PRE-ANTHESIS PARTITIONING OF DRY MATTER IN SUNFLOWER CROPS.

N. Trápani*, F. Villalobos** and A.J. Hall*.

* I.F.E.V.A., Facultad de Agronomía - Universidad de Buenos Aires. Avda. San Martín 4453. 1417 Buenos Aires, Argentina.
** Departamento de Agronomía. E.T.S.I.A., Universidad de Córdoba, Apartado 3048, Córdoba 14080, España.

Summary

Robust descriptions of dry matter partitioning dynamics are needed to model the growth and yield of the sunflower crop. We used data from 4 experiments which included 5 cultivars grown under conditions of near optimal water and nutrient availability to evaluate the partitioning coefficients for stem, laminae, inflorescence and roots. These were defined as the slopes of the linear regressions of organ dry weight on total plant dry weight. Regressions were sectioned as appropriate.

The dynamics of partitioning to the stem could be described by two coefficients applying to the emergence-bud visible and bud visible-anthesis stages, respectively. Complementary changes in the coefficients for laminae and fine roots took place at the bud visible stage. Once rapid growth of the inflorescence had become established, further changes in partitioning to roots and laminae, but not to stem, took place. Values of the coefficients changed only slightly between experiments.

The validity of the estimated partitioning coefficients was tested against data obtained in an independent experiment and a satisfactory description of organ biomass dynamics was obtained. We conclude that the use of stable partitioning coefficients which change at defined ontogenetic stages provides an adequate basis for modeling biomass partitioning to organs during the pre-anthesis phase in crops grown under adequate supplies of water and nutrients.

INTRODUCTION

Robust descriptions of dry matter partitioning dynamics are needed to model the growth and yield of the sunflower crop. Although the control of many of the processes involved in dry matter partitioning in crops are poorly understood, simple approaches can yield sufficiently good results and give reasonable estimates of organ growth provided the daily dry weight increment of the crop is known . This is particularly true for crops growing under near optimum conditions, for which developmental effects on partitioning are not confounded by water and nutrient stresses.

Our aim was to define potential dry matter partitioning coefficients for the sunflower crop during the pre-anthesis phase of the crop cycle. The basis for our analysis is the notion that the daily crop biomass increment is partitioned among the plant organs in proportions that can change during development but which maintain their value over fairly extended portions of the crop cycle (e.g. Milford et al., 1988; Connor et al., 1981). During the duration of each phase of constant partitioning, the slope of the organ biomass/plant biomass plot provides an estimate of the partitioning coefficient. An objective definition of the change-over from one phase to the next can be achieved using optimization techniques to fit two-phase linear regressions to the organ biomass/plant biomass relationships for consecutive phases.

In this paper we report the results obtained applying this analytical framework to results from experiments conducted using several cultivars, at two sites, in four separate seasons in which crops were grown under conditions of good water and nutrient availability. The usefulness of the derived partitioning coefficients was tested using data from another, independent, experiment.

MATERIALS AND METHODS

Experiments

Data were obtained from: a) sunflower crops grown in the field at Junín (34°33'S, 60°57'W) in the 1985-86 season (JU86), and at Buenos Aires (34°35'S, 58°29'W) in the 1987-88 (BA88) and 1989-90 (BA90) seasons; b) sunflower plants grown in hydroponics simulating a crop at Junín in the season 1982-83 (JU83). The details of the experiments are given in Hall et al., 1985; Trápani et al., 1992; Chimenti and Hall, unpublished data, and some pertinent information is summarized in Table 1. Field grown crops were irrigated, fertilized and maintained free of weeds. Total biomass per plant at anthesis ranged across experiments from 80 to 450 g/pl.

Measurements and observations

Biomass determination

Plant (aerial or total) and organ biomass accumulation was determined by periodic harvests, the number of which varied between experiments (Table 1). In some experiments (BA88, JU86 and BA90) fine root biomass was estimated from data on tap root biomass from a previously determined fine root/tap root ratio (cf. Trápani et al., 1992). Organ compartments considered were stem (which included the tap root and petioles), fine roots (called roots) leaves (laminae) and head (receptacle plus florets).

TABLE 1. Number of harvests from emergence to anthesis (E-A), crop density ($pl.m^{-2}$), and plant material used in the experiments. (For coding experiments see text).

