Agronomic performance of landrace and certified seeds of maize in West Timor, Indonesia

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Abstract

Although landrace maize in West Timor has lower yield than open pollinated maize varieties it has agronomic characteristics which can be explored to increase yield. Maize is a staple food and the main crop in subsistence dry-land farming systems in West Timor, Indonesia. Whilst annual rainfall averages between 600 and 2000 mm, maize yields in the province average a little over 2 t/ha whilst research indicates that yields >4 t/ha are achievable with improved varieties, agronomy and nutrition. An issue that contributes to poor yield is the variable quality of seed used for sowing. Three landrace populations (local A, B and C) and two open pollinated varieties (Piet Kuning and Lamuru) were grown in the villages of Benlutu and Mnelalete in the province of East Nusa Tenggara (ENT), Indonesia. Trials employed a split plot design with three replications. This study demonstrated wider variability of agronomic performance of landrace maize with regard to seedling emergence, plant and ear height, and yield than certified improved open pollinated varieties. These results flag issues of seedling viability and genetic variability within landrace populations which will be investigated in future research designed to improve crop yields and the food security of the subsistence farming community.

Key words

food security, grain storage, maize, seed viability and yield.

Introduction

Maize is an important commodity in Indonesia and as a source of carbohydrate is second only to rice. Domestic demand for maize in Indonesia is increasing every year, leading to the importation of 1.4 million tonnes in 2006 (AFSIS 2009). The five largest maize producing provinces in Indonesia are East Java, Lampung, North Sulawesi, South Sulawesi and East Nusa Tenggara (ENT) (Rachman 2003). Farmers in ENT province produce and consume maize as a staple food from an area of about 80,000 ha (Saenong & Pabage 2007). Food shortages frequently occur in ENT due to low yields of maize and other major crops as a result of unpredictable and fluctuating rainfall. Whilst the average maize yield in ENT has increased from 2.3 t/ha in 2003 to 2.5 t/ha in 2008, yields are still lower than the national average of 3.7 t/ha and much lower than the potential yield of the widely used open pollinated variety Lamuru (7.6 t/ha) (Statistik Pertanian Indonesia 2010; BALITSEREAL 2010).

An issue that contributes to the poor yield in ENT is the quality of seed used for sowing with many farmers growing traditional landrace maize and retaining seed from one season to the next using a range of traditional grain storage practices (Swastika et al. 2004). Often the crops grown from this seed are variable in stature, are asynchronous in flowering time and highly variable in yield. Many people argue that West Timor landrace maize has low yield potential and should be replaced by the more advanced open pollinated and hybrid varieties. This view does not take into account the positive characteristics of the landrace maize with farmers considering them well adapted to the local environment (Ndaparoka 2009), preferred local consumers (Zeven 1999) and less susceptible to maize weevil (Williams & Guteres 2006). Furthermore, Ceniceros et al. (2003) argued that the biggest challenges to increased maize productivity in East Timor were identifying varieties best suited to the specific climatic and soil condition, improving landrace germplasm, and reducing post harvest pests. Piggin et al. (2004) however, working in East Timor, found that introduced maize varieties with the potential for higher yields have been well accepted by local farmers with an adoption rate of around 78%. Those who had not adopted indicated that the superior ability of landrace maize to protect against weevil attack was the main reason for their continuing use of the landrace maize (*Seeds of Life, Annual Research Report* 2006; Williams et al. 2008). Because of the poor knowledge of the agronomic and physical characters of West Timor's landrace maize, research is being carried out to determine the specific characteristics of landrace maize and production systems, with the aim of determining the best approach for improving maize production and yield in West Timor.

Method

Five varieties, three West Timor landrace maize populations collected from farmers (a sample of 1 kg from each of three farmers in each village) and two improved open pollinated maize varieties (Piet Kuning and Lamuru) were sown in two experiments in Benlutu village (550 m asl) and Mnelalete village (750 m asl) in ENT province, Indonesia. The landrace maize seed had been stored from the previous season (eight months stored) using traditional farmers' storage methods, while certified seed of Piet Kuning and Lamuru was bought from the local government seed production company (four months stored). A split plot experimental design (three replications) was used with the main plot being level of nitrogen application (0 kg urea and 200 kg urea/ha (92 kg N/ha)) and the sub plots being maize variety (Local A, Local B, Local C, Piet Kuning and Lamuru). Each experimental plot consisted of three rows 80 cm apart and 10 m long (24 m^2). Seeds were hand planted every 40 cm within the row with 2 seeds planted at each point. Planting was done on the 10th January 2010 in Benlutu and the 22nd December 2009 in Mnelalete, with nitrogen applied at two and four weeks after planting (half each time). Hand weeding was used to control weeds. In Benlutu 1,085 mm of rain was recorded over 78 days during a growing season of 110 days. In Mnelalete 791 mm fell over 51 days (Local meteorology station's primary data). Data were collected on number of emerged seedlings seven days after planting, plant height and ear height at seven days before harvesting and length of cob, 100 grain weight and grain and stover (leaves and stalks) yield at harvesting. Data was analysed using SPSS version 18 (Norusis 2008).

