วารสารเกษตร 6,4: 253-263 (2533)

Journal of Agriculture 6,4 : 253-263 (1990)

EFFECTS OF RATES AND TIMES OF NITROGEN SUPPLY ON GROWTH AND YIELD OF SUNFLOWER C.V. HYSUN 33

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ABSRACT : A study on the effects of rates and timing of nitrogen supply on the growth and yield of sunflower cv. Hysun 33 conducted at the Faculty of Agriculture, Chiang Mai University from November 1988 to March 1989 under lowland irrigated conditions. A low rate and a high rate of nitrogen (50 and 150 kgN/ha, respectively) were applied at the following stages of growth: (i) at sowing, (ii) at sowing and after weeding, (iii) at sowing and budding, and (iv) after weeding and budding. The experimental design consisted of a split plot with the two N-levels used as the main plot and with timing of application used as the sub-plot. A nil application of N was included in the experiment as check plot.

There was no significant difference in seed yields due to the timing of N application. The split application of nitrogen, however, did result in increases in seed yields. A highest yield of 3.4 ton/ha was recorded. In comparison to the check plot, seed yields increased by 16% with the low level of N application and by 42% with the high level of N application. Seed oil contents tended to decrease as increasing N levels. A contrary result was observed for protein content. Mean values of between 42.9% and 46.1% for oil content and 16.1% and 23.1% for protein content were observed. Leaves demonstrated a greater capacity for remobilization of both DM and N to seeds than did stems or petioles and capitulum. As the application of N increased there was an accompanying decrease in the remobilization percentage. Remobilization was between 21.1% and 34.6% for DM in leaves and between 38.4% and 75.4% for N in leaves. The lowest remobilizations for DM and N were between 3.4% and 13.7% and 57.8% and 62.9% in stems plus petioles, repectively.

INTRODUCTION

Sunflower is one of the most important oil crops in the world. In Thailand, sunflower has been grown in various parts of the country although more for its seeds is confectionary or as a decorative plant than for its oil. As sunflower has adapted well to the northern Thailand especially, extensive research has been undertaken in the hope to further facilitate its adoption crop by other Thai farmers as an alternative crop. Many agronomic farm trials conducted in the North and Northeast have shovn sunflower to give varying yields ranging between below 0.5 ton/ha and up to 2.8 ton/ha (Anon, 1987). Low soil fertility, drought and cultivars are the main account for low yields. In regard to soil fertility, lack of nitrogen is the most critical nutrient limiting growth and yield.

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As nitrogen fertilizer is comparatively expensive in Thailand, the application of nitrogen at rates and times for optimum benefit should be considered in order to minimize nitrogen loss and maximize economic return. Effective use of nitrogen fertilizer depends on rates and times of nitrogen supply (Muirhead *et al.*, 1984; Steer and Hocking, 1984),cultivars (Steer *et al.*, 1985), and soil fertility area, plant response to timing and supply rate o nitrogen need investigation.

The objective of this study, there fore,is to evaluate the effects of rates and times of nitrogen application on growth and yield of the hybrid sunflower cv. Hysun 33 grown under lowland irrigated condition.

MATERIALS AND METHODS

An experiment was conducted at the Multiple Cropping Centre, Faculty of Agriculture, Chiang Mai University, during November, 1988 to March 1989 under lowland irrigated condition. An analysis of soil sample is presented in Appendix 1.

A commercial hybrid of sunflower cv. Hysun 23 sown in a split plot design with three replications. The treatments were as follow :

Main - plot (N - rates)	x	Sub - plot (Times of application)
1.50 kg/ha (Low N)		1. All at sowing (s)
2.150 kg/ha (High N)		2. Onehalf at sowing and the other half after weeding (S+W)
		3. One half at sowing and the other half at budding (S+B)
		4. One half after weeding and the other budding (W+B)

Nitrogen was applied via the broadcasting and raking of ammonium sulphate.

Plots were 3 x 15 m. The spacing between rows and plants were 75 cm and 50 cm, respectively. All experimental plots were applied with 30 kg P, 30 kg K, and 10 kg Borax per hectare as basal fertilizers before sowing.

