Agronomic Responses and Nitrogen Use Efficiency of Local and Introduced Corn (*Zea Mays* L.) Genotypes to Different Levels and Sources of Nitrogen in Two Corn Growing Areas in Timor-Leste

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The experiment was conducted during dry season from May to September 2009 in two maize growing areas in Timor-Leste (East Timor) with different climatic and soil characteristics to evaluate the agronomic response, productivity and nitrogen (N) use efficiency of five maize genotypes (local variety, Sele, Suwan 5, IPB var 4 and USM var 10) under eight N fertilizer treatments: [control (without fertilizer); P and K without N; 30 kg N per ha (100% organic); 30 kg N per ha (50% organic + 50% inorganic); 30 kg N per ha (100% inorganic); 60 kg N per ha (100 organic); 60 kg N per ha (50% organic + 50% inorganic); and 60 kg N per ha (100% inorganic)].

The experiment was arranged in split-split plot with five varieties and three replications. The result indicated that growth and yield of maize varieties were better in Lospalos than in Baucau. The application of N fertilizer at 30-60 kg N per ha did not improve the growth and yield of maize plants due to water limitation in both sites. The N recovery efficiency of maize plants were not also affected by N fertilizer application, although Sele and Suwan 5 had relatively higher N recovery efficiency. On the other hand, the internal efficiency of N increased with increasing fertilizer application (0-60 kg N per ha) in 100 % organic fertilizer application. This was also observed on local variety and Sele in Baucau (severe water limitation), and on Suwan 5 in Lospalos (unstressed during early vegetative stage).

Generally, Suwan 5 and the local variety had better overall performance in Lospalos and in Baucau, respectively. Further evaluation is needed using varying sources of N fertilizer at 0-30 kg N per ha for possible improvement of yield and improving nitrogen use efficiency (NUE) of these genotypes during wet season where water is not a limiting factor in Timor-Leste.

Introduction

Maize and rice are the main production of staple food crops and dominate the agricultural systems in Timor-Leste. Many factors affect grains yield of maize such as variety, level-source of nitrogen fertilization and local of planting due to different soil and climatic characteristics. Result of maize grain yield depends on the adaptability of the introduced varieties compared with the local variety that is higher adaptated to local conditions. However, to the trend towards higher level of N fertilizer rate and sources, introduced high yield variety respond more favourably.

Results of maize yield depend on characteristic of the soil and climatic per location, therefore study on the effect of different locations is necessary to compare soil and climatic condition.

Maize yield is greatly affected by fertilizer applications, and N is one of the essential nutrients that often limit the crop yield. Gomez (1984) reported that corn yield is improved by increasing level of N fertilizer application.

One of the alternatives to increase corn production on per unit area basis is the cultivation and introduction of high yielding genotypes that are adapted to Timor-Leste conditions. In addition, the response of such genotypes to fertilizer application, particularly nitrogen (N) and combination of organic and inorganic fertilizer should be considered into account. Hence, a study to evaluate the performance of selected corn genotypes grown under varying N fertilizer levels and sources was conducted in two major corn production areas in Timor-Leste.

The purpose of the present investigation was to study the effect of eight nitrogen fertilizer rates and sources in five varieties of maize in two different growing maize areas of Timor-Leste.

Material and Method

The experiment was conducted from May to September 2009 in two major corn growing areas in Timor-Leste, namely: Lospalos, Lautem District and Baucau, Baucau District.

Three Maize genotypes (local variety, Sele and Suwan five), that were initially evaluated to have high yield potential under Timor-Leste conditions, and two maize genotypes (IPB Var 4 and USM var 10) from the Philippines were grown under eight fertilizer treatments (0 F, 0 N + PK, 30 kg N (100% OF), 30 kg N (50% OF + 50% IF), 30 kg N (100% IF), 60 kg N (100% OF), 60 kg N (50% OF + 50% IF), 60 kg N (100% IF) .

The experiment was laid out in split-split plot in randomized complete block design with three replications. The two locations served as the main plot, eight fertilizer treatments served as the subplots, while the five corn genotypes were the sub-subplots. The experiment occupied a total area of 3,877.5 m^2, with 120 experimental plots per location, the plot size was 5 x 4.5m.

Table 1 – Chemical characteristics of the soil in the experimental sites at Lospalos and Baucau, Timor-Leste

SOIL PARAMETER	LOSPALOS	BAUCAU	METHOD OF ANALYSIS
pH	6.68	6.67	Potentiometric method
Organic matter (%)	3.27	3.67	Walkey – Black method
Total N (%)	0.24	0.26	Kjeldahl method
Available P (ppm)	32.64	101.58	Bray 1 method
Available K (ppm)	131.87	147.95	Bray 1 method

Analyses were done at the Soil Laboratory, Faculty of Agriculture, University Udayana, Bali, Indonesia.

