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Effects of N Fertilization on the Growth and Yield of Two Maize Hybrids[1]

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Abstract: A single-cross maize hybrid, Tainung No. 351, and a double-cross hybrid, Tainan No. 11, were grown in the field at a density of 58,800 plants/ha in the fall of 1983. N rates of 75, 150, 225 and 300 kg/ha were supplied in the form of ammonium sulfate. Samplings were made at a two-week interval starting from mid-silking to maturity. Leaf area and N and total nonstructural carbohydrate (TNC) concentrations were determined in plant fractions. The purposes of this study were to compare the physiological differences between the two hybrids and to clarify the physiological basis of the high yield potential of Tainung No. 351. Results showed that increased N fertilization delayed the dates of heading and silking. Grain yield of Tainung No. 351 increased with increasing N level, due mainly to higher kernel number per ear which could compensate for the loss of lower 100-kernel weight. N had positive effects on plant N concentration, leaf area and dry matter accumulation. N use efficiencies (unit grain yield per unit N supplied) of Tainung No. 351 were 90.5 and 27.3 at N rates of 75 and 300 kg/ha, respectively. Corresponding values for Tainan No. 11 were 68.9 and 19.9. Yield efficiencies (unit grain yield per unit leaf area) were 3.06 and 2.96 g/dm^2 for Tainung No. 351 and 3.50 and 3.17 g/dm^2 for Tainan No. 11 at N rates of 150 and 300 kg/ha, respectively. Within 2 weeks after silking, stalk and cob acted as temporary sinks to store N and TNC for the subsequent needs of grain filling. TNC concentration was above 13% in the stalk of mature Tainung No. 351 plants but was below 3% in Tainan No. 11. This fact indicated that carbohydrate translocation of the high-yielding Tainung No. 351 was less efficient. Yield could be further enhanced through increasing kernel weight. Limiting factors to grain yield of Tainan No. 11 were presumed to be both source capacity and sink size. Experimental results suggested that nutritional requirements of Tainung No. 351 was high. Appropriate dense planting might be a good measure under satisfactory conditions to increase leaf area and photosynthetic ability. Further understanding of the interaction between N and C metabolism was important in order to increase kernel number and kernel weight simultaneously and hence the yield of Tainung No. 351.

The overproduction of rice has caused problems to the national economy of this country in recent years. Maize, with its high yield potential and wide adaptability, is

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the most promising crop in substituting for part of the paddy rice. Grain yield of the commercial, double-cross maize varieties in Taiwan averaged at only 3.5 t/ha. In 1984, Taiwan Agricultural Research Institute released a single-cross maize variety, Tainung No. 351, which can yield 6 t/ha of grain on an islandwide basis. The new variety is expected to dominate the acreage within a few years.

As a single-cross hybrid, Tainung No. 351 is uniform in plant development and possesses very strong growth vigor compared with the double-cross hybrids. Higher grain yield of maize can be obtained by increasing biological yield and the efficiency of partitioning dry matter to the economic organ (i.e., high harvest index). However, it is known that for maize, modern hybrids perform better only when grown under high levels of fertilizers. As a consequence, the increased productivity is usually associated with a drop in the efficiency of nutrient utilization [2,3]. Nitrogen plays a very important role in the grain production of maize. Differences in N utilization among genotypes have been demostrated, not only in differential response to N fertilizer, but also in differences in absorption and in utilization of absorbed N [4,9,13]. Thus Tainung No. 351 may be a superior, N efficient hybrid compared with Tainan No. 11.

This study investigated the responses of Tainung No. 351 and Tainan No. 11 hybrids to different levels of N fertilization. In addition to yield components, several physiological characters were also studied in order to obtain detailed information on maize grown in Taiwan. Hopefully, the results of this experiment can provide useful suggestion to the future improvement of varieties and cultural practices.

