The heterozygosity of corn variety of NAI following half-sib selection compared to one of its parents

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Introduction

Corn is widely grown and is considered to be the major staple food crop in Timor-Leste, with cultivation on 80,000 ha followed by rice (35,000 ha) (Nabais et al., 2008). Annual production is about 120 tons, which means only 1.5 t ha^{-1}. Biotic and abiotic stresses, such as disease, drought and flood are the major constraints causing yield reduction in the country that affect the food shortage annually.

To fulfill the domestic demand particularly for food, the Ministry of Agriculture and Forestry (MAF) with the International Corn Foundation (ICF)/International Agricultural Research Institute (IARI) of Kyungpook National University, South Korea, started a corn breeding program in February 2004. In collaboration with the national program staffers and Australian Seed of Life Program, four maize populations, Arjuna, Kalinga, Suwan 1, and Suwan 5, were selected for downy mildew (DM) resistance (R). The first two cultivars were bred in Indonesia, while other two cultivars were bred in Thailand.

From the random crosses, the joint team led by Prof. Kim Soon-Kwon (ICF/IARI) then developed successfully a new open-pollinated variety (OPV) named NAI and released it in March, 2007. NAI was generated from the population of Suwan 5 and Arjuna. Suwan 5 was an improved line from Suwan 1 (1982) at Kasetsart University (KU) Farm in Suwan and released in 1993 (Jampatong et al., 2000). Meanwhile, Arjuna was generated from TC1 (Thai Composite 1) Early DMR (S) C2 (Cycle 2) from Thailand, released in 1980 and recorded as highly tolerant to DM (*Peronosclerospora maydis*) (Subandi, 1984) and (Sutoro et al., 2007).

NAI was developed for both resistant to downy mildew (DM) and drought (Kim, 2007). This first OPV developed in East Timor also adapted well to DM, Southern corn leaf blight caused by *Helminthosporium maydis* Nisik (Syn *Bipolaris maydis* Nisik) and Southern rust (*Puccinia polysora*) with high yield in Aceh, Indonesia. It was named as Jagung Aceh for new improved variety (Hendri, et al., 2010).

Materials and methods

Half-sib selection with testcross

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We selected 400 ears of NAI population based on desired feature to develop a new cycle by using half-sib selection with testcross. Ears were obtained from previous rainy season crop in 2008. Half seeds of each selected ears were planted in ETR in an isolated field. The half remnant seeds were bulked and planted as pollen sources. The materials were then planted at Loes Research Station on December 27th, 2008. Field was designed in 2 m length with 75 cm wide row. Seeds of pollen sources and female (ETR) lines were planted in 2 and 5 rows, respectively. Two to three seeds per hill were sown with 30 cm between hills. Weeding was done by hand. We did not apply any fertilizer or pesticide. We kept only one plant per hill for each line. Female tassels were emasculated before the pollen shed. Important agronomic characteristics, such as DM, drought and lodging tolerance, vigorous and uniformity, were rated. Ten of 400 lines were selected. Five to ten superior progenies per row were selected. The population was reconstituted by compositing equal quantities of seeds from selected plants and superior testcross progenies.

Fig A. Seeds selection of the first cycle of NAI by Prof. Kim Soon-Kwon in Lospalos (October, 2009). Fig. B. On-farm demonstration of the first cycle of NAI in Lospalos (February, 2010). Fig. C. Recommended cultivation practice with one seed one hill at on-farm demonstration in Viqueuqe (February, 2010). Fig. D. Farmers' field day (FFD) of on-farm demonstration of NAI in Viqueque (February, 2010)

On-farm trials implementation

The composite seed was multiplied in an isolated area during the second crop season in Lospalos, under the cooperation of MAF, ICF and KOICA in May 2009. The desired features of each plant were evaluated and separated for on-farm trial. Thirty on-farm trials were conducted in four districts: Dili, Ermera, Viqueque and Lospalos, in December 2009. Arjuna and local cultivars were also included in the on-farm trials. Seeds were planted in plots with the dimensions of 10 m x 10 m wide with 25 cm x 75 cm for plant distance and one plant per hill. Demonstrators followed local cultivation practices, weeding with hand, without using fertilizer or any chemical. Six sets of on-farm trials in Lospalos and Viqueque were intensively observed. We conducted farmers' field day (FFD) to know their preferences toward the yield performance of the first cycle of variety NAI.

Investigation

Data was collected on important agronomic characters, such as plant height (PH), ear height (EH), tassel length (TL), commercial value (Co.V.) and dry mater (Dr.Mt.). DM infection was observed in two weeks and four weeks after planting. DM was rated from 1 to 9 (1= a few infection, highly tolerant and 9 = 91 - 100% infection, plant die). Co.V. was rated from 1 to 9 (1= excellent and 9= poor) during mature stage to determine the mean of the important agronomic traits such as yield, vigorous, tolerant to biotic and abiotic stresses and also lodging. Commercial value (Co.V.) is usually used by breeders to save time during their observation. PH, EH and TL were measured 2 weeks before harvested. Dry matter was measured with analytic balance. Data was analyzed by using the SAS 9.1 GLM program.

