THE EFFECT OF CROP WATER STATUS ON THE YIELD, COMPOSITION AND PROCESSING QUALITY OF SUNFLOWER SEED

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Summary

Hullability is a seed trait in sunflower which affects the efficiency of oil extrusion and the quality of the oil cake produced from the seed. Environmental conditions during seed production determine the hullability. The influence of high and a low crop water status during the grain filling stage, exercised through irrigation, on the composition and hullability of sunflower seed, the potential oil and oil cake yield and the protein content of the oil cake was investigated in a field trial for three cultivars. The relative water content of the leaves, which was measured regularly showed that the difference in water stress between the two treatments was mild and persisted for 25 days from the opening of the inflorescences. Seed yield was reduced with 23%, hullability with 14% and kernel oil content with 2.3% by this water stress. The potential oil yield, oil cake yield and composition of the oil cake however, were not affected by the water stress. Due to the difference in seed composition and hullability, the potential oil yield, oil cake yield and protein content of the oil cake differed among cultivars.

Keywords: Sunflower, water stress, yield, hullability, seed quality.
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Introduction

It is well known that water stress has a profound effect on the yield of sunflower (Muriel & Downes, 1974; Talha & Osman, 1975). Seed composition is also affected by water stress. Water stress during the vegetative and reproductive growth stages reduces the seed oil content (Muriel & Downes, 1974; Hall *et al*., 1985). Seed protein content however, seems to be less affected by water stress after anthesis than the oil content (Connor & Sadras, 1992).

The effect of water stress on seed hullability, a seed trait determining the efficiency of seed processing and the quality of the oil cake produced from oil extraction, is still unknown. Currently available indications are that the hullability is affected by water stress but these indications are apparently contradicting. Denis *et al*. (1994) who has grown several genotypes at two localities, found the hullability of seed from the drier locality to be higher than seed from the wetter locality. Merrien *et al.* (1992) and Baldini & Vannozzi (1996) on the other hand, found the hullability of seed from a frequently irrigated treatment to be higher than that of a less frequently irrigated treatment.

As water stress affects yield and seed composition, the aim of this field trial was to create two levels of crop water status during the reproductive period, to quantify it and measure its effect on the seed yield, some physical and chemical seed characteristics, hullability and the potential oil and oil cake yields of three cultivars.

Materials and Methods

A field trial, designed with three complete blocks was planted on 20th November 1997 at ARC-Grain Crops Institute, Potchefstroom, Republic of South Africa. Plots consisted of four rows spaced at 0.9 m and 10 m long. After emergence seedlings were thinned to 35 000 plants ha^{-1}. Treatments consisted of cultivars (HV 3037, PAN 7392 and SNK 37) and crop water status (high and low crop water status). The high crop water status treatment received 55 mm at 1 and at 14 days after growth stage R4 (Schneiter & Miller, 1981) respectively, while the low crop water status treatment received no irrigation. From growth stage R4 to maturity, four relative small rain storms of less than 10 mm day^{-1} occurred but on 25 days after R4, 93 mm of rain was recorded.

To quantify the crop water status, the relative water content of the leaves was measured twice a week from R4 to R8. This was done by clipping approximately 4 cm^2 from the tip of one of the five upper leaves from four randomly chosen plants from the two inner rows of each plot between 12:00 and 13:00. The cuttings from each plot, were immediately sealed in a plastic bag to prevent water loss, transported to a laboratory and the fresh weight determined. After floating the cuttings on de-ionised water in closed petri-dishes for 18 h at room temperature in darkness, the turgid mass was measured. The dry mass was measured after drying at 75EC for 3 h. The relative water content (RWC) was calculated:

RWC = ((Fresh mass - dry mass)/(Turgid mass - dry mass)) H 100%

Grain yield was measured by harvesting 8 m each from the two central rows per plot. The hectolitre mass, moisture content, thousand seed weight, hull content and hullability were measured as previously described by Nel *et al*. (1999). After dehulling, samples of the seed, kernels and kernel rich fractions were chemically analysed for oil, protein, crude fibre and moisture content (PPECB Quality Assurance Laboratory, P.O. Box 433, Silverton, 0127, South

Africa).

The processing quality of the seed was considered to be the potential oil yield, the oil and moisture free yield, protein and crude fibre content of the kernel rich fraction. The potential oil yield was calculated as follows: potential oil yield = (yield of the kernel rich fraction H oil content of the kernel rich fraction), where the yield of the kernel rich fraction = (mass of kernel rich fraction after dehulling / mass of seed used for dehulling).

Results and Discussion

Due to the irrigation applied to the high water status plots, the RWC of the high and low water status treatments differed from the R4 stage until 25 days later when 93 mm of rain, alleviated it. The occurrence of rain of less than 10 mm day^{-1} had no measurable effect on the RWC nor were differences among cultivars measured at any stage. According to norms laid down by Hsiao (1973), the difference in water stress between the two treatments varied from moderate at 8 and 11 days after R4, to mild at 15, 18 and 22 days after R4. Calculated for the period of measurement which covered the whole grain filling period, the RWC of the low and high water status treatments was 77.8 and 71.4% respectively. The low water status treatment therefore experienced a mild stress compared to the high water status treatment (Hsiao, 1973) for approximately 70% of the reproductive growth period.

