THE OPTIMUM TIMING OF NITROGEN APPLICATION TO IRRIGATED SUNFLOWERS

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ABSTRACT

Glasshouse experiments with sunflower cv. Hysun 30 have shown that seed number per plant, the major component of yield, is determined by the level of N supply before floret initiation, single seed weight by the supply after floret initiation and oil % DW seed after anthesis. We have tested these results in field experiments so as to make recommendations to farmers on timing of N fertilizer application. Shoot dry weight and total N content responded positively (cf. zero N control) to single N applications given in the irrigation water at six different times up to full anthesis. The nitrate concentration in the petioles of the 3 youngest fully-expanded leaves responded positively at all application times. After reaching a maximum it decreased exponentially with time after application, irrespective of the stage of crop development at time of N application. The largest seed number was obtained from the N application just before floret initiation and the largest single seed weight when N application was split between 6 times, consistent with the glasshouse results. In other field experiments different cultivars were compared with the aim of identifying types that might be well-suited to irrigated production. Those having, genotypically, large numbers of seeds (i.e. with a large generative front at floret initiation) responded better to early N application than those having fewer seeds. However, some of the fewer-seeded cultivars showed continued receptacle growth through anthesis and so responded well to N application just before anthesis and produced large single seed weights and large seed weights per plant.

INTRODUCTION

We have shown in glasshouse experiments, using N supply as the variable, the time when components of yield of oilseed sunflower are determined during plant development (Steer **et al.**, 1984). The major component and that most sensitive to N supply is seed number which is determined early in plant development, during floret initiation. Single seed weight responds to the N supply after floret initiation and mainly before anthesis, during floret growth. Oil % seed DW is depressed by high N supplies after anthesis.

In irrigated sunflower production, split N application and supply of N fertilizer in the irrigation water are two methods for obtaining the best seed yields per unit N applied (Muirhead **et al.**, 1984). The glasshouse results suggested certain stages in plant development when N application is most effective. These have been tested in field experiments and are reported here.

MATERIALS AND METHODS

The experiments were conducted in consecutive summers on a site that had a cropping history: summer sudax, winter oat, sunflower experiment 1, winter oat, sunflower experiment 3. Experiment 2 was conducted on a site that had been growing lucerne, adjacent to experiment 1. Fertilizer was applied only in the sunflower experiments: 20 kg P per ha at sowing and N as the experimental variable (see results).

The soil was a transitional red-brown earth. The site had been laser-levelled to a zero slope N/S and 1:2200 E/W. Each treatment plot was 11*12 m, separated from each other on N and S by access tracks and on E and W by vertical plastic sheets in the soil effectively preventing lateral movement of water and N.

In experiment 1 the main treatment was time of N application (see Table 1) with plots split between cultivars: Hysun 30 (Pacific Seed Co.) and Sirosun 132H (CSIRO experimental F1 hybrid). In experiment 2 the main treatment was cultivar: Siroleo, a CSIRO early-maturing open-pollinated line; Hysun 30, Sirosun Bianca Grande, a long-season giant confectionary type; and Sirosun 152H, a CSIRO hybrid. Fifty kg N per ha was applied 3 times: before sowing, after floret initiation and at early anthesis. The main treatment in experiment 3 was time of N application (see Fig. 2) with plots split between 3 cultivars: Bianca Grande, Sunfola 68.3 (Pacific Seed Co.) and Sirosun 892952, a CSIRO 3-way cross related to 152H.

Irrigation water was metered onto each plot through a machine that also allowed measured amounts of N fertilizer, urea, to be applied in the water. The necessity for irrigation was calculated from pan evaporation and tensiometer readings, and N application from the stage of crop development.

Sowing dates were: experiment 1, 20 Dec 1982; experiment 2, 21 Dec 1982; experiment 3, 2 Nov 1983. The results reported are from plant populations of 100 000 per ha in experiments 1 and 3, and 75 000 per ha in experiment 2. Shoots were harvested at different stages in crop growth and separated into stems, leaves, petioles and reproductive parts. Dry weight (DW), N content and yield components were determined and results tested by analysis of variance. In the analysis of experiment 3 the N content of the preceding winter oat crop in the plots was used as a covariate.