Samples were harvested at anthesis (R5 = 73 DAE) and at maturity (R9 = 110 DAE). Six plants from two inner rows in each sub-plot were at soil level and divided into laminae, stems, petioles, and capitulums. At maturity the capitulum was divided into seeds and receptacle. Samples were dried to constant weight at 70°C, and then weighed and ground before total N analysis. Seeds were analysed for protein (% N x 6.25) and oil contents. Total N and oil were measured, respectively. The micro Kjeldahl method and ether extraction.

Remobilization of dry matter or N from organs between anthesis and maturity was calculated as:

$$\text{Remobilization (\%)} = \frac{\text{Amount at anthesis} - \text{Amount at maturity}}{\text{Amount at anthesis}} \times 100$$

Recovery of dry matter or N at anthesis and maturity due to N supply was calculated as:

$$\text{DM recovery (kg DM/kg N)} = \frac{\text{Amount of a designed treatment} - \text{Amount of check}}{\text{Applied N}} \times 100$$

$$\text{N recorery (\%)} = \frac{\text{Total N of a designed treatment} - \text{Total N of Check}}{\text{Applied N}} \times 100$$

RESULTS AND DISCUSSION

Shoot Dry Matter and Nitrogen Contents

The shoot (leaves, petioles, stems and capitulum) DM and N contents at anthesis and maturity as affected by rates and times of N supply on either DM or N contents and as the interaction was not observed, Figure 1. is presented as a mean of the times of N supply treatments.

At anthesis, both DM and total N were not influenced by rates and times of N supply. But both DM and N contents of the plants did show positive responses to N supply when compared with the check plot (0 kg N/ha). The increasing N supply from 50 to 150 kg per hectare had a tendency to increase the total N but did not reach a significant level.

At maturity, there was a significant in total DM (shoot DW + seed DW) among the treatments, but total N was markedly affected only by the rates of N supply. Both DM and total N for any timing of N supply, significantly increased with increasing N supply. Higher DM was observed when N supply was split. Increases in total N due to split application of N did not reach a significant level.

Total DM (shoot and seed) and total N were higher at maturity than anthesis. It was observed, however, that shoot DM and its N content were lower at maturity than anthesis. That could be due to the remobilization of assimilate to seeds (Table1). Hence, higher total DM and total N at maturity are accounted for by seed production.