	Experiment			
	JU83	JU86	BA88	BA90
Number of harvests E - A	4	9	10	10
Plant density	4.5	3.57	4.76	5.1
Plant material	Lines B14 R16	Hybrids Contiflor 3 Contiflor 8 Junín 1-12	Hybrids Contiflor 3 Contiflor 8	Hybrid Contiflor 3

Phenology

Crop phenology was followed from emergence to anthesis. The bud visible stage was recorded when 50 % of the plant population was in the corresponding stage. Anthesis was recorded when 50 % of the inflorescences had eight rows of anthesed florets.

Data analysis

Plots of organ dry weight per plant against total plant dry weight were analyzed separately for each organ, cultivar and experiment. Inspection suggested that there were two stages during the emergence-anthesis phase at which large changes in partition occurred for two or more organs. Data were therefore grouped for analysis into two partially overlapping phases: a) emergence (E) -beginning of rapid head growth (RHG) and b) bud visible (BV) - anthesis (A). Objective estimates of the partition coefficients and the value of total plant biomass at which their value changed within phases a) and b) were obtained using the Non Lin

program of SYSTAT (Wilkinson, 1986) by fitting the following piecewise linear regression model to the data: BO=b*BT for BT<Bx and BO=c+d*BT for BT>Bx, where BO and BT are organ and total biomass per plant respectively and the slopes b and d of the first and second straight lines are the partitioning coefficients (PC); Bx is the unknown break-point of the function. The SYSTAT package estimates optimum solutions for Bx, b and d. When the optimization algorithm could not be resolved, a simple linear regression was applied to the data.

Correspondence between values of Bx and phenological stages for the E - RHG phase was established by comparing values of Bx with observed plant dry weights at given phenological stages. For the BV - A stage, values of Bx and curves fitted to the biomass/time relationship were used to estimate the number of days before anthesis this stage was reached.

Observed plant biomass dynamics for a Contiflor 3 (C3) crop obtained in BA88 were synthesized by fitting a cubic polynomial to the biomass/time plot. The usefulness of the PC's derived from JU86 and BA90 was tested by applying these coefficients to the description of organ biomass dynamics observed in BA88. To do this, daily biomass increments derived from the fitted polynomial were distributed among organs using the appropriate PC's. The PC's of the various organs were changed on the date of observed BV in BA88 and 15 days before observed A of the same crop (explained below).

RESULTS AND DISCUSSION

The organ biomass/total plant biomass relationships changed during crop development, with each organ exhibiting a characteristic pattern (Fig.1). Straight lines provided useful descriptions of these relationship and the changeover values at which important variations in partition occurred in at least two organs were identified (see below) as being BV and RHG. Of the three organs which grew throughout the emergence-anthesis phase, the stem was unusual in that only one change in partitioning could be detected by this analysis (Fig.1a).

Partitioning coefficients were fairly stable across experiments (Table 2) and for each of the three developmental phases identified in this analysis, the sum of PC's for all organs was close to 1.00.

The values of Bx estimated for the E-RHG data set coincided, within the error of the estimates, with plant total biomass at BV (Table 3) and values of Bx estimated for each organ coincided with that of the remaining organs in the same experiment (data not shown). The values of Bx for the BV-A data set were

statistically undistinguishable across organs within an experiment and the start of RHG occurred about 15 days before anthesis.

TABLE 2 Biomass partition coefficients calculated for the periods emergence-bud visible (E-BV), bud visible-beginning of head rapid growth (BV-RHG) and RHG-anthesis (A). Means and standard errors from 4 experiments and 5 cultivars (n=8).

Period	Stem	Laminae	Fine roots	Head
E-BV	0.36±0.02	0.43±0.02	0.19±0.02	--
BV-RHG	0.60±0.02	0.29±0.02	0.07±0.01	0.03±0.01
RHG-A	0.60±0.02	0.16±0.01	0.05±0.02	0.16±0.02

When the estimated PC's were used to describe biomass partitioning among organs for C3 in BA88, the results were satisfactory (Fig 2).