Results and discussion

Mean grain yield in Benlutu and Mnelalete, (Tables 1) showed no significant difference as a result of nitrogen application nor significant interaction between nitrogen and variety ($p > 0.05$). There was, however, a significant yield difference between the five entries ($p < 0.05$) with Lamuru achieving the highest yield at both Benlutu (3.9 t/ha) and Mnelalete (2.4 t/ha). Piet Kuning was not significantly different from the three maize landraces at either site.

The maize yield of all varieties at Mnelalete were much lower than at Benlutu due to low rainfall during the flowering and grain filling periods (mid February to mid April 2010 with 29 rain days and a total of 352 mm rainfall). In contrast there was relatively consistent rain throughout the period at Benlutu from March to April 2010 (42 rain days with a total of 572 mm rainfall). However all landrace populations at Benlutu and local A and C at Mnelalete had significantly higher yield stover compared to the two varieties.

Table 1. Variety x grain yield (t/ha) for maize trials at Benlutu and Mnelalete, West Timor (2009/10).

Variety	Benlutu		Mnelalete	
	Mean grain yield (t/ha)	Mean stover yield (t/ha)	Mean grain yield (t/ha)	Mean stover yield (t/ha)
Local A	2.7 (b)	10.5 (b)	1.9 (b)	5.8 (b)
Local B	3.1 (b)	10.7 (c)	1.4 (b)	5.2 (a)

Local C	3.0 (b)	9.2 (b)	1.1 (b)	5.9 (b)
Piet Kuning	3.0 (b)	6.8 (a)	1.1 (b)	4.8 (a)
Lamuru	3.9 (a)	7.6 (a)	2.4 (a)	4.7 (a)
	CV a = 14; CV b = 8 *	CV a = 16; CV b = 9	CV a = 17; CV b = 13	CV a = 12; CV b = 10

Notes: Any value in each parameter followed by the same letter means insignificant difference at $p < 0.05$

* CV a stands for coefficient of variation of fertiliser treatment; CV b stands for coefficient of variation of variety treatment

The agronomic characteristics of the five maize types at both sites are shown in Tables 2 and 3. Seedling emergence of the two open pollinated varieties in Table 2 was significantly higher than the three landrace maize populations at the two sites. It can be surmised that the results are a response to the length of time and the way that the seed was stored between seasons. Landrace maize seed was stored above the kitchen cooking fire for eight months while the open pollinated varieties were stored for just four months under temperature and humidity controlled conditions (Delouche 2005).

Whilst nitrogen rate did not significantly affect yield at either site there was a significant difference in plant height, ear height and weight of 100 seeds. Plant and ear height of landrace maize (Table 2 and 3) were significantly higher than Lamuru and Piet Kuning (p: 0.05). Compared to Lamuru, the plant and ear height of Piet Kuning variety was not significantly different (p: 0.05).

Table 2. Comparison of maize agronomic characteristics (emergence and plant height) at Benlutu and Mnelalete (2009/10 season).

Maize	Seedling emergence (%)		Plant height (cm) x N rate (kg/ha)					
	Benlutu	Mnelalete	Benlutu			Mnelalete		
			0 N	90 N	Mean	0 N	90 N	Mean
Local A	64 c	63 c	295	297	295 b	194	209	202 b
Local B	66 b	66 b	305	311	308 b	172	200	186 b
Local C	70 b	71 b	304	306	305 b	207	212	210 c
Piet Kuning	77 a	77 a	244	233	239 a	159	173	166 a
Lamuru	81a	82 a	226	233	229 a	156	162	159 a

Mean			274.8	276	178	191
CV	6.4	6.5	CV a = 9.2; b = 5.0 *		CV a = 18.0; b = 6.8	

Notes: Any value in each parameter followed by the same letter means insignificant difference at $p < 0.05$
* CV a stands for coefficient of variation of fertiliser treatment; CV b stands for coefficient of variation of variety treatment

Table 3: Comparison of maize agronomic characteristics (ear height and 100 grain weight) at Benlutu and Mnelalete (2009/10 season).

