16), Tillers had already been initiated at our date of clipping (Fig. 1). The hormonal conditions needed for tiller expression had thus already been met. The effect of our treatment was to limit or prevent tiller development.

Clipping studies with forage grasses have shown that tiller numbers are reduced by clipping as long as growing points are not cut [see Troughten (15) as cited by Youngner (16)]. In our experiments, the growing point (apex) of the plant was at ground level or 2 or 4 cm below the level of our cut. We therefore did not cut close enough to the apex to cause tiller proliferation.

Our observed reduction in tillering can probably be explained on a basis of available carbohydrate supplies. There was obviously a reduction in the availability of photosynthate following leaf removal. Leaf area was quite quickly reestablished following clipping, but in all cases reestablished plants were smaller (less total aboveground material) than controls. Furthermore, of the total aboveground material produced, reestablished plants partitioned less of this material into tillers than did controls (Table 3). Apparently, regrowth of leaves associated with the main stalk was given priority in clipped plants, and carbohydrate supply for tiller production was minimized.

Our results are consistent with the observations of Youngner (16) that tiller growth occurs only after the requirements for growth of the main stalk are satisfied. Mitchell (11) found that *Lolium* spp. would not tiller following clipping unless sufficient available carbohydrate reserves were established beforehand. Carbohydrate reserves were probably minimal in our seedling corn plants at the time of treatment.

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J. Amer. Soc. Hort. Sci. 105(4):567–570. 1980.

Partitioning of Dry Matter in Open-pollinated and F_1 Hybrid Cultivars of Asparagus[1]

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Additional index words. plant growth, *Asparagus officinalis,* leaf area

Abstract. **Variations in plant growth, partitioning of dry matter and leaf area in seedling plants of F_1 hybrid and open-pollinated *Asparagus officinalis* L. were measured and related to the yielding ability of the mature plants. The distribution of dry matter differed between F_1 hybrid (UC157) and the open-pollinated (OP) (UC72) cultivar. The root biomass was greater in the F_1 throughout the experiment. From 2 to 14 weeks after emergence percent dry weight of root per plant ranged from 32 to 54 for the F_1 and from 24 to 48% for the OP and percent dry weight of fern per plant ranged from 65 to 42% for the F_1 and from 72 to 48% for the OP. Very high positive correlations were found between number of roots and stalks, length of stalk and root length, and "leaf" area and cladophyll dry weight.**

Hybrid asparagus generally has higher yields, and vigor and greater biomass accumulation than open-pollinated plants (1). The effects of vigor and biomass accumulation on spear yields have been documented for various open-pollinated (OP) but not for the recently developed hybrid asparagus cultivars. In 1971, Liou and Hung (7) showed that seedlings of various open-pollinated asparagus cultivars differed in the numbers and weights of various plant parts. Previous asparagus growth studies have dealt mainly with yield and characters such as earliness (2, 3), plant or brush vigor (4, 9), and the multiple characters of brush vigor, early yield, and sex expression (5). This study was done to measure the partitioning of dry matter to various plant parts in hybrid and open-pollinated asparagus

[1]Received for publication December 21, 1979.

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cultivars, and to relate the variations in partitioning to the large differences in spear yields between hybrid and open-pollinated cultivars. UC157 F_1 hybrid and UC72 open-pollinated asparagus were selected as test cultivars since they have been observed to differ significantly in yields of mature plants (1). Three experiments were conducted from January 1978 to May 1979. The data presented here is from the third experiment since it includes leaf area measurements and is representative of the plant growth and partitioning of dry matter data collected from the previous 2 experiments.

Materials and Methods

A 14-week experiment was conducted at the University of California at Davis from January to May 1979. Sized pregerminated seeds of UC157 and UC72 asparagus were planted 1 cm deep in pots with diameters of 10 × 10 cm, 15.3 × 17 cm, and 21 × 21 cm. The seeds were planted in a potting mix of equal parts of mortar sand, vita peat, and Yolo loam soil and grown in a greenhouse at temperatures of 29°C day and 18° night. Nutrients were applied in every second irrigation as ½-strength Hoagland's nutrient solution (6). For control of *Fusarium* sp., soil drenches of benomyl fungicide were applied at planting and 1 month later.