Materials and Methods

This experiment was conducted at the experimental farm of Taiwan Agricultural Research Institute. A single-cross maize hybrid, Tainung No. 351 (TA 80-2598 × TA 80-1410), and a double-cross hybrid, Tainan No. 11((2027-3-5 × LY 22-4) × (PH9-DMR × AME III)), were selected as experimental materials. Kernels of the maize hybrids were overplanted at a spacing of 85×20 cm on Sept. 27, 1983 and thinned to 58,800 plants/ha (one plant per hill) after emergence. Nitrogen rates of 75, 150, 225 and 300 kg /ha were supplied in the form of ammonium sulfate. Forty percent each of N was applied at planting and 25 days after emergence (DAE) which occurred on Oct. 2, 1983. The remaining 20% was applied 44 DAE. Rates of P_2O_5 and K_2O supplied at planting were 70 and 90 kg/ha, respectively. Each experimental unit consisted of nine-row plot containing 41 plants per row. Randomized complete block design was employed with three replications.

Samplings were made at a two-week interval starting from mid-silking to maturity. Five plants per plot were harvested for the first five samplings (silking to 8 weeks after silking) and 15 plants were taken from each plot for the last sampling for yield determination. The plants were divided into the following parts immediately after harvest: tassel, stalk, upper leaves (leaf blades from nodes above the ear position), ear leaves, husks, cob and grain. Leaf area and N concentration of each plant fraction were determined. Concentration of total nonstructural carbohydrates (TNC) was analyzed in grain and stalk internodes above and below the ear node only. Yield components investigated included ear length, unfilled ear length, kernel row number, kernel number per ear, 100-kernel weight and shelling rate. Grain yield was expressed in the unit of kg/ha. Since all the filled grains were collected, results showed a relatively high kernel number per ear and low 100-kernel weight.

Leaf area was measured with a LI-3000 leaf area meter (LI-COR Co., USA). Plant parts were dried at 80°C for 48 hrs in an air-drafted oven. Dried samples were then ground in a Wiley mill by using a 40-mesh screen for chemical analyses. Nitrogen was analyzed by the Kjeldahl method. TNC was analyzed according to the method of Smith [16]. Ground samples were first hydrolyzed with takadiastase ("Clarase" 40,000, courtesy of Miles-Kyowa Co., Japan) at 40°C for 44 hrs, and reducing sugars were measured by the Shaeffer-Somogyi copperiodometric titration method. This method of hydrolysis for the determination of TNC has been demonstrated by Streeter and Jeffers [17] and tested by this laboratory as most acceptable for precision, accuracy and recovery of standard added to the samples.

Results

Some agronomic and yield characters of maize hybrids grown under different levels fo N fertilization were shown in Table 1. There was a tendency that N application could delay tasseling and silking. The duration between tasseling and mid-silking was 9 days for Tainung No. 351 and 4—5 days for Tainan No. 11. The growth duration (

Table 1. Some agronomic and yield characters of maize hybrids grown under different levels of N fertilization[a]

Character	Tainung No. 351				Tainan No. 11			
	N_1	N_2	N_3	N_4	N_1	N_2	N_3	N_4
Days to Tasseling	50	51	51	53	43	43	45	47
Days to Silking	59	59	60	62	48	48	50	51
Days to Harvest	137	137	139	139	128	128	129	130
Plant Height (cm)	177	182	182	181	181	185	180	181
Ear Length (cm)	14.7	15.0	15.6	15.4	14.6	15.3	15.3	16.0
Unfilled Ear Length (cm)	2.4	2.2	2.3	1.8	2.3	2.2	2.2	2.1
Kernel Row Number	14.7	14.4	14.9	15.1	12.9	12.8	12.7	12.2
Kernel Number per Ear	621	598	670	791	529	599	615	567
100-Kernel Weight (g)	19.0	20.2	18.5	18.0	17.9	17.7	16.9	16.9
Shelling Rate (%)	81.5	79.8	80.5	79.7	81.2	82.0	80.5	81.8
Grain Yield (t/ha)	6.79	7.01	7.83	8.19	5.17	6.10	5.35	5.97
Harvest Index	0.53	0.50	0.51	0.49	0.54	0.56	0.53	0.55

[a] N_1 : 75 kg-N/ha, N_2 : 150 kg-N/ha, N_3 : 225 kg-N/ha, N_4 : 300 kg-N/ha,

days from emergence to harvest) was 9-10 days longer for Tainung No. 351 than for Tainan No. 11 but no fertilizer effect was observed. Plant height was almost the same for the two hybrids and again, no significant difference among N treatments existed.