Maize	Ear height (cm) x N rate (kg/ha Urea)						100 grain weight (g) x N rate (kg/ha)					
	Benlutu			Mnelalete			Benlutu			Mnelalete		
	0 N	90 N	Mean	0 N	90 N	Mean	0 N	90 N	Mean	0 N	90 N	Mean
Local A	152	161	160c	91	102	96b	28.9	33.7	31b	25	29	27a
Local B	154	155	155c	84	90	87b	28.3	34.2	31b	27	28	27a
Local C	150	151	150c	99	102	100b	28.4	34.3	32b	28	30	29a
Piet Kuning	111	114	113b	78	85	81a	31.6	34.0	33b	24	25	24a
Lamuru	91	93	92a	74	80	77a	37.7	41.3	40a	24	26	25a
Mean	132	136		85	92		31	36		26	28	
	CV a = 13.5; b = 8.0 *			CV a = 10.4; b = 9.4			CV a = 10.3; b = 4.2			CV a = 19.5; b = 9.3		

Notes: Any value in each parameter followed by the same letter means insignificant difference at $p < 0.05$
* CV a stands for coefficient of variation of fertiliser treatment; CV b stands for coefficient of variation of variety treatment

100 grain weight for Lamuru was significantly higher than Piet Kuning and the three landrace populations at Benlutu but were not significant at Mnelalete. These data could be interpreted to indicate that the lack of rainfall around flowering and grain-filling at Mnelalete impacted on grain weight as has been reported by Agrama (1996) and Khalily et al. (2010).

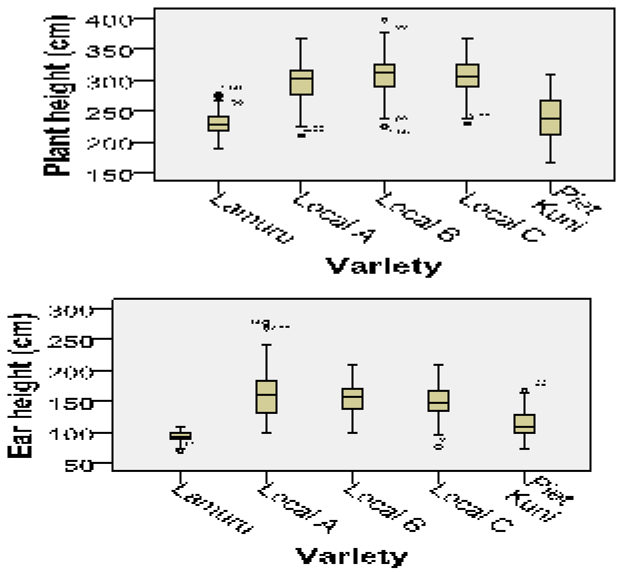

Figure 1. Plant height (left) and ear height (right) for the five maize tested at Benlutu

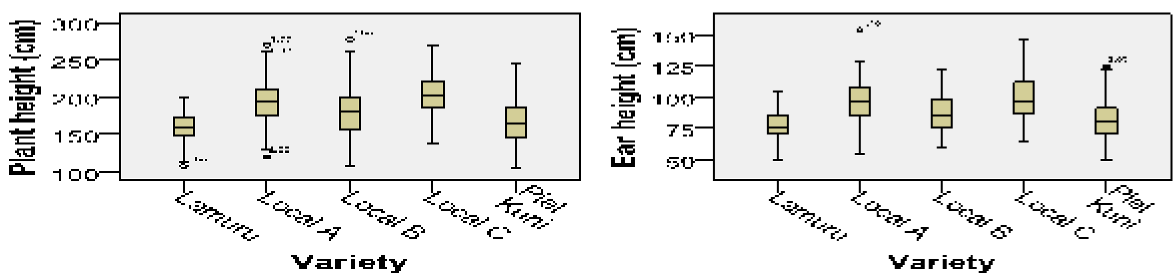

Figure 2. Plant height (left) and ear height (right) for the five maize tested at Mnelalete.

The variation in plant and ear height of the five maize entries is shown in figure 1 and 2. At Benlutu, the least variation in plant and ear height was exhibited by Lamuru with the shortest stature exhibited by the two open pollinated varieties (Lamuru and Piet Kuning). However at Mnelalete variation in plant and ear height was higher, likely a result of the lack of in-season rainfall

Conclusions and future work

This study has demonstrated the variability in yield and agronomic performance of landrace maize with regard to seedling emergence, plant and ear height compared to certified improved open pollinated varieties. This crop-stand variability is possibly contributed to by low seed viability resulting from poor storage conditions, variable seasonal climatic conditions and/or high genetic variability within the landrace populations. The impact of genetic variability and the enhancement of agronomic management of landrace maize will form components of future research.

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