Table 1. Shoot dry weight and N content in response to 120 kg N ha^{-1} applied at different stages of crop development. Mean of two hybrids (Hysun 30 and Sirosun 132H). Experiment 1.

Days after sowing		42	60	72	85	103
N application at:		g shoot dry weight per plant				
Zero		36.7	83.2	135.7	183.3	157.2
Pre-plant	(-10*)	36.2	96.2	128.0	196.5	123.8
Floral stage 1	(22)	38.1	118.1	153.4	233.3	181.5
Floral stage 8	(38)	-	101.6	135.6	208.9	156.7
Early anthesis	(56)	-	-	143.6	204.0	160.2
Full anthesis	(63)	-	-	-	195.3	159.5
Full anthesis + 7 days	(70)	-	-	-	210.0	172.4
Split	(-10,22,38,56,63,70)	38.0	84.6	144.3	209.4	174.7
LSD 0.05		NSD	22.2	19.1	29.6	31.4
		mg shoot N per plant				
Zero		996	1218	1913	2280	2318
Pre-plant		858	1595	1902	2708	1827
Floral stage 1		1433	2398	2932	3460	3192
Floral stage 8		-	2020	2490	3092	2809
Early anthesis		-	-	2823	3559	3164
Full anthesis		-	-	1943	3281	2998
Full anthesis + 7 days		-	-	-	3131	3131
Split		1034	1579	2685	3429	3211
LSD 0.05		146	636	509	587	694

* days after sowing

RESULTS AND DISCUSSION

The application of 120 kg N per ha caused a response in shoot DW and N content (Table 1) irrespective of the time of application except that pre-plant N was ineffective. The greatest DW response was to N supplied at floral stage (FS)1 (FS defined by Marc and Palmer, 1981). The application of 20 kg N per ha six

Differences between cultivars

Experiment 2 was carried out to assess the benefit that long-season cultivars might have for irrigated production where water supply will not be limiting late in crop growth. Despite having a short-season cultivar, Siroleo, and a long-season one, Bianca Grande, the days from sowing to physiological maturity did not differ greatly under irrigation (Table 3); a common observation in irrigated production in our region. The latter two cultivars produced fewer seeds per plant than the 2 hybrid cultivars. Seed number was positively correlated with the size of the generative front during floret initiation (see Palmer and Steer, this volume). A large shoot DW at floret initiation did not invariably support a large generative front e.g. Bianca Grande. Thus genotypically, shoot biomass and size of the generative front are controlled separately, an important concept in breeding for large seed numbers per plant.

Despite the smaller seed numbers in Siroleo and Bianca Grande they out-yielded the 2 hybrids due to large single seed weights. These were associated with a continuation of capitulum growth during anthesis (reported as relative growth rates in Table 3) that did not occur to the same extent in the smaller-seeded, but many-seeded, hybrids.

In addition to the benefits to seed number gained from N applied just before floret initiation (Table 2) some cultivars may give good seed yields per plant if N supply is maintained during anthesis, to support continued growth of the capitulum, producing large single seed weights. This was tested further in experiment 3.