Ear length was 14.6-15.4 cm and unfilled ear length was 1.8-2.4 cm for the two varieties. Tainung No. 351 had more kernel rows on the ear (average 14.8) than Tainan No. 11 (average 12.7). Consequently, the former hybrid had more kernels per ear than the latter. Nitrogen rate had a positive effects on kernel number per ear for Tainung No. 351 but the relationship was less clear for Tainan No. 11. On the contrary, heavy N fertilization tended to decreased 100-kernel weight. For example, weight of 20.2 g and 18.0 g were observed for N treatments of 150 and 300 kg/ha, respectively, for Tainung No. 351. A similar trend was also found in Tainan No. 11.

Table 1 also showed that shelling rate was comparable between the two hybrids. Tainung No. 351 was more responsive to fertilization in showing increased grain yield with increasing N rate. Grain yield was 6.79 t/ha at 75 kg-N/ha and over 8 t/ha at 300 kg-N/ha. The relationship was less significant for Tainan No. 11 as the highest yield recorded was 6.10 t/ha for plants supplied with 150 kg-N/ha. Grain yield decreased somewhat at higher N rates. Harvest indices were generally above 0.50 while higher values were observed for Tainan No. 11.

Changes in leaf area per plant during grain development as a result of N fertilization were shown in Table 2. In general, N showed positive influences on the leaf area of both hybrids. For Tainung No. 351, leaf area increased from 27.4 to 47.1 dm^2/plant

Table 2. Effects of N fertilization on the leaf area (dm^2/plant) during grain filling of maize hybrids

*Hybrid	Week after Silking	N Applied (kg/ha)			
		75	150	225	300
Tainung No. 351	2	27.4	38.9	33.3	47.1
	4	31.9	39.1	38.9	42.5
	6	33.2	38.3	44.7	39.8
	8	30.3	31.5	34.6	37.4
Tainan No. 11	2	27.8	29.6	31.9	32.0
	4	26.3	26.8	31.5	31.2
	6	24.7	25.6	26.9	29.0
	8	23.8	26.5	30.6	31.5

as N increased from 75 to 300 kg/ha, when measurement was made at 2 weeks after silking. However, exceptions were four in that 150 kg-N/ha treatment had higher leaf areas than 225 kg-N/ha treatment, at least during the first 4 weeks after silking. In most cases, the decrease of leaf area with the advance of grain development was minor. The most significant reduction was found in Tainung No. 351 supplied with 300 kg-

N/ha where a 20% decrease occurred between 2 to 8 weeks after silking. Comparison between the two hybrids indicated that although plan height was similar, Tainung No. 351 had higher leaf area values than Tainan No. 11, especially under the highest N fertilization rate. In addition, maximum leaf area was obtained at 225 kg-N/ha for Tainan No. 11, suggesting that further increase in N fertilization was uneffective for both leaf development (Table 2) and grain yield (Table 1). On the other hand, the single-cross Tainung No. 351 performed better when grown under the highest level of N-fertilizer.

The influences of N fertilization on the N concentrations in different plant parts of maize hybrids Tainung No. 351 and Tainan No. 11 were shown in Tables 3 and 4, respectively. Although there was a general tendency that higher N level could increase

Table 3. N concentrations (%, dry basis) in different plant fractions of maize hybrid Tainung No. 351 as affected by levels of N fertilization

Plant Fraction	N Level (kg/ha)	Weeks after Silking					
		0	2	4	6	8	11
Upper Leaf Blade[a]	75	2.49	2.84	2.59	2.40	1.97	1.23
	150	2.61	2.65	2.52	2.35	2.12	1.32
	225	2.60	2.97	2.63	2.24	2.08	1.50
	300	2.92	2.61	2.56	2.31	2.16	1.52
Ear Leaf Blade	75	2.64	2.54	1.96	2.30	1.77	1.29
	150	2.55	2.39	2.23	2.26	1.92	1.35
	225	2.74	2.49	2.39	2.24	2.03	1.69
	300	2.95	2.48	2.45	2.41	2.17	1.63
Stalk	75	0.56	0.56	0.46	0.43	0.35	0.30
	150	0.70	0.55	0.55	0.45	0.33	0.30
	225	0.66	0.61	0.47	0.50	0.39	0.28
	300	0.69	0.69	0.51	0.54	0.36	0.29
Husk	75	1.17	0.83	0.63	0.46	0.38	0.25
	150	1.25	0.98	0.58	0.57	0.50	0.25
	225	1.49	0.94	0.63	0.54	0.46	0.25
	300	1.26	0.82	0.70	0.67	0.56	0.24
Cob	75	2.28	1.64	1.69	1.08	0.81	0.28
	150	2.48	1.56	1.80	1.26	0.93	0.57
	225	2.91	1.74	1.90	1.12	0.94	0.55
	300	2.58	1.83	2.30	1.29	1.02	0.50
Grain	75		2.54	2.54	1.93	1.58	1.35
	150		2.52	2.31	1.91	1.66	1.48
	225		2.61	2.15	2.04	1.63	1.56
	300		2.77	2.79	2.28	1.68	1.58

