et al.*, *1969).* In addition to the utilization of carbohydrates for shoot growth, the drop in dry weight of rhizome may be caused by reduction of nutrients uptake as attributed to the decomposition of roots in uptake zone (May, 1960).

It has been generally accepted that immediately after defoliation, energy balance becomes negative; energy and carbon skeletons are needed for production of new tissues but the plants have limited photosynthetic capacity because of low leaf area. Consequently, reserve carbohydrates stored mainly in rhizomes of rhizomatous plants are utilized to produce new leaves and shoots, resulted in decrease of rhizome growth and TNC content. The new leaves produced, however, could carry on photosynthesis to supply all organic compounds necessary for continued growth.

In this experiment, the difference in temperature following each cutting time apparently influenced the change in TNC content and rhizome+stubble dry weight. The higher temperature following September cutting yielded more leaf dry weight than those following October cutting. Although the higher temperature following September cutting was more favourable for photosynthesis compared with following October cutting, it also might increase the rate of respiration, including the respiration of large amount of underground rhizomes. Consequently, TNC content and rhizome +stubble dry weight decreased more sharply than those following October cutting. The more leaf area produced, however, resulted in the earlier and more rapid recovery.

The change in TNC content of plants following October 17 cutting was not consistent with the change in rhizome+stubble dry weight. Following sharp decreases after cutting, while TNC content in stubble tended to level off and that in rhizome decreased, rhizome +stubble dry weight tended to increase. This trend in the growth of rhizome and TNC change suggests that the surplus of energy produced by the reduced photosynthetic activity under lower temperature in October might not be enough to accumulate within plants and to form new leaf tissues, which was preferentially used to produce more new rhizome tissues. It seems that this preferential growth in rhizome is a characteristic response to defoliation in *Imperata*. This response explains the retarded regrowth under short cutting interval (Holmes et al., 1976 ; Rusdy et ***al., 1995)*** and ecological characteristics (Rusdy ***et al.,*** 1992) of Imperata.

Although White (1973) stated that the level of reserve carbohydrates in lower regions of stems at cutting apparently affected the regrowth rate for the first 2 to 7 days following herbage removal, this experiment reveals that the period of dependence on reserves in ***Imperata*** is longer, even after September defoliation.

From practical point of view, under environmental conditions of September -October, it can be recommended that defoliation interval of 20-30 days is not dangerous to regrowth ability of ***Imperata.*** In case the control of ***Imperata*** is necessary, application of herbicides at the 12th day after September cutting may be very effective in killing the grass, since herbicide application is generally most effective when timed to coincide with the minimum reserve carbohydrates of a perennial species.

REFERENCES

Ayeni, A. 0. and W. B. Duke 1985 The influence of rhizome features on subsequent capacity in speargrass (*Imperata cylindrica* (L.) Beauv.). *Agric. Ecosystems and Environment, 13* : 309-317

Brown, R. H. and R. E. Blaser 1963 Relationship between reserve carbohydrate accumulation and growth rate in orchard grass and tall fescue. Crop. Sci., 5 : 577-582

Butterworth, M. H. 1985 *Beef Cattle Nutrition and Tropical Pastures.* Longman, London and New York

Chadhokar, P. A. 1977 Establishment of stylo (*Stylosanthes guyanensis)* in kunai *(Imperata cylindrica)* pastures and its effect on dry matter yield and animal production in the Markham valley, Papua New Guinea. *Trop. Grassld*, 11 : 263-272

Crowder, L. V. and H. R. Chedda 1982 *Tropical Grassland Husbandry.* Longman, London and New York

Davidson, J. L. and F. L. Milthorpe 1965 Carbohydrate reserves in regrowth of cocksfoot *(Dactylis glomerata* L.). *J. By. Grassld Soc.*, 20 : 15-18

Davies, A. 1988 The regrowth of grass swards. In "The Grass and Crop", ed. by M. B. Jones and A. Lazenby, Chapman and Hall, London, pp. 85-117

Falvey, L. 1981 *Imperata cylindrica* and animal nutrition in South East Asia : A review. *Trop. Grassld*, 15 : 52-56

Holmes, J. H. G., C. Lemere and J. H. Schottler 1976 *Imperata cylindrica* for cattle production in Papua New Guinea. In "Biotope Workshop on Alang-alang *(Imperata cylindrica),* July 27-29", Bogor, Indonesia

Humphreys, L. R. 1981 *Environmental Adaptation of Tropical Pasture Plants.* Macmillan Publishers, London

Jones, C. A. 1985 C4 Grasses *and Cereals.* John Wiley and Sons, New York

May, L. H. 1960 The utilization of carbohydrate reserves in pasture plants after defoliation. *Herb. Abstr., 30:* 239-245

Pearce, R. B., G. Fissel and G. E. Carlson 1969 Carbon uptake and distribution before and after defoliation of alfalfa. *Crop Sci., 9* : 756-759

Rusdy, M., Y. Masuda, Y. Nakano and I. Goto 1992 Ecological characteristics of *Imperata cylindrica* var. *koenigii* in Kuju-Aso area, Kyushu. *J. Fac. Agr., Kyushu Univ., 37* : 179-188

Rusdy, M., Y. Masuda, Y. Nakano and I. Goto 1995 The growth and nutritive value of *Imperata cylindrica* var. *koenigii* as influenced by nitrogen fertilization and cutting interval. *J. Fac. Agr., Kyushu Univ., 39:* 183-190

Seth, A. K. 1970 Chemical control of *Imperata cylindrica* (L.) Beauv. in Malaysia. *Weed Res.*, 10 : 87-93

Somogyi, M. 1952 Notes on sugar determination. *J. Biol. Chem.*, 195 : 19-23

Weinmann, H. 1947 Determination of total available carbohydrates in plants. *Plant Physiol., 22: 255-261*

White, L. M. 1973 Carbohydrate reserves of grasses: A review. *J. Range Mangt, 26* : 13-18

Youngner, V. B. 1972 Physiology of defoliation and regrowth. *In* "The Biology and Utilization of Grasses", ed. by V. B. Youngner and C. M. McKell, Academy Press, New York, pp. 292-303