Statistical Analysis

The analysis of variance was computed using the Statistical Analysis System (SAS version 6.12). Treatment mean comparison was done using Least Significant Difference (LSD).

Results and Discussion

Table 2 – Ear length of five corn genotypes grown in Lospalos and Baucau, Timor-Leste, 2009, Dry Season (DS).

GENOTYPE	EAR LENGTH (cm)		
	Lospalos	Baucau	Mean
Local	13.84	12.57	13.21 b
Sele	14.44	13.1	13.77 ab
Suwan 5	14.92	13.12	14.02 a
IPB Var 4	12.78	11.98	12.38 c
USM Var 10	12.72	12.04	12.38 c
Mean	13.74 a	12.56 b	

Means followed by a common letter in a column (variety mean) and in row (location mean) are not significantly different at 5% level of significance by Least Significant Difference (LSD).

Ear length was not significantly affected by the fertilizer treatment, the differences could be assumed to be genotypic in nature. This further strengthens the trends in agronomic and physiological

parameters that were not affected by fertilizer treatment. Hence, it can be assumed that there is sufficient nutrient in the soil to support plant growth without applying fertilizer. The soil analysis conducted before planting showed that there was medium soil organic matter (SOM) level in Baucau (3.27%) and in Lospalos (3.67%). Therefore, even without applying N fertilizer, the soil SOM was sufficient to supply the nutrient needs of the maize plants.

Table 3 – Ear diameter of five corn genotypes grown in Lospalos and Baucau, Timor-Leste, 2009, Dry Season (DS).

GENOTYPE	EAR DIAMETER (cm)		
	Lospalos	**Baucau**	**Mean**
Local	4.24 a	3.78 c	4.01 C
Sele	4.32 a	3.87 bc	4.10 BC
Suwan 5	4.33 a	3.84 c	4.09 BC
IPB var 4	4.28 a	4.02 b	4.15 BC
USM var 10	4.31 a	4.22 a	4.27 A
Mean	4.30A	3.95B	

Means followed by a common letter, in a column (variety mean), and in a row (location mean) are not significantly different at 5% level of significance by LSD.

Between locations, significantly larger ear diameter was obtained in Lospalos (4.30 cm) compared with Baucau (3.95 cm). Bigger ear diameter was obtained from USM Var 10 (4.27 cm), while the smallest was in local variety (4.01 cm)

Table 4 – Number of kernels per ear in five corn genotypes grown in Lospalos and Baucau, Timor-Leste, 2009, Dry Season (DS).

GENOTYPE	NUMBER OF KERNEL PER EAR		
	Lospalos	**Baucau**	**Mean**
Local	356.1	231.2	293.7
Sele	366.1	244.5	305.3
Suwan 5	378.2	239.6	308.9
IPB Var 4	339.9	248.5	294.2
USM Var 10	344.9	241.9	293.1
Mean	356.9a	241.1b	

Means followed by a common letter in a row (location mean) are not significantly different at 5% level of significance by LSD.

The higher number of kernels per ear in Lospalos, compared with Baucau, could be attributed to the relatively higher rainfall in Lospalos, while there was none at all in Baucau. Although irrigation was applied in both locations, maize plants grown in Baucau had experienced mild stress at different growth stage, considering the amount of applied in every irrigation schedule (6 x during the whole growth period).

Final kernel number is normally established at about 2-3 weeks after pollination. Any stress imposed during this period greatly affects kernel set. Hanway (1963) demonstrated that a limited partitioning of dry matter to reproductive tissues during the critical period (bracketing silking) results in low numbers of kernels set. Furthermore, ovules remain undeveloped resulting in many kernels being small and lighter in weight.

Table 5 – 1000 grain weight in five corn genotypes grown in Lospalos and Baucau, Timor-Leste, 2009, Dry Season (DS).

GENOTYPE	1000 GRAIN WEIGHT (g)		
	Lospalos	**Baucau**	**Mean**
Local	243.2 ab	241.8 ab	242.5 A
Sele	232.9 bc	221.6 cd	227.2 B
Suwan 5	241.8 ab	212.1 d	226.9 B
IPB var 4	246.3 a	215.7 d	231.0 B
USM var 10	237.9 ab	220.2 cd	229.1 B
Mean	240.4 A	222.3 B	

Means followed by a common letter in the location x genotype interaction in a column (variety mean) and in row (location mean) are not significantly different at 5% level of significance by LSD.

Among the genotypes, the local variety had the heaviest grains (242.5 g per 1000 grains) compared with the other genotypes. The higher 1000-grain weight obtained in Lospalos could be due to favourable climatic conditions (precipitation) during the grain filling stage. This supports the findings of Haloi and co-workers (1986), wherein water stress was claimed to cause failure of kernel development, reducing the number, size and weight of kernels.