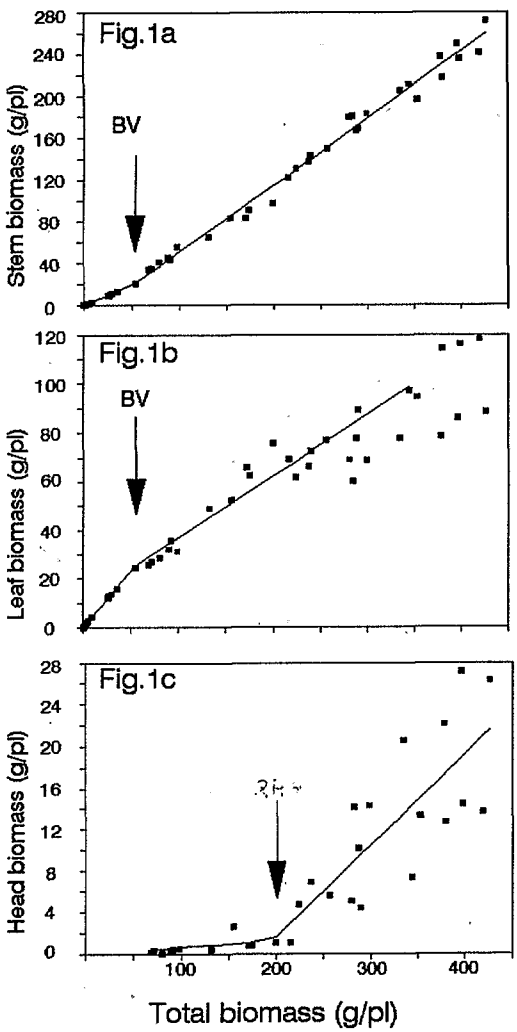
TABLE 3. Total biomass observed (BT), n=3 (1), n=4 (2) and n=3 (3) and estimated (Bx) corresponding to changes in partitioning to the stem in Contiflor 3 sunflower crops and their phenological state. Means and standard errors.

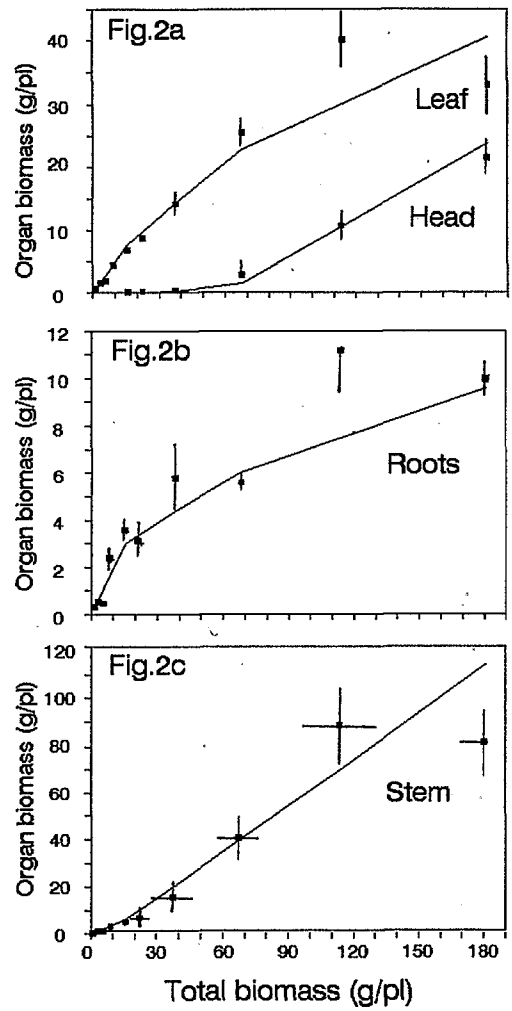
Experiment	BT (g/pl)	Bx (g/pl)	Phenology
JU86 (1)	58.3 ± 9.51	51.7 ± 11.71	Bud visible
BA88 (2)	22.5 ± 3.59	25.3 ± 4.16	Bud visible
BA90 (3)	10.0 ± 4.02	12.9 ± 3.49	Bud visible

We conclude that the use of simple linear partitioning coefficients which change at fixed ontogenic stages can be used to simulate biomass partitioning in sunflower crops growing under adequate conditions of water and nutrient supply.

Figure 1: Organ biomass vs total biomass - a: stem, b: leaf, c: head - of sunflower plants of the JU86C3 crop. Symbols are observed values; lines are fitted functions (see text for explanation).

Figure 2: Organ biomass vs total biomass of sunflower plants of the BA88C3 crop. Symbols are observed values and their standard errors (not shown when smaller than symbols). Lines are estimated values (see text for explantation).





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