

Identification of Tropical Late Yellow Maize Germplasm under Water Stress Conditions

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ABSTRACT

Drought is a limiting factor for maize production of Thailand. It damages an estimated annually 3 to 22% of the planted area, resulting in yield losses of approximately 129,000 to 858,000 metric tons. During the dry season of 2004, tropical late yellow maize (*Zea mays* L.) germplasm including 41 inbreds, 36 hybrids and 35 open pollinated varieties (OPV's) were evaluated in separate trials under water stress during flowering stage and under non water stress conditions at Nakhon Sawan Field Crops Research Centre (NSFCRC), Tak Fa, Nakhon Sawan province. Each group,treatments were arranged in randomized complete block design with three replications. The water stress condition was managed by irrigation withdrawal achieving severe drought stress during flowering stage, compared to non water stress or well watered condition irrigated weekly. The objectives were to compare some agronomic traits of tropical late yellow inbreds, hybrids and OPV's and to identify superior germplasm for further use in hybrid development programme. Significant differences ($P_{0.05}$) were found among tested inbreds, hybrids and OPV's for all traits measured. Grain yield (GY) of inbreds, hybrids and OPV's were 772, 3,837 and 2,388 kg ha⁻¹ with anthesis - silking interval (ASI) ranged from -0.3 to 10, 0 to 6.3 and 0 to 12 days, respectively. Grain yield was positively correlated with number of ears per plant (EPP), chlorophyll content (CHE) and number of seeds per row (SPR). It indicated that increase in GY under water stress was associated with increase in EPP, CHE and SPR. The ASI and LRO were negatively correlated with GY, suggesting an increase in GY was associated with a reduction in ASI and LRO. Several

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inbreds, hybrids and OPV's showed good performance under water stress condition. Four inbreds, one hybrid and two OPV's had greater grain yield (GY) and number of ears plant-1 (EPP), but shorter ASI than overall mean.

Key words : drought, maize, stress, anthesis-silking interval

Introduction

Drought stress is the most widespread abiotic constraint for maize production in the tropics, where most maize is grown under rainfed condition. In Thailand, drought was reported as a priority constraint for maize production in many agroecozones and it was almost every year (Eskasingh *et al.*, 2004). According to reports issued by the Office of Agricultural Economics, the estimated value of damage loss was 10 to 80 million US dollars per year. Maize drought area affected, varied from 49,000 to 393,000 hectares or from 3 to 22% of the total growing areas. Maize is usually affected to stress at any stages, (Grant *et al.*, 1989). Decrease in water potential availability to permanent wilt-

ing point during pre-flowering, flowering and post-flowering stages reduced grain yield by 25, 50 and 21%, respectively (Denmead and Shaw, 1960). Hence, NSFCRC's Maize Breeding Programme has collaborated with CIMMYT in developing a group of inbreds, hybrids and open-pollinated varieties by using some breeding procedures. Different sources of tropical late yellow inbreds, hybrids and open-pollinated varieties were evaluated in separate trials under water stress and non water stress conditions at NSFCRC, Nakhon Sawan province, Thailand during the rain-free dry season of 2003/2004. The objectives of this study was to compare some agronomic traits of promising tropical late yellow inbreds, hybrids and open-pollinated varieties and to detect the association of grain yield with some secondary traits under water stress condition.

Material and Methods

The groups of tropical late yellow maize germplasm from NSFCRC, CIMMYT, Kasetsart University and private seed companies were involved in this study. Forty one inbreds, 36 hybrids and 35 open-

pollinated varieties were arranged in three separate trials of RCB with three replications. Individual plots consisted of two rows, 5.0 m long with the row spacing of 0.75 m and 0.20 m between plants. Plant densities were approximately 66,000 plant/ha. The water stress condition was managed by irrigation withdrawal achieving severe drought stress during flowering (irrigation was stopped from the 9th leaf stage till two weeks after mid flowering) compared to well watered under normal weekly irrigation approximately 30 mm each week. Soil at testing sites had pH 7.3, organic matter of 2.87%, available P (Bray II) of 61 ppm and exchangeable K of 166 ppm. Fifty kg/ha of N and 62.5 kg/ha of P_2O_5 (312 kg of 16-20-0) were applied as basal fertilizer prior to planting. An additional 100 kg/ha of N (476 kg of ammonium sulphate) was applied as top - dressing at 30 days after planting. A mixture of herbicides namely atrazine and alachlor, were applied after planting to suppress weed.