[a]Leaf blades from nodes above the ear position.

Table 4. N concentrations (%, dry basis) in different plant fractions of maize hybrid Tainan No. 11 as affected by levels of N fertilization

Plant Fraction	N Level (kg/ha)	Weeks after Silking					
		0	2	4	6	8	11
Upper Leaf Blade[a]	75	2.74	2.55	2.75	2.60	2.11	1.31
	150	2.39	2.68	3.02	2.56	2.52	1.35
	225	3.30	2.91	2.74	2.48	2.37	1.57
	300	2.38	2.79	2.83	2.53	2.44	1.34
Ear Leaf Blade	75	2.83	2.64	2.42	2.20	2.01	1.25
	150	3.39	2.87	2.56	2.31	2.26	1.32
	225	3.16	2.86	2.37	2.43	2.33	1.56
	300	3.37	2.82	2.41	2.50	2.52	1.50
Stalk	75	0.77	0.62	0.62	0.52	0.35	0.29
	150	0.88	0.93	0.74	0.59	0.41	0.29
	225	0.82	0.81	0.69	0.56	0.48	0.44
	300	0.88	0.78	0.70	0.61	0.66	0.34
Husk	75	1.24	0.84	0.60	0.53	0.39	0.20
	150	1.38	0.83	0.74	0.53	0.39	0.22
	225	1.66	1.02	0.70	0.55	0.47	0.28
	300	1.48	0.81	0.77	0.65	0.65	0.23
Cob	75	2.58	1.60	1.18	1.17	0.72	0.32
	150	2.63	1.88	1.22	0.99	0.93	0.36
	225	2.94	1.56	1.21	1.05	0.92	0.28
	300	2.89	1.57	1.23	1.06	1.19	0.25
Grain	75		2.16	2.59	1.64	1.31	1.16
	150		2.17	2.82	1.72	1.57	1.35
	225		2.16	2.54	1.60	1.76	1.48
	300		2.27	2.55	1.55	1.76	1.49

[a]Leaf blades from nodes above the ear position.

N concentrations, the results were not consistent when each sampling was taken into consideration. No significant difference in leaf N concentration was found between ear leaf and upper leaf blades for Tainung No. 351. Nitrogen decreased during grain-filling for both hybrides, particularly during the last 4–5 weeks of sampling (6 to 11 weeks after silking). Leaf N decreased from 2.4–3.4 % at silking to 1.3–1.7 % just before harvest. Stalk contained less N than leaf blade. Stalk N concentrations ranged between 0.5-0.8 % at silking and were about 0.3—0.4 % at maturity.

The husks had about 1.5% of their dry weight as N at the time of silk emergence. The decrease of husk N concentration was continuous throughout grain development but the most obvious decline was found in the first 2 weeks after silking. Mature ear contained less than 0.3% N in the husks(Tables 3 and 4). Nitrogen concentration in the cob (2.5-3.0 %) was comparable to that in the leaf blade at silking. However, the decline during grain-filling was much more significant. Translocation of N out of the cob was most prominent during the last 2—3 weeks of sampling. The concentration of cob was about 0.5% for Tainung No. 351 and only 0.3% for Tainan No. 11 when plant approached maturity.

Highest grain N concentration of Tainung No. 351 hybrid was recorded when first sampling was made at 2 weeks after silking. In other words, N concentration of grain decreased continuously during grain-filling. It declined rapidly between 4 and 8 weeks after silking which was in accordance with the rapid increase of grain dry weight. Statistical analysis showed no significant difference in grain N for N rates above 150 kg/ha. Grain N concentration was lower when only 75 kg-N/ha was applied (Table 3). Similar pattern was also found in Tainan No. 11 (Table 4). The only differences were that there was an increase in grain N between 2 to 4 weeks after silking and N concentration in the mature grain of Tainan No. 11 was lower than that of Tainung No. 351.