All pots were planted at the same time and harvested on a weekly schedule beginning 1 week after seedling emergence. the experiment was conducted in the following manner: for harvest at 1 and 2 weeks after emergence, a planting of 5 plants/10-cm pot; for 3 weeks after emergence, 3 plants/10-cm pot; for 4 weeks, 3 plants/15.3-cm pot; for 5 to 7 weeks, 2 plants/15.3-cm pot; for 8 and 9 weeks, 1 plant/15.3-cm pot; and for 10 to 14 weeks, 1 plant/21-cm pot. The pots were arranged in a completely randomized design with 6 replications (pots) for each cultivar per harvest date. Each pot was considered an experimental unit.

Each week the seedlings were removed from their pots and the soil was gently washed from their roots. All ferns, stalks, and storage roots over 1 cm long were counted. The additive height of all ferns per pot was recorded as total fern height. Total storage root length was measured as the additive length of all roots per pot. Individual root length was measured from the rhizome to a point where it was indistinguishable from the secondary roots. All data taken on a per pot basis were divided by the number of plants per pot and the results were recorded on a per plant basis.

The seedlings were dissected into root, rhizome, and foliar portions. The total foliar portion is termed fern in this paper. The fern was further dissected into stalk and cladophylls beginning the 6th week after emergence. Cladophylls, and branches less than 3 times the diameter of a cladophyll (0.5 mm), were considered to be photosynthetic organs and were separated from the stalks. Adhering seeds were discarded before the rhizomes were weighed. The dissected portions were oven-dried at 85°C for 72 hr and their dry weights recorded. The mean dry weights of fern, rhizome, and roots were used to determine the respective percents of dry-weight accumulation.

The area of photosynthetic tissue (leaf area) was considered as the area intercepting light on a planar field. These areas were measured with a Li-Cor model LI-300 electronic area meter. The fresh cladophylls and branches were spread out to minimize overlap before they were fed into the area meter. The leaf areas were used in calculating the leaf area ratios (LAR = cm^2 leaf area per (g) dry weight of whole plant) at each harvest date for each variety.

Linear-regression curves were calculated for the measured variables with time as the independent variable. Differences in regression curves between the 2 cultivars were evaluated by analysis of variance of the regression coefficients (8) for their respective variables. Correlation coefficients were calculated between certain variables for a better description of the relation observed.

Results and Discussion

The OP cultivar accumulated significantly more dry weight in the fern than the F_1. More than half of the biomass was in the fern during the first 9 weeks in the F_1 and the first 12 weeks in the OP (Fig. 1). The respective dry-weight percentages in the rhizomes for the F_1 and OP cultivars were 6.7 and 10.0% in the first week but thereafter averaged 2.8% and 2.9%. The percent of dry weight accumulated in the root systems was significantly higher in the F_1 from the 2nd week on, ranging from 32.5 to 55.4%.

The regression curves for root dry weight, root number, and root length differed significantly (Fig. 2B, 3, and 4) with the F_1 being a greater producer than the OP. Total plant dry weights were significantly greater for the F_1 (Fig. 2A). More stalks were produced by the OP plants (Fig. 3) and the analysis of the regression slopes showed the difference to be significant.

Regression curves for the dry weights of rhizomes and ferns (Fig. 2 C&D) and cladophylls and stalks did not differ significantly, although the F_1 showed a trend toward greater rhizome and fern dry weights during the last part of the experiment. Total stalk height per plant (Fig. 4) and cladophyll