Days from planting to anthesis (AD) and silking (SD) were calculated from the date on which 50% of the plants had begun

shedding pollen or had silks emerged from the husk. Anthesis-silking interval (ASI) was obtained by subtracting AD from SD. Chlorophyll content (CHE) was measured from the ear leaf at the mid flowering stage using a SPAD meter. Leaf rolling score (LRO) was measured for plot on a scale from 1 to 5 (1=unrolled and 5=leaf is rolled like on onion leaf). Number of ears per plant (EPP) was counted total ears with at least one fully developed kernel and divided by the number of harvested plants, in each plot. Number of seeds per row (SPR) was determined by dividing a total number of seeds by the total number of rows. Grain yield (GY), adjusted to 15.0% moisture content (MC) was estimated from shelled grain. Seed weight (TSW) was obtained from 1,000 kernels weight. Drought index (DI) was the ratio of its yield under stress to non stress, relative to the ratio of the grand mean yield of all genotypes under stress to non stress condition. Analyses of variance were performed using MSTAT procedure for detecting differences.

Results and discussion

Analyses of variance among inbreds, hybrids and OPV's indicated significant difference due to genotypes for all traits (Table 1). Grain yield of inbreds, hybrids and OPV's ranged from 17 to 2,615, 1,597 to 5,513 and 1,197 to 4,613 kg/ha and ASI ranged from -0.3 to 10 days, from 0 to 6.3 days and from 0 to 12 days respectively. Several inbreds showed leaf firing and scored

5 for LRO due to high temperature (38 °C) and low relative humidity at 57%. Mean CHE were 39.9, 46.1 and 44.9 µg/cm for inbred, hybrid and OPV's respectively. EPP ranged from 0.1 to 1.3 ear/plant for inbred; from 0.4 to 0.7 ears/plant for hybrid and from 0.3 to 0.9 ears/plant for OPV's. Seed per row of inbred, hybrid and OPV's were 14, 30 and 27 seeds/row while TSW were 182, 231 and 266 gm respectively.

Table 1. Minimum, maximum of mean grain yield and some agronomic traits of maize under water stress condition at Tak Fa, in dry season 2004

Traits	Inbred			Hybrid			OPV		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
GY (kg/ha)	17	2615	772*	1597	5513	3837*	1197	4613	2388*
ASI (day)	0	10.0	3.9*	0	6	2*	0	12.0	6.0*
LRO (1-5)	1.0	5.0	3.5*	1.0	4.0	2.6*	1.6	4.0	2.9*
CHE (µgcm)	20.7	54.7	39.9*	35.0	54.8	46.1*	37.0	51.9	44.9*
EPP (ear)	0.1	1.3	0.5*	0.4	0.7	0.6*	0.3	0.9	0.6*
SPR (kernel)	1	23	14*	24	36	30*	20	31	27*
TSW (g)	48	279	182*	148	271	231*	232	308	266*

GY = grain yield, ASI = anthesis-silking interval, LRO = leaf roding score,

CHE = chlorophyll content, EPP = ear per plant, SPR = seed per row, TSW = seed weight

*, ** significant at the 5 and 1% levels respectively

Grain yield was positively correlated with EPP, CHE, and SPR. It indicated that increase in GY under water stress was associated with increase in EPP, CHE, and SPR (Table 2). The TSW was also positively correlated with GY for inbreds and hybrids. But it was not appeared in OPV's, indicating that SPR was more important than TSW. ASI

and LRO were negatively correlated with GY, suggesting an increase in GY under water stress was associated with a reduction in ASI and less LRO. The results confirm previous report which ASI and EPP were the important secondary traits for drought tolerance (Edmeades *et al.*,1995).

