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Senescence behavior of the whole plant in four rice cultivars

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Summary. A non-sequential mode of senescence pattern (determined on the basis of decline of chlorophyll and protein) in the Ratna cultivar and a sequential mode of senescence in the Pusa, Masuri and Kalojira cultivars were observed in intact rice plant. When the panicles were removed from the plant, a delayed senescence compared with the intact control plants was observed. Again, when both panicle and daughter shoots were removed from the plant, leaf senescence of the mother plant was further delayed. The senescence behavior of the newly-developed daughter shoot was identical with that of the mother plant.

While studying the mechanism of monocarpic senescence in the Jaya cultivar of rice, Biswas and Choudhuri[2] observed a non-sequential mode of leaf senescence where the younger flag leaf senesced earlier than the older 2nd leaf from the top. It was subsequently confirmed that higher depletion of metabolites from the flag leaf of Jaya rice was the cause of its earlier senescence[3-4] which support the view that plants may exhaust themselves in producing fruits[5]. The present paper reports that in different cultivars of rice, both the non-sequential (as described in Jaya) and the sequential mode of whole plant senescence occurred. Thus, out of 4 cultivars studied, only one showed a non-sequential senescence pattern, while the other 3 showed a sequential one, suggesting that the non-sequential mode of senescence is not a generalized phenomenon in rice and that the pattern of senescence is an inherent character of the cultivar, as was evident from the study of senescence pattern of leaves of daughter shoots from the 2 categories of plants.

4 rice (*Oryza sativa* L.) cultivars, viz., Pusa, Ratna (both dwarf and photoinsensitive), Masuri and Kalojira (both tall and photosensitive) were taken as experimental materials. 30-day-old seedlings from the seed bed were transplanted with 1 seedling per hill at a spacing of 25 × 30 cm in 1 m^2 plot.

Experiments were carried out with leaf samples from the upper 2 leaves of control (intact) as well as from surgically manipulated (where the plants were subjected to surgical alterations) plants of the 4 rice cultivars during the reproductive phase of development (from anthesis to fully ripened seeds) which extended from 65 to 93 days in Pusa, 75 to 103 days in Ratna, 110 to 138 days in Masuri and 115 to 143 days in Kalojira. A decline in the levels of chlorophyll and protein measured in the 2 uppermost (flag and 2nd) leaves at intervals of 7 days from anthesis was taken as an indicator of senescence[2]. Chlorophyll was extracted and estimated following the method of Arnon[6] and protein by the method of Lowry et al.[7].

When panicles were removed from the plants, a daughter shoot developed from the axil of the 2nd and the 3rd leaf from the top of the mother plant. These daughter shoots were capable of producing panicles generally with 2 leaves. The development of the daughter shoots started 7 to 10 days after panicle removal. The anthesis stage of the daughter shoot appeared after 25 days in Pusa, 28 days in Ratna, 45 days in Masuri and 48 days in Kalojira. The senescence pattern of the upper 2 leaves of the daughter shoots was also recorded from the time of the anthesis stage to the senescent stage of the daughter plant at intervals of 7 days. The above experiment was performed in 2 ways. In one set of experiments, the panicles were removed and the daughter shoots were allowed to develop from the axils of the 2nd and the 3rd leaves. In another set, the panicles were removed and the daughter shoots were periodically removed as soon as they developed in order to prevent the formation of any alternative sink. In both cases, the senescence pattern of the flag and the 2nd leaf of the mother as well as the daughter plant, when present, was recorded.

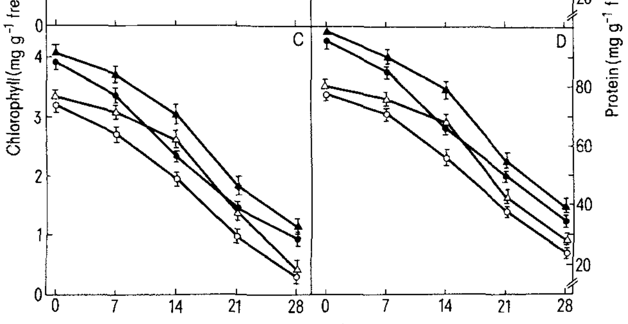


Figure 1. Changes in the content of chlorophyll in the flag leaf (△—△) and 2nd leaf (○—○) and protein in the flag leaf (▲—▲) and 2nd leaf (●—●) from (A) Pusa, (B) Ratna, (C) Masuri and (D) Kalojira during reproductive development. Data were recorded at intervals of 7 days from anthesis to senescent stage. Each experiment was replicated 6 times and the mean values were determined. SE (N = 6) is indicated by bars.

