Deep Soil Water Use and Peanut Productivity: Effects of Sowing Date and Initial Soil Water Availability

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INTRODUCTION

Most part (97%) of Argentine peanut (*Arachis hypogaea* L.) production takes place in a region located between 32 and 35º S and between 62 and 64º W. In spite of its monsoonal climate (with 539 153 mm of rainfall between November and March), unpredictable periods of variable water deficit are very frequent in this region, and usually overlap the critical period of pod set for November sown crops. These conditions have negative effects on seed numbers and final grain yield (2, 3). Management practices for reducing these constraints are: (i) to increase soil water storage, and (ii) to delay sowing date. The latter allows the crop to '*escape*' from the occurrence of water deficit during pod set, but has the negative effect of a poor growing environment (low irradiance and temperature) during seed filling (1). The **objective** of this research was to evaluate the effect on water use of peanut crops of different (i) levels of stored water in deep soil layers, and (ii) sowing dates. Crop capacity for water uptake from deep soil layers was evaluated by means of the apparent rooting velocity (*ARV*) and water absorption rate (*K*).

MATERIALS & METHODS

Field experiment during 2008/09 at INTA Manfredi (31º49'S, 63º46'W), on a typic Haplustol soil.

Treatments and Design: factorial combination of (i) two sowing dates (early: 21-Oct; late: 2-Dec), in main plots, (ii) two levels (low: 30%; high: 70%) of plant available soil water (*PASW*) in deep soil layers (60 to 200 cm) from R_3 onwards, in sub-plots, and (iii) two peanut cultivars produced by INTA (FLORMAN and ASEM), in sub sub-plots. There were three replicates.

Sub-plots were established after drying the soil close to the permanent wilting point (Fig. 1A) by means of a preceding wheat crop. Surface soil water (0-60 cm) was kept near field capacity up to R_3, and no additional irrigation was applied to any plot from this stage onwards. Rainfall water was excluded all along the cycle by means of mobile shelters (Fig. 1B).

Measurements and Analyses:

-Soil water content was surveyed gravimetrically (0-60 cm) and by means of a neutron probe device (at soil layers >60 cm). Biomass production, seed yield, and seed yield components were evaluated.

- Apparent rooting velocity (*ARV*, in cm day^{-1}) was obtained as the slope from the linear relationship between maximum soil depth at which water uptake was registered in subsequent measurements and time from sowing.

- Water absorption rate (*K*, in mm mm^{-1} day^{-1}; i.e., day^{-1}) represents the proportion of soil water absorbed daily by the crop. It was obtained from the following equation:

$$\theta_d = \theta_{d-1} - (\theta_{d-1} - \theta_{Ll}) * K$$

where θ_d (cm^3 cm^{-3}) is volumetric water content on day *d*, θ_{d-1} (cm^3 cm^{-3}) is volumetric water content on the previous day, and θ_{d-1}-θ_{Ll} *is* volumetric water content above the lower limit (Ll) on the previous day. Data were analyzed by ANOVA.