Table 2. Phenotypic correlation coefficient (r) between grain yield and secondary traits under water stress condition at Tak Fa, in dry season, 2004

Traits	Phenotypic correlation coefficient (r)		
	Inbred	Hybrid	OPV
GY	1	1	1
ASI	-0.57**	-0.33*	-0.73**
LRO	-0.80**	-0.57**	-0.75**
CHE	0.69**	0.40*	0.33*
EPP	0.90**	0.68**	0.81**
SPR	0.76**	0.42**	0.62**
TSW	0.49**	0.37*	0.11

GY = grain yield, ASI = anthesis-silking interval, LRO = leaf roding score,

CHE = chlorophyll content, EPP = ear per plant, SPR = seed per row, TSW = seed weight

*, ** significant at the 5 and 1% levels respectively

Mean GY under water stress of inbreds, hybrids and OPV's were 772, 3,837 and 2,388 kg/ha compared to 2,955, 8,141

and 6,290 kg/ha under non stress condition with yield reduction of 73.8, 52.8 and 62.0 %, respectively (Table 3). Under water

stress condition, several inbreds, hybrids and OPV's showed good performance. Among the top ten inbreds, four of them, are Nei 452026, Nei 452004, Nei 452003 and Nei 452022, gave greater yields than overall mean (722 kg/ha) and their DI were 2.16, 1.46, 2.48 and 1.88, respectively. Nei 432001 and Nei 452008 were least ASI (-0.3 days) compared to 3.9 days of overall mean (Table 4). For EPP, Nei 452026, Nei 452003 and Nei 432001 had 1.3, 1.0 and 0.9 ears/plant, respectively which were significantly different from the overall mean (0.5 ears/plant). The two promising inbreds, Nei 452008 and Nei 452026 have been evaluated for combining ability in testcrosses and used as testers for hybrid development programme. The GY of top ten hybrids ranged from 4,669 to 5,513 kg ha⁻¹ compared to the overall mean of 3,878 kg/ha. One of them yielded significantly different from the overall mean. NSX 022018 had the highest yield, its DI was 1.38, ASI was 0.3 day and EPP was 0.7 ears/ plant, respectively. The ASI of the top ten hybrids ranged from 0 to 2.3 days compared to the overall mean of 2.6 days and EPP ranged from 0.6 to 0.7 ears/plant

compared to the overall mean of 0.6 ears/plant under water stress. For the top ten OPV's, the GY ranged from 2737 to 4613 kg/ha and ASI ranged from 0 to 6.2 days. Two of them, NP 99202 and KS K 97F7 yielded greater than the overall mean (2,388 kg/ha), their DI were 1.53 and 1.48, respectively. NP 99202 also gave more ears per plant (0.9 ear/plant) with ASI of 2.7 days. The DPT-YEL C9, a drought tolerant population from CIMMYT yielded 2842 kg/ha, and it had the least ASI and more number of ears per plant (0.8 ears/plant). The ASI of tested inbreds and hybrids were shorter than OPV's, because they were developed at the testing site with temperature of 37-39° C, so they could adapt to high temperature environment in dry season.

Conclusion

Grain Yield under water stress condition during flowering stage of inbreds, hybrids and OPV's were 772, 3,837 and 2,388 kg/ha with yield reduction of 73.8, 52.8 and 62.0 %, respectively compared to non water stress condition. Their ASI were 3.9, 2.6 and 6.2 days, and EPP were 0.5, 0.6 and

Table 3. Mean grain yield and DI of top ten inbreds, hybrids and OPV's under water stress compare to non water stress at Tak Fa, in dry season