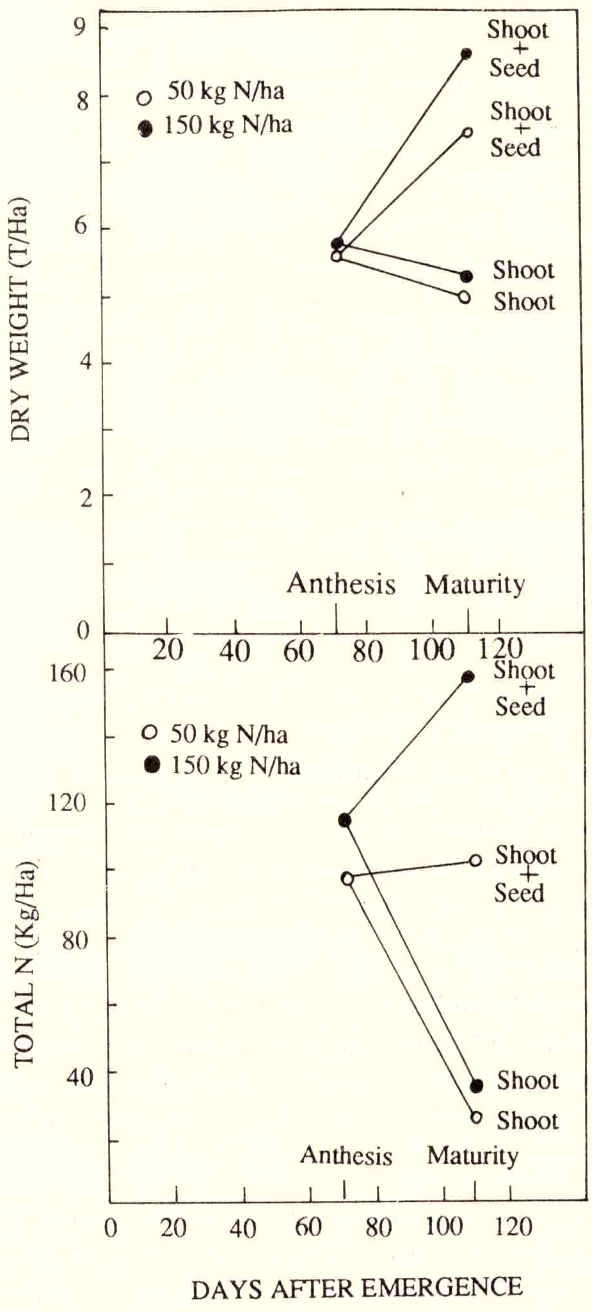

Figure 1. Dry matter and nitrogen accumulation of sunflower cv. Hysun 33 at anthesis and maturity as affected by N supply.

Table 1. Dry weight and N-contents of plant organs of sunflower cv. Hysun 33 at anthesis and maturity in responses to rates and times of N application.

N-rates (kg/ha)	Time of N-application					Time of N-application				
	S	S+W	S+B	W+B	Mean	S	S+W	S+B	W+B	Mean
	DW (kg/ha)					N contents (% DW)				
At Anthesis:(73 DAE)										
Leaf: (check = 872)						(Check = 872)				
50	1216	1196	1246	1322	1245a	3.68	3.91	4.09	3.58	3.82^{a}
150	1216	1355	1499	1557	1407b	3.49	4.39	4.04	4.16	4.02^{a}
Mean	1216	1276	1373	1440		3.59	4.15	4.07	3.87	Int.^{NS}
	a	a	a	a		b	a	ab	ab	
Stem+Petiole:(Check = 2472)						(Check = 0.58)				
50	3147	2963	2959	3198	3067a	0.64	0.69	0.72	0.75	0.70^{a}
150	2763	2538	3051	2630	2746a	0.58	1.04	0.82	0.81	0.81^{a}
Mean	2955	2715	3005	2914		0.61	0.87	0.77	0.78	Int.^{NS}
	a	a	a	a		b	a	ab	ab	
Capitulum: (Check = 923)						(Check = 2.19)				
50	1450	1253	1203	1285	1298a	2.22	2.34	2.40	2.39	2.34^{a}
150	1286	1370	1657	1200	1378a	2.34	2.67	2.51	2.49	2.50^{a}
Mean	1368	1312	1430	1243		2.28	2.51	2.46	2.44	Int.^{NS}
	a	a	a	a		a	a	a	a	
At Maturity: (110 DAE)										
Leaf: (Check = 665)						(Check = 0.91)				
50	858	599	866	983	827a	0.90	0.91	0.88	1.07	0.94^{a}
150	844	1121	1310	1168	1111a	1.17	1.38	1.26	1.27	1.27^{b}
Mean	851	860	1088	1076		1.04	1.15	1.07	1.17	Int.^{NS}
	c	bc	a	ab		a	a	a	a	
Stem+Petiole: (Check = 2233)						(Check =0.33)				
50	2539	2392	2815	2843	2647a	0.22	0.22	0.32	0.28	0.26^{a}
150	2670	2767	3116	2929	2871a	0.36	0.35	0.35	0.31	0.34^{a}
Mean	2605	2580	2966	2886		0.29	0.28	0.34	0.30	Int.^{NS}
	a	a	a	a		a	a	a	a	
Receptacle: (Check = 892)						(Check = 0.72)				
50	1011	959	1116	1431	1129a	0.76	0.76	0.74	0.84	0.78^{a}
150	1128	1289	1331	1292	1260a	0.93	1.15	1.22	1.17	1.12^{b}
Mean	1070	1124	1224	1362		0.84	0.96	0.98	1.01	Int.^{NS}
	a	a	a	a		a	a	a	a	

Values with the same letter in the same row or column are not significantly different at 5% level.
N.S = non significant ($P > 0.05$).

Dry Matter And Nitrogen Content of Plant Organs

Dry weights (DW) and nitrogen concentration of various organs (leaves, stems plus petioles and capitulum or receptacle) at anthesis and maturity are summerized in Table 1. At anthesis, DW of any plant organs was not significantly affected by rates and timing of N supply with the exception of leaf DW which was affected by N supply rate. Leaf DW significantly increased as N supply was increased.