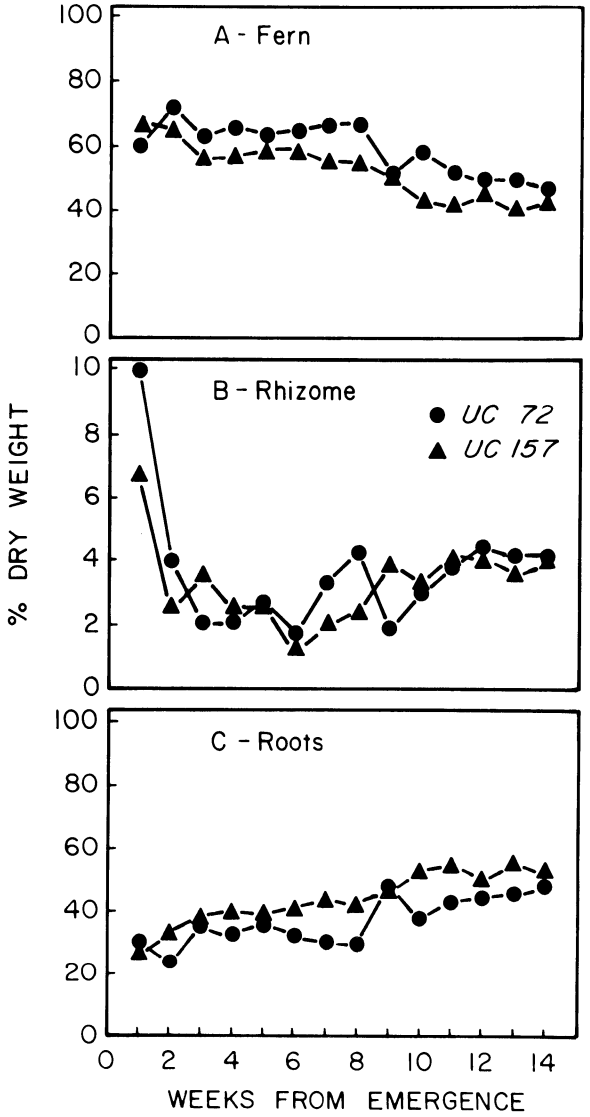

Fig. 1. Percent of dry weight in fern, rhizome and roots of F_1 (UC157) and OP (UC72) asparagus seedlings during 14 weeks growth in greenhouse. Fern and root dry weight percentages are statistically different at 5% level as tested by student's t distribution.