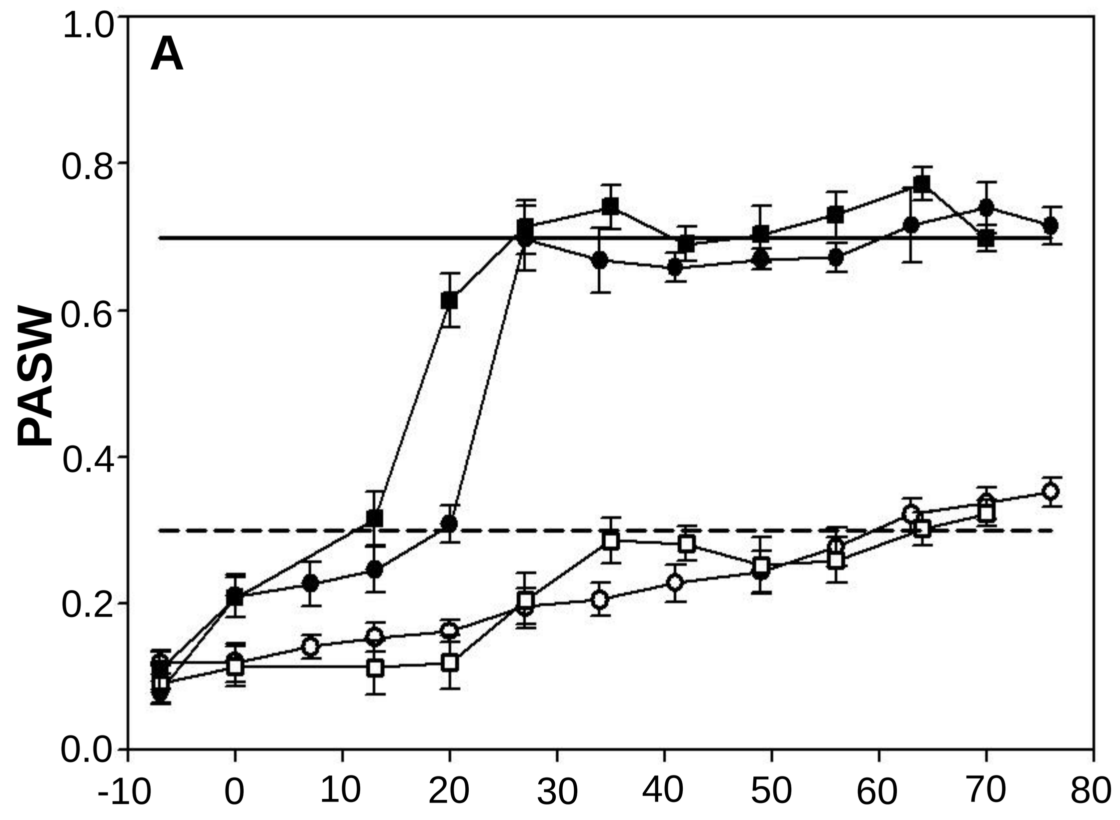

Figure 1. (A) Evolution of plant available soil water (*PASW*) up to R_3 for the 60-200 cm soil layer; black symbols and the solid horizontal line are for 70% *PASW*, white symbols and the dashed horizontal line are for 30% *PASW*; squares are for the early sowing and circles for the late sowing. Vertival bars represent the standard error of the mean. (B) View of experiment, with rain-out shelters next to plots on a sunny day.

RESULTS

All treatments caused a signifcant variation in peanut productivity (Table 1), especially on biomass production, grain yield and seed numbers. The largest decrease in most of these traits was registered for late-sown crops grown on reduced soil water availability (30% *PASW*). The *ARV* was modified only by water regime: (i) at 70% *PASW,* it was 2.34 cm d^{-1} and plants reached maximum apparent water absorption up to 250 cm soil depth (Fig. 2A), and (ii) at 30% *PASW,* rooting was delayed, the *ARV* could not be estimated by means of a linear model, and maximum rooting depth was only 150 cm at the end of the drought period, probably due to an increased soil strength that impaired root penetration. *K* was always maximum up to 70 cm (Fig. 2B). From that depth onwards, the 70% *PASW* treatment had larger *K* values in the late than in the early sowing date, This difference could be related to the larger canopy size and light interception (data not shown) up to R_3 (i.e., before the drought period) of the late than of the early sowing. For the 30% *PASW* condition, the only difference among treatments for deep soil water absorption was for cv. FLORMAN in the early sowing date, which had a reduced *K* (P < 0.05) as compared to the other treatments. This response suggests that root density of this (cultivar x *PASW*) combination did not reach the critical threshold that grants full water extraction by plants, probably due to limited assimilate availability. Differences among treatments in *ARV* and *K* caused a significant (P < 0.05) variation in residual *PASW* (Figure 3).