In general, the effects of rates and timing of N supply on nitrogen concentrations in all organs were similar. Nitrogen concentration in all organs increased significantly when either a low rate or a high rate of N supply was split. But increases in nitrogen concentration due to increased N supply did not reach a significant level. In terms of concentration and the total, leaves had a higher nitrogen content than other organs while the lowest content was observed on stems and petioles. This means that partitioning of N occurred more in leaves than other organs.

At maturity, only leaf DW increased slightly with increased N supply. Concentrations of N in both leaves and receptacle increased significantly with increased N supply. The timing of N supply produced no effect on either DW or N concentration in any organ. As observed at anthesis, the highest N concentration was recorded in leaves and the lowest one in stems and petioles.

Both DW and N concentration for all organs were lower at maturity than at anthesis. This probably reflects the remobilization from those organs to seeds. The degree of reduction was different among the organs and the reduction in N concentration was greater than DW for all organs. Higher remobilization of DW and N was greater in leaves than in stem + petioles and capitulum (Table 2). This

Table 2. Effects of N supply on remobilization (%) of dry weight and nitrogen of various organs of sunflower cv. Hysun 33 between anthesis and maturity.

Organs	N supply (kg/ha)		N supply (kg/ha)	
	50	150	50	150
	Dry weight		Nitrogen	
Leaves	34.6	21.1	75.4	68.4
Stems+Petioles	13.7	3.4	62.9	57.8
Capitulum	12.9	8.6	66.8	55.3

date indicated that the percentage of N remobilized in leaves ranged between 38.4 to 75.4 (means of N supply timing) and that this depended on the rates of N supply. This contrasts with percentage ranges of 57.8 to 62.9 and 55.3 to 66.8 which were observed, respectively,in stems plus petioles and capitulum. These percentages are in ranges previously observed by Steer *et al.* (1986). As N in leaves plays an important rate in leaf photosythesis (Peaslee and Moss, 1966, cited by Gardner *et al.* , 1985), a strong reduction in N could there by haves a detrimentral effect on over all leaf photosynthesis efficiency and especially when leaves are subjected to N efficiency. In regard to DW, it was found that the percentage reduction ranges were 21.1 to 34.6 and 8.6 to 12.9 respectively. A smaller percentage reduction range was found for stems plus petioles. A weak remobilization of stems could favour stalk strength as the plants could then maintain resistance to lodging as has been found with maize (Valle, 1981).

Seed Yields And yield Components

Unlike the timing of N supply treatments, Level of N did produce a significant difference in seed yields and yield components (Table 3). When 50 and 150 kg per hectare of N were applied this resulted in increased yield of 13% and 30% respectively. Increased seed yield was due to increases in all three yield components. Split application of N tended to increase seed yields but not to a significant level. The higher yield was obtained with either a low or high N supply, and with the application at sowing and the rest at budding. Yield tended to decline when the application of N was late (the W + N treatment).

Seed Oil and Protein Contents

Both seed oil and protein content were affected by rates of N supply but it is not very likely that they were affected by timing (Table 4). Oil content was lower with higher N supply but contradictor results were observed for protein content. Oil content percentage ranges of 45.5 to 47.7 were observed for the lower N supply compared to 40.2 to 46.0 for the higher one. For protein, the observed values were between 17.7 to 18.6 and 21.7 to 24.1 for low and high N supply respectively. Table 4. shows the negative correlation between oil and protein content in seeds. As oil content increased, protein content decreased. This consequently explains why a lower oil content was obtained when there was a higher N application.

N concentration in seeds or other organs with specific phenological growth stages has been widely used to define plant status, e.g. defficient, marginal, critical and adequate. The defficient and adequate concentrations of N in seeds have been defined in the USA as 2.4-2.5% and 3.3% respectively (Reuter and Robinson 1986). If these figures are used as evaluative criteria on the N concentrations observed in this study (Table 4), they indicate that adequate in N concentration. Plants with the low N supply treatment (50 kg N/ha) can be described as in a marginal critical zone.

Table 3. Yields and yield components of sunflower cv. Hysun 33 in responses to rates and times of N application.