Grain yield was affected by the crop water status with the low status treatment yielding 23% less than the high water status treatment (Table 1). The thousand seed weight was affected by both cultivar and crop water status. Calculated over cultivars the thousand seed weight for the low crop water status treatment was 18% lower than that for the high water status treatment. Approximately 78% of the reduction in grain yield, due to the water stress, can therefore be attributed to the reduction in thousand seed weight.

Hull content was affected by cultivar and a water status H cultivar interaction (Table 1). The hull content of PAN 7392 and SNK 37 at the high crop water status treatment were 24.1 and 22.2% respectively, which were higher than for the low water status treatment at 23.5 and 21.5% respectively. The opposite was found for HV 3037, having values of 19.9 and 21.6% for the high and low water status treatments respectively. The change in hull content was however small in comparison to the changes in yield and the hull content brought about by the water status treatments.

Hullability was affected by both crop water status and cultivar (Table 1). Hullability for the low crop water status treatment was 14% lower than for the high water status treatment. This supports the observations of Baldini & Vannozzi (1996) and Merrien *et al.* (1992) that seed from frequently irrigated plots hulled easier than seed from less frequently irrigated plots. Differences in hullability amongst cultivars were larger than between the high and low crop water status treatments with HV 3037 having only 60% of the hullability of PAN 7392.

The production of fine material which is an indication of losses during processing was affected by cultivar and a water status H cultivar interaction (Table 1). PAN 7392 and SNK 37 produced 11.5 and 8.7% fine material at the high crop water status level declining to 10.6 and 6.8% respectively for the low level. HV 3037 on the other hand showed an increase in the production of fine material from 6.5 to 7.4% from the high to the low crop water status treatments respectively.

Seed oil content was not affected by the crop water status treatment but by cultivar only (Table 1). This seems to contradict the results of Alessi *et al*. (1977), Hall *et al*. (1985), Muriel & Downes (1974) and Talha & Osman (1975). However, the moisture free oil content of the kernels was affected by the water status treatment (data not shown) with the low status being 62.9% compared to 64.4% of the high water status treatment. The mild water stress thus reduced the oil content of the kernels which was most likely obscured for the seed analyses due to the presence of the hulls. The protein and crude fibre content of the seed were not affected by the water status treatments. Seed oil and crude fibre content were affected by cultivars as is well known from experience (Table 1).

The moisture and oil free yield and protein content of the kernel rich fraction, which is an indication of the yield and quality of the oil cake that can be expected, was not affected by the water status treatment but by the cultivars (Table 1). The crude fibre content of the kernel rich fraction was not affected by the water status treatment nor by cultivar which is unexpected considering the differences in hullability observed. This might be explained by variation of the crude fibre content of the hulls. Theerta Prasad & Channakrishnaiah (1995) reported the fibre content of hulls to vary from 59.19 to 86.64%. Smith *et al*. (1989) also found the crude fibre content of South African produced seed to vary from 12.80 to 27.94%, much more than the oil or protein content.

Conclusions

The low crop water status treatment developed a mild water stress for the first 25 days of the reproductive growth period, compared to the high crop water status treatment. Grain yield which was reduced by 23% was more sensitive to this water stress than any of the physical or chemical seed traits. Hullability was reduced by 14% and the kernel oil content by only 2.3% while the seed composition was not affected. Potential oil yield was not affected by the water stress nor were the potential oil cake yield, protein and crude fibre contents. How the seed quality parameters will be affected by moderate or severe water stress and stress during the latter part of the reproductive stage is still unknown. Due to the difference in seed composition, hullability and production of fine material of cultivars, the potential oil yield, oil cake yield and protein content differed amongst cultivars.

Table 1 Grain yield, thousand seed weight (TSW), hull content (HC), hullability (H), fines produced, the moisture free oil, protein, and crude fibre (CF) content of the seed, the potential oil yield (POY) and the oil and moisture free protein and crude fibre content of the kernel rich fraction (KRF) of three sunflower cultivars as affected by crop water status during the grain filling period

Factor		Grain yield	TSW	HC	H	Fines	Seed oil	Seed protein	Seed fibre	POY	KRF protein	KRF fibre
		(kg/ha)	(g)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Water	High	2814	61.4	22.1	66.9	8.9	50.3	18.2	18.2	41.0	47.1	24.2
	Low	2170	50.6	22.2	57.5	8.3	49.6	19.6	17.9	41.6	49.1	23.8
Cultivar	HV3037	2570	56.6	20.8	46.3	7.0	50.7	19.8	16.5	43.2	48.6	24.1
	PAN7392	2483	49.4	23.8	80.2	11.1	46.9	19.0	20.5	36.6	50.1	23.2
	SNK37	2422	62.0	21.9	60.0	7.7	52.2	17.8	17.1	44.1	45.6	24.7
Significance of the F values from analysis of variance												
Water status		**	**	ns	**	ns	ns	ns	ns	ns	ns	ns
Cultivar		ns	**	**	**	**	**	ns	**	**	*	ns
W H C		ns	ns	**	ns	**	ns	ns	ns	ns	ns	ns

**,* Significant at the P = 0.01 an 0.05 probabilty levels respectively, ns = not significant.
W H C = water status cultivar interaction.

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