Figure 1 shows the pattern of senescence in terms of decline in chlorophyll and protein of the flag and the 2nd leaf from the top in 4 rice cultivars. Sequential senescence, i.e. the older leaf senescing first, was observed in the cultivars Pusa, Masuri and Kalojira whereas in Ratna, non-sequential senescence, i.e. the younger flag leaf senescing first, was observed after seed maturation (about 14 days after anthesis). This study indicates that the non-sequential mode of senescence, as observed in Jaya rice[2], is not universal in rice. There are rice cultivars which may show a sequential mode of senescence, and whether the mechanism of monocarpic senescence is the same in both categories of rice plant mentioned above remains to be ascertained.

Figures 2a (chlorophyll) and b (protein) show that the excision of the panicle from the plant slowed down the senescence of leaves in terms of the average decline of chlorophyll and protein of the 2 leaves compared with the intact control. Thus, when the panicles were removed from the plants and the daughter shoots were allowed to grow, the loss of chlorophyll and protein was checked in surgically altered plants in comparison with control plants. The maintenance of chlorophyll and protein with plant age after panicle removal was maximal in Ratna, followed by Kalojira. It is also interesting to note that the removal of the panicle induced the development of a daughter shoot at the leaf axil of 2nd and 3rd leaf in all 4 cultivars of rice, and this act of removal delayed the senescence of the mother plant and a sequential mode of senescence of the upper 2 leaves was achieved even in the cultivar Ratna, which otherwise showed the non-sequential mode (data not shown here).

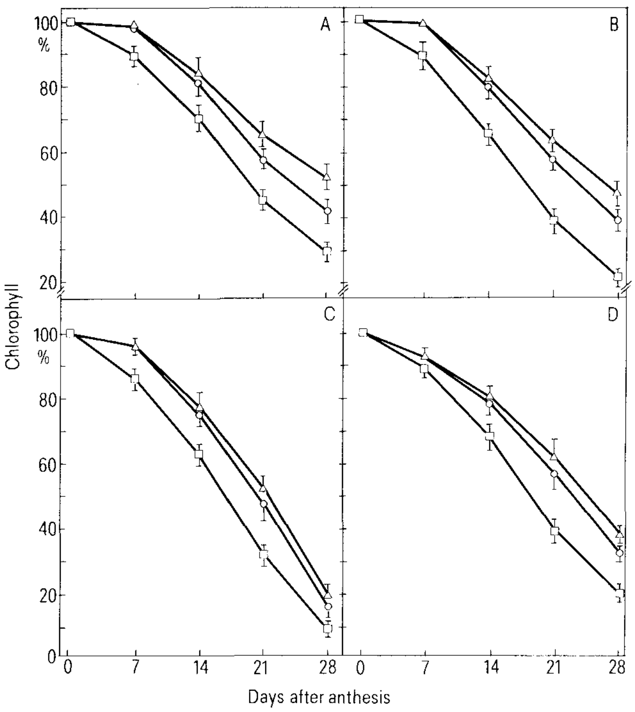
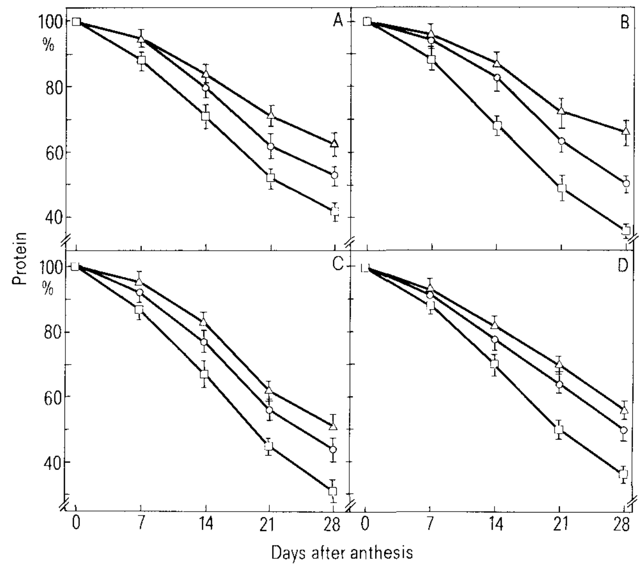