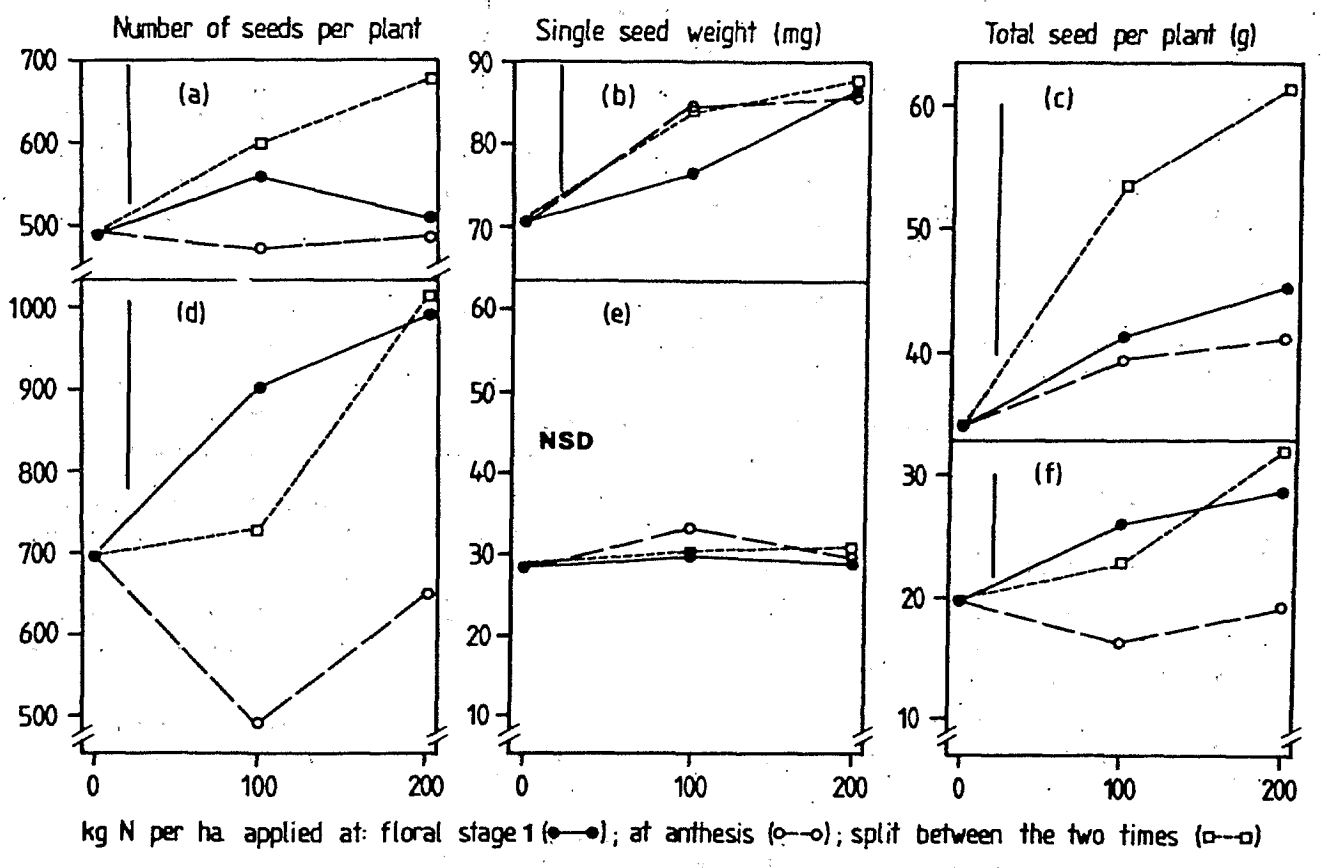

Fig. 2. Yield of Bianca Grande (a,b,c) and Sirosun 892952 (d,e,f) as a function of N supply. Experiment 3. Vertical bars are LSD P<0.05.

In experiment 3 two rates of N were applied either at FS 1 (29 days) or just before anthesis (65 days) or split between the two times. Seed yields are shown in Fig. 2; timing of N application had a significant effect except on single seed weights. The many-seeded hybrid, Sirosun 892952, responded in seed number per plant to N application just before floret initiation but not to N applied at anthesis. By contrast, Bianca Grande showed a poor response by seed number to early N. Possibly the range of size of the generative front (Table 3) in this cultivar is small and so the response to early N is limited. In addition, shoot DW at FS 8 was depressed by 200 kg N whereas in Sirosun 892952, shoot DW increased with N supply up to 200 kg N per ha (not shown).

Single seed weight of the hybrid hardly responded to N supply whereas it did in Bianca Grande, particularly to 100 kg N applied at anthesis or split application. The product of seed number and single seed weight, seed weight per plant, shows the benefit of split N application to Bianca Grande. To Sirosun 892952, however, split N application provided no advantage over N applied just before floret initiation.

CONCLUSION

Nitrogen may be applied most effectively to sunflower crops just before floret initiation occurs, about 20 to 30 days after sowing. This application supports the production of large numbers of florets per capitulum which is particularly important for the many-seeded hybrids. A second N application just before anthesis is particularly important for cultivars that have the ability for continued high growth rates of the capitulum through anthesis. This supports the development of large single seed weights.

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