No significant effect of N fertilization on the concentration of total nonstructural carbohydrates (TNC) was found among N treatments. However, the changing pattern of TNC concentration in the stalk was different from that of N and differences existed

Table 5. Concentrations (%, dry basis) of total nonstructural carbohydrates in the stalk and grain of maize hybrids as affected by levels of N fertilization

Hybrid	Plant Fraction	N Level (kg/ha)	Weeks after Silking					
			0	2	4	6	8	11
Tainung No. 351	Stalk[a]	75	25.1	32.4	36.3	29.2	34.0	12.8
		150	23.9	35.2	33.5	34.7	21.9	15.1
		225	24.9	26.0	29.3	32.7	31.3	13.0
		300	24.7	30.4	31.9	32.4	29.5	13.0
		Mean	24.6	31.0	32.8	32.2	29.2	13.5
	Grain	75	37.2[b]	31.7	37.4	65.8	70.6	76.0
		150	39.1	29.3	39.4	67.8	73.9	76.0
		225	38.0	21.4	54.5	67.2	71.5	73.8
		300	40.4	27.2	46.5	60.0	66.2	74.1
		Mean	38.7	27.4	44.4	65.2	70.6	75.0

Table 5. (continued)

Hybrid	Plant Fraction	N Level (kg/ha)	Weeks after Silking					
			0	2	4	6	8	11
Tainan No. 11	Stalk[a]	75	23.8	25.7	41.1	18.7	13.4	3.2
		150	22.7	27.0	44.9	25.4	20.6	2.6
		225	22.7	26.9	39.4	22.9	29.8	3.2
		300	24.3	24.4	39.1	20.9	25.8	2.7
		Mean	23.4	26.0	41.1	22.0	22.4	2.9
	Grain	75	37.6[b]	23.0	47.9	66.2	72.0	77.9
		150	37.3	24.5	45.8	67.9	73.3	79.8
		225	40.4	27.4	43.5	66.6	67.2	72.9
		300	40.3	28.8	41.5	64.4	67.3	76.3
		Mean	38.9	25.9	44.7	66.3	70.0	76.7

[a]–Including stalk internodes above and below ear node only.
[b]–Including cob for sampling at the time of silking.

between the two hybrids (Table 5). For Tainung No. 351, mean TNC concentrations in the stalk internodes just above and below the ear node across N treatments were 24.6, 31.0, 32.8, 32.2, 29.2 and 13.5% at 0, 2, 4, 6, 8 and 11 weeks after silking, respectively. There was a slight increase in the first two weeks and a marked decrease in the last two weeks of grain development. For Tainan No. 11, stalk TNC concentration increased from 23.4% to 41.1% within 4 weeks after silk emergence but dropped back to 22.0% in the next 2 weeks. Although the highest stalk TNC concentration of Tainan No. 11 (41.1%) exceeded that of Tainung No. 351 (32.8%), it was much lower in the mature plant (2.9%) than that of Tainung No. 351 (13.5%).

Increase of TNC concentration in the grains during the whole filling period was almost the same for the two hybrids. The cob contained 39% TNC when analyzed at silking time. TNC concentration of the young grains (two weeks after silking) was about 27% and the linear increase thereafter lasted for 4 weeks. The incraese levelled off afterwards and the mature grain contained 75–77% of TNC on a dry weight basis.

Discussion

According to the Corn Breeding Laboratory of Taiwan Agricultural Research Institute, Tainung No. 351 is 10–20 days longer in growth duration and 20 cm taller in plant height than No. 11 when sown in late September. This experiment failed to find any difference in plant height between the two hybrids. Experiments conducted by this laboratory in the fall crop season of 1983 showed that Tainan No. 11 could grow as tall as Tainung No. 351 in many locations of Taiwan (unpublished data). Moleba and Hart[11] also reported no difference in plant height between N rates of 150 and 300 kg/ha. Daynard and Muldoon [5] indicated that taller plants tended to anthese and silk earlier and produce more grain. Remison and Fajemisin [14] stated that N application hastened flowering of maize plants. In this aspect, the authors found that the influence of plant height on flowering and yielding characters must be restricted within variety. In addition, N application delayed rather than hastened the time of tasseling and silking (Table 1). The difference between this experiment and Remison and Fajemisin's result might be due to genotypic variation.