Figure 2. *a* Changes in percentage decline of chlorophyll over zero time during reproductive development of intact plant (□—□) and of plants where panicle (○—○) and both panicle and daughter shoot (△—△) were removed in (A) Pusa, (B) Ratna, (C) Masuri, and (D) Kalojira. Data were recorded as for figure 1.



b Changes in percentage decline of protein over zero time during reproductive development of intact plant (□—□) and of plants where panicle (○—○) and both panicle and daughter shoot (△—△) were removed in (A) Pusa, (B) Ratna, (C) Masuri, and (D) Kalojira. Data were recorded as for figure 1.

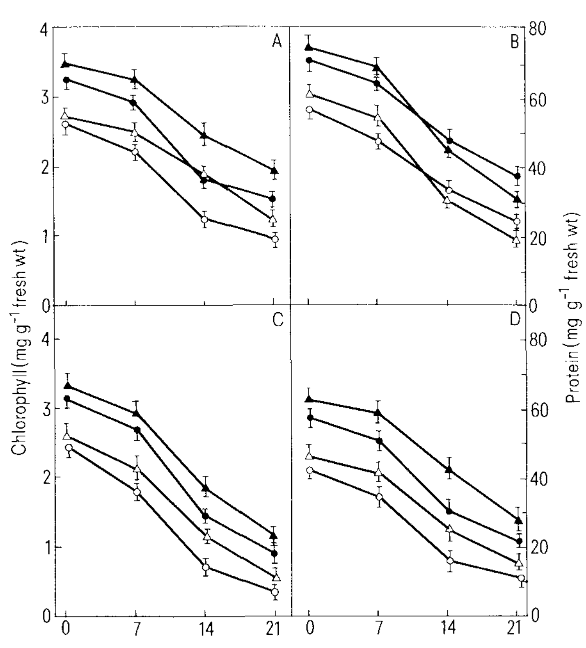


Figure 3. Changes in the contents of chlorophyll in the flag leaf (△—△) and 2nd leaf (○—○) and protein in the flag leaf (▲—▲) and 2nd leaf (●—●) from the daughter shoots of (A), Pusa, (B) Ratna, (C) Masuri, and (D) Kalojira during reproductive development. The estimations were made at intervals of 7 days from anthesis to senescent stage. Data were recorded as for figure 1.

The development of daughter shoots at the axil of the 2nd and 3rd leaves provides an alternative sink for mobilization of nutrients from these leaves, and the periodic removal of daughter shoots from the leaf axils further delayed the senescence of the mother plant. It can be argued that if sink capacity is reduced, there is less drawing-out of nutrients from the source leaf, which results in significant delay in its senescence. This shows that the mobilization of nutrients from source leaf to sink initiates senescence of the source leaf.

Figure 3 shows the senescence pattern of the flag and the 2nd leaf of the daughter shoot with the progress of its development in 4 rice cultivars. The interesting feature is that the pattern of senescence of the 2 uppermost leaves of the daughter shoot of each cultivar was identical with that of its mother plant, i.e., the cultivars showing a sequential mode of senescence (e.g. Pusa, Masuri and Kalojira) had daughter shoots showing a similar mode of senescence. The non-sequential mode of senescence was, on the other hand, observed in both the mother and the daughter plant of the cultivar Ratna only. Thus, it can be stated that the mode of sequential and non-sequential senescence in different rice cultivars is an inherent character of each cultivar.

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