Table 1. Main and interaction effects on peanut productivity traits

Sowing (S)	*PASW* (W)	Cultivar (C)	Biomass m^{-2} (R_3-$R_{6.5}$)	Seed Yield m^{-2}	Seed number m^{-2}
Early	70%	ASEM	490 a	216 ab	442 b
		FLORMAN	488 a	192 b	410 bc
	30%	ASEM	315 b	132 c	360 cd
		FLORMAN	279 bc	102 cd	290 de
Late	70%	ASEM	467 a	246 a	560 a
		FLORMAN	208 cd	101 cd	248 ef
	30%	ASEM	128 ed	67 de	185 fg
		FLORMAN	63 e	47 e	129 g
***P* values**		S	0.01	0.0044	0.0162
		W	< 0.0001	0.0002	0.0017
		C	0.0025	0.0003	0.0001
		SxW	NS	NS	0.0336
		SxC	0.009	0.013	0.0036
		WxC	NS	0.01	0.01
		SxWxC	0.026	0.033	0.002

Different letters within a column indicate significant differences among treatments (P<0.05)

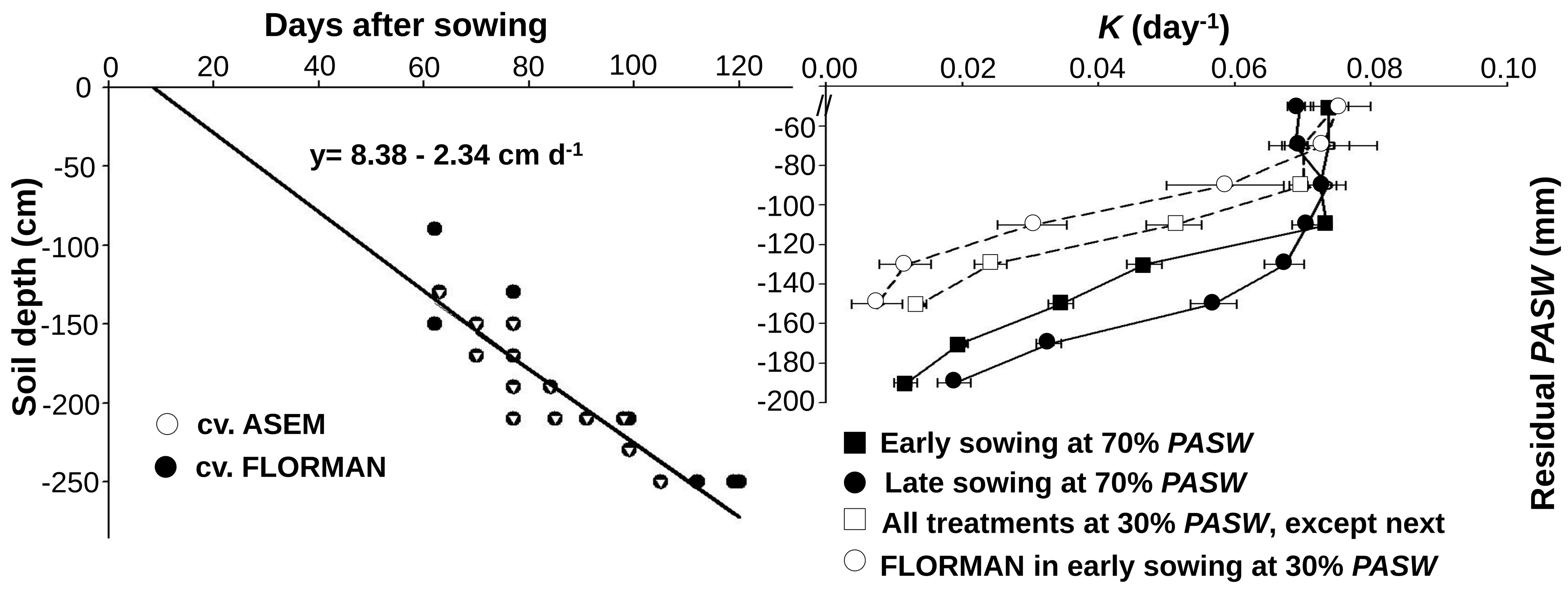

Figure 2. (A) Evolution of maximum depth of soil water uptake of two peanut cultivars grown at 70% *PASW*. The slope of fittel linear model is the *ARV*. **(B)** Water absorption rate *(K,* day^{-1}*)* at different soil depths.