Table 6 – Grain yield of five corn genotypes grown in Lospalos and Baucau, Timor-Leste, 2009, Dry Season (DS).

	GRAIN YIELD (t per ha)		
GENOTYPE	**Lospalos**	**Baucau**	**Mean**
Local	4.63	2.99	3.81
Sele	4.58	2.89	3.74
Suwan 5	4.95	2.73	3.84
IPB var 4	4.48	2.86	3.67
USM var 10	4.40	2.85	3.63
Mean	4.61a	2.86b	

Means followed by a common letter in a row (location mean) are not significantly different at 5% level of significance by LSD.

Grain yield was not affected by genotypes, although the highest yielding genotype (Suwan 5) under Lospalos condition had higher yield than the other genotypes by 0.32-0.55 t per ha. Under the low yielding environment of Baucau, the test corn genotypes did not differ, with a yield range of 0.10-0.26 t per ha, but relatively higher yield was obtained in local variety.

The higher grain yields in Lospalos could be attributed to better agronomic responses such as: day of silking, taller plants, more leaves per plant, more dry matter production (but insignificantly different HI), high growth rate and better development of yield contributing components (number of kernel per ear, grain weight). The better performance of the maize genotypes in Lospalos than Baucau could be attributed to better growing condition in the region, particularly, since plants were not exposed to severe water deficiency during the growing period. Fertilizer treatment effect was not observed in both sites, and it seems that the major elements needed for maize growth are not limiting.

General Discussion

The two locations where the experiment was conducted are characterized by adequate endogenous nutrient supply (OM, N, P and K). Solar radiation is adequate and temperatures are within the optimum corn growing range. However, rainfall is limiting, Lospalos have a rainfall of 605.7 mm, wherein 91% of the precipitation occurred in May (early vegetative stage of maize plant) and remaining 9% (56 mm) occurred in June to September or the remaining 40% of the growing period. A more severe case was experienced in Baucau, wherein no rainfall occurred from planting to harvest. The above situation prompted the researcher to irrigate the test plants (not usually done by the farmers) before planting, 15 DAP, 30 DAP, 45 DAP, 60 and 75 DAP to at least maintain growth of the maize plants but not irrigated (5.1 mm per irrigation schedule) at the optimum level.

The 551 mm rainfall during the early growth stage of maize plants in Lospalos was reflected on the generally better performance of maize genotypes in the area compared with Baucau. This was reflected on the better agronomic (day of silking, plant height, number of leaves, straw dry matter and total dry matter), physiological (leaf area index and crop growth rate), and yield components (ear length, ear diameter, number of kernels per ear and 1000-grain weight) in Lospalos. These were reflected on the higher mean grain yields obtained in Lospalos (4.61 t per ha) than in Baucau (2.86 t per ha).

The effect of N fertilizer treatments were not significant in all parameters measured, except the nutrient use efficiency. Although some interaction effects of location x genotype, and location x genotype x fertilizer treatment were observed. Most of the significant variations were attributed mainly to the genotype. Thus, the application of fertilizer did not improve the yield or yield-determining parameters in general. This was observed consistently, even when fertilizer N was applied in the form of 100% OF, 100% IF or their 50:50 combination.

For the nutrient use efficiency parameters, the trends of N uptake is opposite of the usual trend, i.e., N uptake increased with increasing amount of N fertilizer applications, with the exception to the 100% OF application at 30 kg N per ha a generally decreasing trend in N uptake with increasing N fertilizer (0-60 kg N per ha) was obtained regardless of fertilizer source (100% OF, 100% IF or 50% OF + 50% IF) in Lospalos while remained constant in Baucau. With the available information, the major limiting factor for both sites is water (rainfall) which is severe in Baucau. Insufficient water could be the reason why maize plants did not respond to added N fertilizer in both sites.

Genotypic differences were observed in some parameters in both locations, particularly on some yield components such as ear length, ear diameter and 1000-grain weight, but were not on grain yield. In spite of these genotypic differences, Suwan 5 appeared have higher yield than the other genotypes in Lospalos, while the local variety is the best in Baucau. Due to this limitation, N recovery efficiency decreased with increasing fertilizer N level. Nitrogen recovery efficiency is generally higher in Lospalos than in Baucau. The internal efficiency of N appears to be improved by use of 100% OF, and this needs further evaluation.

The present study showed that, the local variety and Suwan 5 should be further evaluated at 0-30 kg N per ha N fertilizer, specifically to evaluate their yield performance under better growing condition (availability of irrigation water) and during wet season (November-February) in Timor-Leste.

Bibliography

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