Inbred	GY (kg/ha)		DI	Hybrid	GY (kg/ha)		DI	OPV's	GY (kg/ha)		DI
	Stress	Non-stress			Stress	Non-stress			Stress	Non-stress	
Nei 452026	2,615	4,628	2.16	NSX 022018	5,513	8,465	1.38	NP 99202	4,613	7,938	1.53
Nei 452004	1,614	4,238	1.46	NSX 022019	5,139	8,535	1.28	KSK 97F7	3,663	6,540	1.48
Nei 452003	1,590	2,435	2.48	NSX 022026	5,047	8,638	1.28	NS1LN	3,303	6,751	1.29
Nei 452022	1,565	3,190	1.88	30 D 55	4,815	9,947	1.03	LY-AL-TO-C2	3,287	6,245	1.39
Nei 412001	1,433	2,985	1.84	PAC 190017	4,785	8,383	1.21	Pop. 28(RRS)C3	3,180	6,815	1.23
Nei 432001	1,386	4,368	1.21	KSX 4452	4,783	9,444	1.07	NP 99203	2,977	7,277	1.08
Nei 452008	1,320	3,470	1.46	Big 919	4,740	8,845	1.14	KSK 97F4MC1	2,928	6,436	1.20
Nei 452006	1,289	4,102	1.20	NK 40	4,700	9,424	1.06	DTP-YEL C9	2,842	7,641	0.98
Nei 412015	1,101	3,539	1.19	NSX 022031	4,696	8,206	1.21	NP 99201	2,842	7,009	1.07
Nei 452009	1,085	2,709	1.53	NSX 022027	4,669	7,792	1.27	SW 1 (RRS)C3	2,737	6,106	1.18
Overall mean	772	2,955	1.00	Overall mean	3,837	8,141	1.00	Overall mean	2,388	6,290	1.00
LSD 0.05	692	1,058	-	LSD 0.05	1,518	1,135	-	LSD 0.05	1,102	1,291	-

GY = grain yield, DI = drought index, OPV's = open pollinateg variety

Table 4. Mean LRO, ASI and EPP of top ten inbreds, hybrids and OPV's under water stress at Tak Fa, in dry season, 2004.

Inbred	ASI (day)	LRO (1-5)	EPP (ear)	Hybrid	ASI (day)	LRO (1-5)	EPP (ear)	OPV's	ASI (day)	LRO (1-5)	EPP (ear)
Nei 452026	2.0	1.3	1.3	NSX 022018	0.3	2.0	0.7	NP 99202	2.7	2.3	0.9
Nei 452004	0.7	2.3	0.7	NSX 022019	0.3	2.3	0.7	KSK97F7	2.0	1.7	0.7
Nei 452003	2.3	1.3	1.0	NSX 022026	1.3	2.0	0.7	NS 1LN	3.3	2.3	0.8
Nei 452022	3.7	1.7	0.7	30 D 55	0.3	2.0	0.6	LY-AL-TO-C2	3.7	2.0	0.8
Nei 412001	2.0	1.0	0.8	PAC 190017	2.3	2.7	0.7	Pop.28(RRS)C3	6.0	2.3	0.7
Nei 432001	-0.3	2.3	0.9	KSX 4452	1.7	2.7	0.6	NP 99203	3.0	3.0	0.9
Nei 452008	-0.3	2.0	0.5	Big 919	0.7	2.7	0.6	KSK 97F4MC1	5.3	2.7	0.7
Nei 452006	1.3	2.7	0.7	NK 40	0.7	2.3	0.7	DTP-YEL C9	0.0	2.7	0.8
Nei 412015	0.7	3.3	0.8	NSX 022031	0.0	1.0	0.6	NP 99201	5.3	2.7	0.7
Nei 452009	2.7	2.7	0.7	NSX 022027	0.0	2.7	0.7	SW 1(RRS)C3	5.3	2.7	0.7
Overall mean	3.9	3.5	0.5	Overall mean	2.6	2.6	0.6	Overall mean	6.0	3.0	0.6
LSD ₀₀₅	4.3	1.2	0.3	LSD ₀₀₅	2.7	1.2	0.1	LSD ₀₀₅	4.3	1.1	0.2

ASI = anthesis-silking interval

LRO, leaf rolling score : 1 = unrolled and 5 = leafrolled like unince leag

EPP = ear per plant

0.6 ear/ plant, respectively. Four inbreds, one hybrid and two OPV's had higher yields and number of ears plant⁻¹ than the overall mean. Positive correlations were found between GY and EPP, between CHE and SPR while negative correlations were found between GY and ASI and also between GY and LRO.

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