N-rates (kg/ha)		Times of application S	S+W	S+B	W+B	Mean
		Seedd DW (kg/ha)				
50		2693	2500	3000	2781	2744[a]
150		3050	3431	3538	3488	3377[b]
	Mean	2872	2966	3269	3135	
		a	a	a	a	
		(Check = 2375)				
		Capitulum size (0 cm)				
50		21.1	21.4	22.7	23.6	22.2[a]
150		24.0	24.3	23.8	25.6	24.4[b]
	Mean	22.6	22.9	23.3	24.6	
		a	a	a	a	
		(Check = 21.8)				
		Seed No./capitulum				
50		1428	1361	1560	1432	1445[a]
150		1435	1628	1665	1612	1585[b]
	Mean	1432	1495	1613	1522	
		a	a	a	a	
		(Check = 1318)				
		100 Seed wt. (g)				
50		7.1	6.9	7.2	7.3	7.1[a]
150		8.0	7.9	8.0	8.1	8.0[b]
	Mean	7.6	7.4	7.6	7.7	
		a	a	a	a	
		(Check = 6.7)				

Values with the same letter in the same row or column are not significantly different at 5% level
N.S = non significant (P > 0.05).

Table 4. Seed oil and protein contents of sunflower cv. Hysun 33 in response to rates and timing of N supply.

Treatment		Oil (% DW)	N (% DW)	Protein (% N x 6.26)
50 kg/ha				
S		45.5	2.87	17.9
S+W		46.0	2.85	17.8
S+B		45.8	2.83	17.7
W+B		47.2	2.97	18.6
	MEAN	46.1	2.88	18.0
150 kg/ha				
S		46.0	3.42	21.7
S+W		42.5	3.79	23.7
S+B		40.2	3.68	23.0
W+B		42.8	3.86	24.1
	MEAN	42.9	3.70	23.1
	Check	44.3	2.57	16.1

Dry Matter And Nitrogen Recovery

The calculation of recovery of DM (kg DM produced per kg N applied) and N (percentage of N uptake per kg N applied) at anthesis and maturity, as influenced by rates and times of N supply, are presented in(Table 5.) At anthesis it was clear that the recovery of both DM and N were affected by rates of N supply, but were unlikely to be affected by the times of application. The lower the rate of N supply, the higher the recovery of both DM and N. The average DM and N recovery of 26.9 kg/kg N and 65.5% respectively were recorded for the lower N supply, compared with 7.9 kg DM/kg N and 31.3% observed on the higher N supply. At maturity as at anthesis, the higher DM recovery was observed on the lower and less differentiated N supply treatments. There was an indication that DM recovery was affected by times of N supply. Application of all N at sowing gave a lower recovery value. As

Table 5. Effects of rates and timing of N supply on recovery of dry matter (kg DM/kg N) and nitrogen (%) at anthesis and maturity of sunflower cv. Hysun 33.

Treatments	Anthesis		Maturity			
	DM	N	Total DM	Total N	Seed DW	Seed N
50 kgN/ha						
S	30.9	62	18.7	30.1	6.4	32.6
S+W	22.9	59	5.7	12.4	2.5	20.6
S+B	22.8	71	32.7	55.2	12.5	47.8
W+B	30.8	71	37.5	41.6	8.1	43.2
Mean	26.9	65.7	23.7	34.8	7.4	36.1
150 kgN/ha						
S	6.7	14.0	10.4	32.8	4.5	29.9
S+W	4.4	37.4	16.3	53.7	7.0	46.0
S+B	12.9	40.7	20.8	57.7	7.8	46.1
W+B	7.5	33.1	18.1	57.7	7.4	40.9
Mean	7.9	31.3	16.4	50.4	6.7	40.7

APPENDIX 1. Soil samples analysis.

pH (1:1)	= 6.3
OM (%)	= 0.96
Available P (ppm)	= 9.66
Available K (ppm)	= 133

for N recover in DM and seed, these were markedly affected by both rates and timing of N supply. The higher recovery was observed from the higher N supply and the split application of N at either a low or high rate resulted in a better recovery. It was noticed that the higher N supply brought a greater N recovery in both DM and seed, while a contradictory result was observed on DM recovery. This could be due to the palnts deposition of more N from root-uptaking in seeds than in vegetative parts since seeds are stronger sink. There was no difference in recovery of seed between two levels of N supply, but the split application of N supply gave a slightly better recovery. The average value of seed yield recovery was between 6.7-7.4 kg/kg N supply.

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