The interval between tasseling and silking was longer for Tainung No. 351 (9 days) than for Tainan No. 11 (4-5 days) (Table 1). One weakness of the high yielding Tainung No. 351 is the high proportion of unfilled ear length and this is suggested by many agronomists, among other reasons, as a result of the longer interval between tasseling and silking which makes the pollens unavailable to the silks. In view of the almost equal length of unfilled ear of the two hybrids and the unpublished results showing unfilled ear length was significant only when very high grain yield was recorded in Tainung No. 351, it is presumed that factors causing the unfilling of upper grains of the ear are complex. The balance between source supply and sink demand is a more reasonable explanation for such a phenomenon.

Grain yield of Tainung No. 351 was higher when more N fertilizer was applied (Table 1). The yield increase was primarily a result of increasing kernel number, as 100 -kernel weight decreased at high N level. Peaslee [12] reported that in corn hybrids, the relative effects of severe N stress were greater on kernel number than on kernel weight. Both characters declined at low N fertilization. 100-kernel weight of this experiment (ca. 20 g) was comparable to that of Badu-Apraku *et al.* [1] but was far below the values (30—40g) reported by Molebu and Hart [11] and Peaslee [12]. Although a negative correlation existed between the number and weight of kernels, yield of Tainung No. 351 should be able to be enhanced further by increasing kernel weight to some extent without a concurrent sacrifice of kernel number.

The double-cross Tainan No. 11 was less responsive to N because grain yield decreased with N levels over 150 kg/ha. Both kernel weight and kernel number restricted grain yield of this variety under high N fertilization. According to Johnson and Tanner [7] and Tollenaar and Daynard [18], final kernel number is established near the time when linear increase in grain weight begins. It is therefore important to provide the maize plants with sufficient nutrients during early grain growth to assure yield depression caused by fewer kernels would not occur.

Moll *et al.* [10] defined N use efficiency as grain production per unit of N supplied to the soil. They found that the mean N use efficiencies of 8 hybrids were 95.7 with 56 kg-N/ha and 26.5 with 224 kg-N/ha of fertilization. Results of this experiment showed that for Tainung No. 351, N use efficiencies were 90.5 and 27.3 with N rates of 75 and 300 kg/ha, respectively. Corresponding values of Tainan No. 11 were 68.9 and 19.9. In other words, the single-cross Tainung No. 351 can use N more efficiently than the double-cross hybrid Tainan No. 11. However, both hybrids showed a drastic decrease in N use efficiency as the amount of N fertilizer applied increased.

Remison and Lucas[15] reported that leaf area index (LAI) was maximum at mid-silking and the decrease afterwards was very rapid. They recorded LAI of 2.5 at 2 weeks after silking and yield of 4.0 t/ha for maize grown with 75 kg/ha of N in Nigeria. Leaf area was also low in this experiment. The highest leaf area recorded (Table 2) corresponded to LAI less than 3. However, yield of 6-8 t/ha for Tainung No. 351 was obtained. Possible reasons for the low leaf area may be that only the green portion of the leaf was measured 2 weeks after silking and the lowermost leaf blades wilted earlier due to rainfall in early growth season. Yield efficiencies, defined by Moleba and Hart[11] as grain yield per unit leaf area, were 3.06 and 2.96 g/dm^2 for Tainung No. 351 supplied with 150 and 300kg-N/ha, respectively. Corresponding values for Tainan No. 11 were 3.50 and 3.17 g/dm^2. The efficiencies were higher than the result (2.78 g/dm^2) obtained by Moleba and Hart[11] with similar growth conditions (60,000 plants/ha and 200 kg-N/ha) in Kansas, USA. However, LAI of maize crop should be increased to 4-5 in order to provide sufficient photosynthetic surface for dry matter production and hence increasing the yield[11].