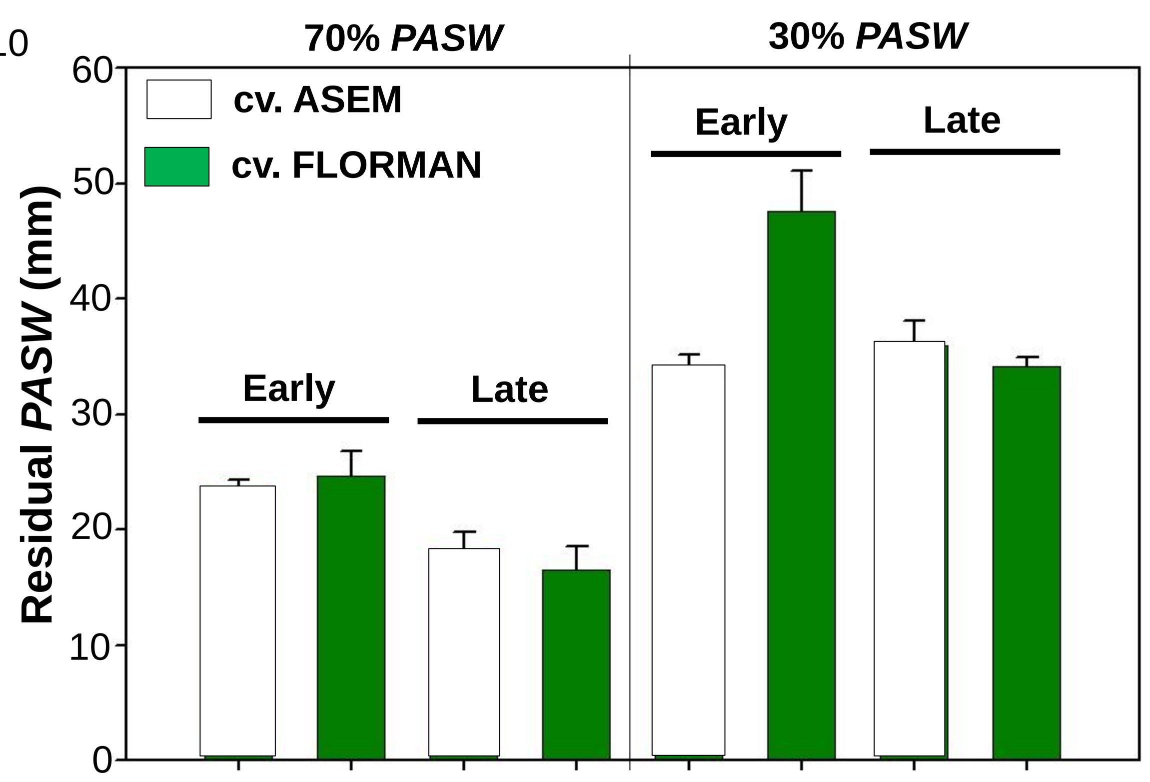

Figure 3. Residual plant available soil water (*PASW*) in deep soil layers (60-200 cm) at harvest for two water regimes (70 and 30% *PASW*), two sowing dates (early and late) and two cultivars (cv). Vertical bars represent the standard error of the mean.

CONCLUSIONS

Peanut capacity for mitigating the negative effects of drought will be limited in crops growing on soils with reduced stored-water in deep layers . This restriction is not only linked to reduced water availability *per se*, it is also the result of a less efficient root system that impairs the capacity of plants for extracting available soil water.

(1) Haro et al., 2007. Field Crops Res. 103:217-228. (2) Haro et al., 2008. Field Crops Res. 109:24-33 (3) Haro et al., 2010. Crop & Pasture Science 61:343-352.