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SEED ABORTION AND YIELD STABILITY: A KEY-ROLE FOR GROWTH PROCESSES OF REPRODUCTIVE ORGANS

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Grain yield is generally viewed as the result of carbon acquisition and allocation which drives grain set and grain filling. Nevertheless, early stages of reproductive development including initiation and growth of floral organs may be crucial for grain yield of crop plants, not necessary through carbon availability. This is illustrated here with two examples: (i) the sunflower capitulum, which actively expands during the period of floret initiation, and (ii) the maize silks, equivalent to stigma and styles of female flowers, which greatly elongate during a short time to be accessible to pollen from male inflorescences. Growth of both organs is very sensitive to drought and impacts the final yield through a reduction in the potential number of grains.

Reproductive development and expansive growth are tightly linked during floret initiation at the meristem of the sunflower capitulum. Floret primordia are centripetally initiated at the generative front which divides the inner zone of the capitulum surface, or meristem proper, from the outer zone supporting the previously initiated florets. The rate of tissue expansion in the central meristematic zone of the capitulum plays an essential role by renewing meristem area, and thus prolonging the period of primordium initiation. The development of the sunflower capitulum is divided into three successive phases between its initiation and the end of floret initiation, each of them corresponding to a specific combination of both processes of tissue expansion and primordium initiation in the meristem. Floret production depends directly from the rate and duration of tissue expansion during the three phases.

The analysis of primordium initiation, tissue expansion and assimilate supply, under various environmental conditions during the period when the number of florets is determined, led to establish a set of equations, which explicitly describe and quantify the relationships between net carbon input, capitulum growth, soluble sugar content in the capitulum, and initiation of floret primordia. Results support the following main assumptions: (i) floret initiation and meristem tissue expansion remain strongly co-ordinated, irrespective of environmental conditions, and both depend on local carbon availability when water supply is unlimited, (ii) the three macroscopic processes, namely C availability (photosynthesis and C allocation), expansive growth (rate of tissue expansion) and reproductive development (duration of phases) are affected in parallel and differentially by water deficits, and (iii) C allocation to organs (and the resulting sugar content) is the consequence, and not the cause, of the differential effect of water deficit on processes (photosynthesis vs tissue expansion) and organs (leaf growth vs capitulum growth).

The growth and emergence of maize silks has a considerable importance in the determination of yield under drought. When soil water deficit occurs before flowering, silk emergence out of the husks is delayed while anthesis is largely unaffected, resulting in an increased anthesis-silking interval (ASI). ASI is a good predictor of grain yield under stress and selection for reduced ASI has been used successfully to increase the drought tolerance of maize. This is generally explained by considering ASI as a negative symptom of assimilate partitioning to the developing spikelets. However analyses of metabolite content in silks and ovaries of plants subjected to soil water deficit indicate carbon accumulation rather than carbon starvation in these organs. On the other hand the temporal and spatial patterns of silk expansion and cell division as affected by soil water deficit demonstrate that ASI is directly related to the processes of cell expansion in the silks, and corresponds to the duration between the end of cell division in the silk and the cessation of elongation in silk apex. The rates of tissue expansion and cell division are reduced according to the intensity of water deficit, resulting in a longer duration of this developmental phase and hence a delayed silk emergence. Genotypes widely differ in the sensitivity of silk elongation to soil water deficit. For example the soil water potential for which silk growth ceases ranges from -0.7 to -1.3 MPa in a panel of 8 inbred lines. Similar range and ranking are observed for the soil water potential for which leaf elongation rate reaches zero: silk and leaf sensitivities are correlated for the studied set of genotypes. Common genetic determinisms also exist between leaf elongation rate and ASI in response to soil and air water deficit (co-location of six QTLs) in a population of inbred lines from tropical parental lines known for segregating for ASI. This suggests common mechanisms for the response of silks and leaf to drought and supports the hypothesis that drought tolerance in maize could partly rely on the maintenance of processes of tissue expansion in both vegetative and reproductive organs. Methods for phenotyping the maintenance of silk growth are currently developed.

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