Concentration of leaf N of both hybrids were near the lower sufficiency level of 2.75% proposed by Jones, Jr.[8]. The decrease in N concentrations of the leaves, stalk, husks and cob during grain development was an indication that a large amount of N was retranslocated to the developing grains. Hay *et al.*[6] estimated that about 60% of the final N in maize kernels was present in the vegetative tissues at pollination, the remaining 40% was obtained from the soil subsequently. The cob had very high N concentration (2.5-3.0 %) at the time of silk emergence (Tables 3 and 4). TNC concentration in the cob could also reach 40% on a dry weight basis at silking. These facts suggested that cob acted as an important temporary sink to store N and carbohydrates to meet the needs of subsequent development of adjacent grains.

TNC concentration in the stalk continued to increase for several weeks after silking, indicating that the stalk possessed the function of sink for TNC during this period. Although the grain-filling of Tainung No. 351 depended more on the contribution of stalk dry weight under heavy N fertilization (unpublished data), TNC concentration in the stalk did not show significant decrease until 8 weeks after silking. On the other hand, stalk TNC of Tainan No. 11 started to decline at 4 weeks after silking. Judged by the dry weight and TNC concentration data, it was proposed that Tainung No. 351 is more photosynthetically active than Tainan No. 11. Stalk of mature Tainung No. 351 plant still contained more than 13% of its dry matter as TNC whereas the value was below 3% for Tainan No. 11 (Table 5). The results showed that a certain amount of TNC in the stalk of Tainung No. 351, which had 100-kernel weight of only 20 g, was unavailable to be transported to the grains. Yield should be increased if the efficiencies of production and distribution of TNC by the plant could be increased simultaneously.

In conclusion, the results of this experiment suggested that nutritional requirements for Tainung No. 351 is high. This hybrid is more responsive to N by showing higher grain yield at higher levels of N fertilization. Grain yield per unit of N supplied to the soil was also higher for Tainung No. 351 than for Tainan No. 11. Appropriate dense planting might be a good measure under fertile soil condition to increase leaf area and photosynthetic ability. Further understanding of the interaction between N and C was important in order to increase kernel number and kernel weight simultaneously through the efficient utilization of photosynthates and hence to increase the yield of Tainung No. 351.

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氮肥用量對兩個雜交玉米品種生長與產量的影響[1]

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摘要

試驗採用單雜交玉米品種臺農351號與雙雜交品種臺南11號爲材料，於 1983 年秋作在田間栽培，密度爲每公頃58,800株，氮肥用量爲75、150、225與 300 kg/ha ；於玉米吐絲（mid-silking）期開始每隔 2 週取樣一次，測度葉面積與植株各器官氮素及非構造性碳水化合物 （TNC） 濃度變化，並調查產量性狀，目的在比較兩個玉米對氮素反應的生理性差異，以及探討臺農 351號高產的理論基礎。試驗結果發現增加氮肥用量可延遲抽穗與吐絲日期，提高臺農 351號種子產量，但臺南11號之產量却以150 kg-N/ha 處理最高；產量提高的主要原因爲一穗粒數增加，足以補償粒重降低的損失而有餘。在75與300 kg-N/ha 處理時，臺農351 號的氮利用效率（產量／施用氮量）爲90.5與27.3，較臺南11號之68.9與19.9爲高；但於150與300 kgN/ha 處理，臺南11號的產量效率（產量／單位葉面積）爲3.50與3.17g/dm²，遠較臺農351號之3.06與2.96g/dm² 爲高，各器官氮素濃度有隨施氮量增加而提高的趨勢，且於種子充實期間大幅下落。莖與穗軸在吐絲後 2 週內具有暫時貯存氮素與TNC 的功能，可供應隨後種子發育的需要。吐絲以後臺南11號莖稈內TNC 濃度較臺農351號爲高，但下降之時間較早，幅度亦大；成熟時臺農351號莖稈內仍含有13%以上的 TNC ，但臺南 11 號僅爲 3 %以下，顯示前者雖爲高產品種，但粒重未臻理想，應謀增加粒重而更提高產量；後者之供源 （source） 能力與積儲 （sink） 容量均有不足，可能並爲產量限制因子。試驗結果認爲臺農 351號玉米品種對營養要素的需求量較高，建議栽植密度宜適量提高，以增加葉面積與生產乾物質能力，對氮素與碳素間相互作用的關係亦應再予瞭解，以求在同時增加粒數與粒重的情形下達到更高產的目標。

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