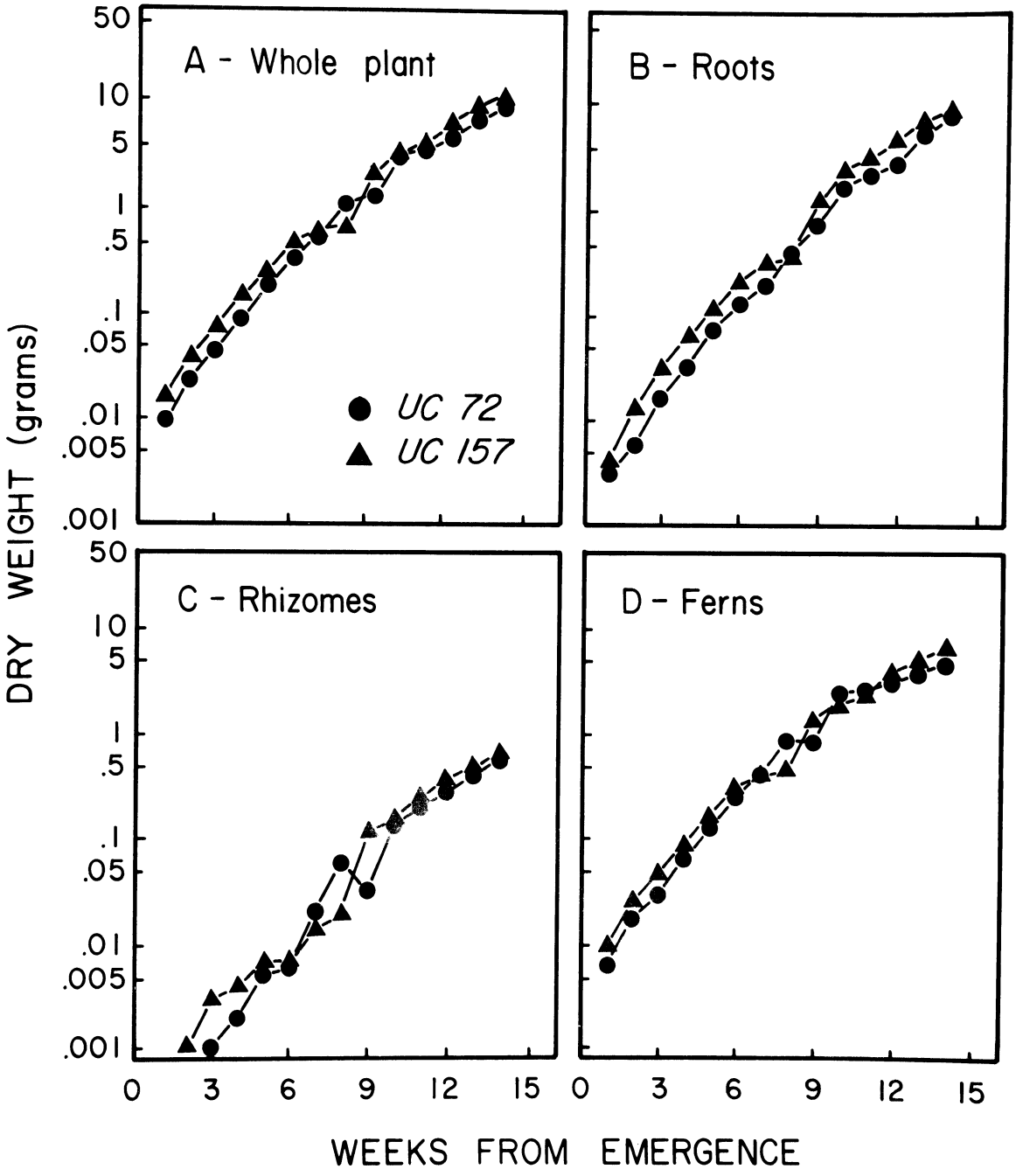

Fig. 2. Dry weights per plant of whole plant (A), roots (B), rhizomes (C), and fern (D) of F_1 (UC157) and OP (UC72) asparagus seedlings during 14 weeks growth in greenhouse.

area were also found to have nonsignificant differences in the regression curves of each variety.

The LAR (Fig. 5A) of the F_1 were significantly below that of the OP in all weeks except 1 and 12. As the experiment progressed a higher proportion of dry weight was accumulated in nonphotosynthetic tissue in each variety. Thus, as the seedlings developed, the LAR gradually declined. While these data may not be indicative of field data, a similar drop in LAR's would be expected during the first several years' growth of the asparagus plant, as a result of the annual increase in root biomass.

As expected, a high correlation coefficient (r = 0.99) was found between "leaf" area and dry weight of cladophylls. An unexpected correlation of r = 0.60 was found between leaf area and fern dry weight (the difference due to the weight of nonphotosynthetic stalk tissue). Therefore, use of the dry weight of cladophylls instead of total fern dry weight should give a more accurate estimate of the "leaf" area of asparagus plants.

High correlations were found also between stalk number and root number (r = 0.99), dry weight of roots and dry weight of fern (r = 1.00), and leaf area and dry weight of roots (r = 0.99).

This experiment has provided 2 partial explanations for the greater yields and vigor of the asparagus F_1 cultivar. The biggest difference in growth found between the 2 cultivars was in the root system. The considerably greater partitioning of dry matter into the root system of F_1s early in growth of the seedling is quite significant. An enlarged root system early in development should allow an asparagus plant to produce greater fern biomass

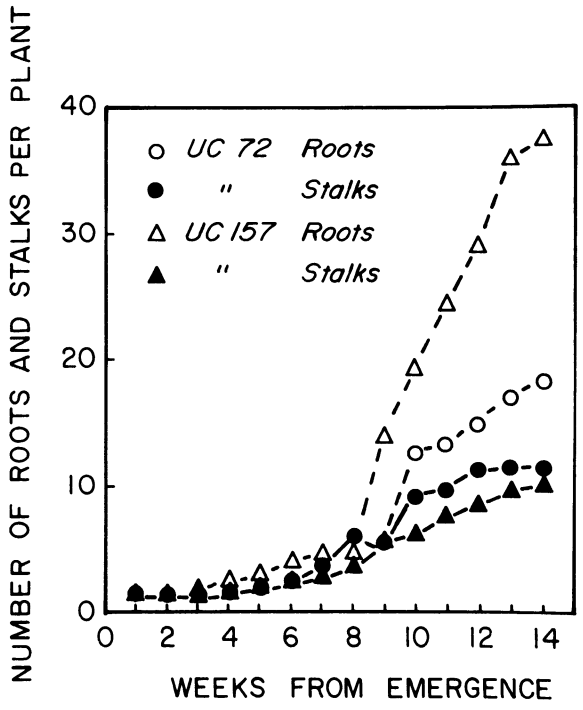

Fig. 3. Number of roots and stalks per plant of F_1 (UC157) and OP (UC72) asparagus seedlings during 14 weeks growth in greenhouse.

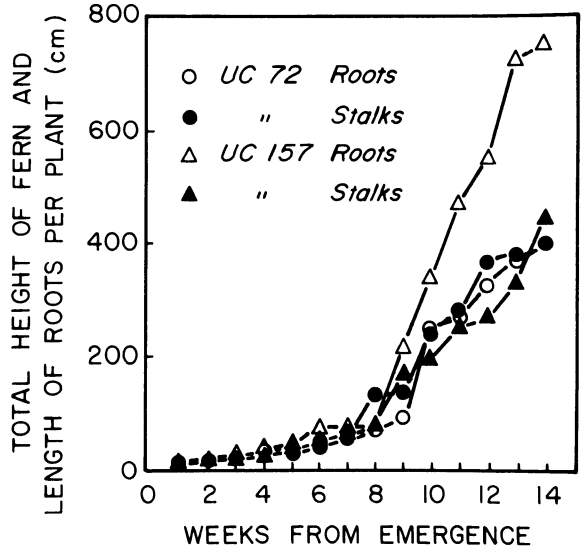

Fig. 4. Total height of fern and length of roots per plant of F_1 (UC157) and OP (UC72) asparagus seedlings during 14 weeks growin in greenhouse.

because of its greater absorptive area, and to store larger amounts of carbohydrates for future growth. Secondly, the F_1 plants with about the same photosynthetic area produced more total dry weight than the OP plants (Fig. 5B). This suggests that one or several of the factors effecting plant efficiency (i.e. respiration rate, photosynthetic efficiency, leaf canopy architecture or quality of storage carbohydrates) are responsible for the difference found between the F_1 and OP cultivars.

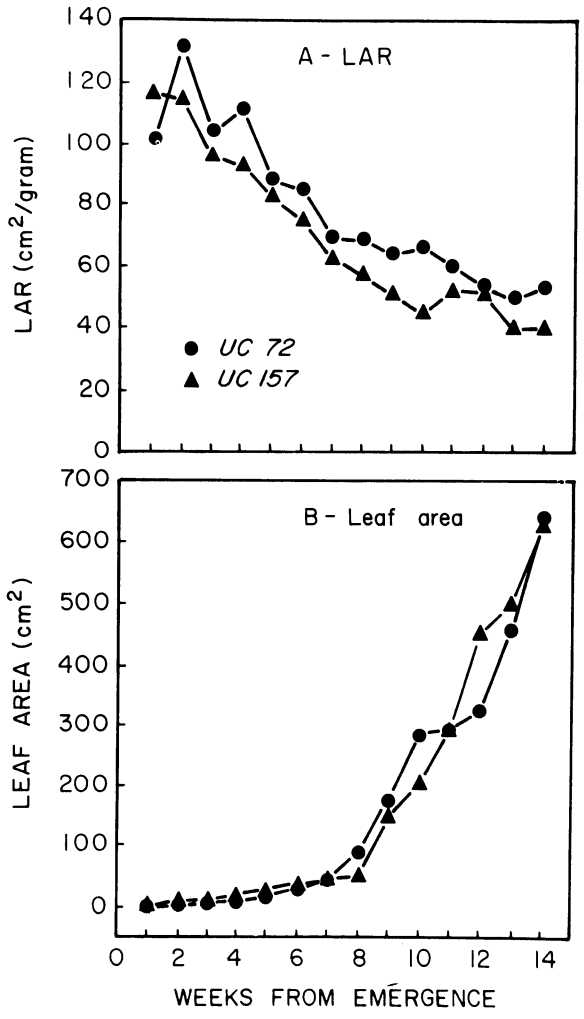

Fig. 5. Leaf area ratios (A) (LAR = cm^2 leaf area per (g) dry weight of whole plant) and leaf area of F_1 (UC157) and OP (UC72) asparagus seedlings during 14 weeks growth in greenhouse.

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