Result and discussion

To evaluate the population performance across the 30 diverse on-farm demonstrations during the first crop, the mean of important agronomic traits at each site were compared to Arjuna and local cultivars. However, an intensive observation was concentrated on 6 demonstrations in Lospalos and Viqueque. The first cycle of NAI revealed outstanding performance with tolerance to DM and lodging with good yield. Plants at two sites of on-farm demonstrations in Muapitine and Fuiloro demonstrated purple color on leaves, symptoms of lack of phosphorous (P).

Among five on-farm trials in Lospalos and one trial in Viqueque, we found symptoms of DM infection only in Mr. Domingos' field in Lospalos. However, infected plants showed segregation traits of off type of NAI. DM infection at on-farm trials and farmers' field in both, Lospalos and Viqueque was not serious. It is probably due to the resistance cultivars have been spread throughout the country such as NAI, Suwan 5 and Sele. Later, two cultivars were released in March, 2007 by the MAF of East Timor and Australian aid cooperation (ACIAR) program with CYMMIT involvement (Seeds of Life, 2007).

Fig. B The agronomic traits data of on-farm demonstration of the first cycle on NAI in Lospalos (Lps) and Viqueque (Vqq), harvested in April 2010.

	DM (T/ha)		PH (cm)		EH (cm)		Co.V. (1-9)	
Demonstrators	**NAI**	**Arjuna**	**NAI**	**Arjuna**	**NAI**	**Arjuna**	**NAI**	**Arjuna**
Almeida (Lps)	16.6	14.7	240	221.7	88.8	81.7	2.3	3.0
Lucia (Lps)	12.2	12.0	159.2	119.2	68.3	63.3	3.8	4.0
Domingos (Lps)	14.5	13.2	221.7	205	80	75	3	3.3
Hipolito (Lps)	21.3	14.7	207.5	171.7	90	90	2.2	3.3
Luis (Lps)	19.6	11.3	248.3	217	101.7	81.7	2.3	3.2
Lucio (Vqq)	17.1	15.4	202.5	187.5	100	92.5	2.5	3.5
Mean	***16.9***	***13.6***	***213.2***	***187.0***	***88.1***	***80.7***	***2.7***	***3.4***

Dry matter (Dr.Mt.) measurement

The result of on-farm trials for stoves dry matter showed highly significant different (*P= 0.001*) among the genotypes and environments (*P= 0.001*) with CV 16.5 %. NAI at Hipolito and Luis' on-farm trials showed highly significant different with 21.3t and 19.6t ha^{-1}, respectively from the mean value 16.9. Genotypes versus environment and locations did not show significant different. The distances from one site to another

were about 5 to 10 km. However, the yield of dry matter was highly affected by environment. It was probably due the differences of cultivation practices and soil fertility in each site.

The lowest stoves dry matter was Arjuna at Luis, Lucia and Domingos with 11.3, 12.0 and 1 ha^{1}, respectively from the mean value of Arjuna (16.9 t ha^{-1}). Hipolito's trial, plants exhibited outstanding with high yield. Among the replications and varieties versus environments there was significant difference shown. This indicates that reducing plant density per ha will not affect the dry matter weight with the normal spacing.

Plant height (PH) measurement

The result of on-farm trials at 6 locations showed highly significant difference (*P=0.001*) in PH among genotypes with CV= 6.2%, environment and genotypes versus environment. The highest PH was NAI at Luis, Almeida and Domingos' on-farm trials with 248.3 cm, 240 cm and 221.7 cm, respectively from the mean value (213.2 cm). The lowest PH was Arjuna at Lucia and Hipolito's on-farm trials with 119.2 cm and 171.7 cm from the mean value (187.0 cm). All replications showed no significant different.

The highest PH of Arjuna was at Mr. Almeida's on-farm demonstration with 221.7 cm. The lowest PH of Arjuna was at Lucia's farm demonstration with 119.2 cm. Agronomic traits which controlled by polygenic genes are easily affected by environment.

Ear height (EH) measurement

Among the genotypes that showed significant difference was (*P= 0.014*) with CV= 14.7%. Genotypes versus environment and locations did not show a significant difference. The highest EH was NAI at Luis and Lucio on-farm trials with 101.7 cm and 100 cm respectively from the mean value (88.1 cm). The lowest EH was Arjuna at Lucia and Domingos' on-farm trials with 63.3 cm and 75.0 cm from the mean value (80.7 cm).

The result of the on-farm trials showed significant and highly significant differences among genotypes and environment, but no significant difference among replications and varieties versus environment, respectively with *Mean: 276.5 cm* and *CV: 9.4%.* The highest EH of NAI was at Mr. Luis' on-farm trial with 101.7 cm. The lowest EH was Arjuna at Ms. Lucia's site trial with 63.3 cm. The highest EH of Arjuna was at Mr. Lucio's on-farm demonstration with 92.5 cm.

Commercial value (Co.V.) rating

The result of on-farm trials at 6 on-farm trials showed highly significant differences (*P= 0.001*) in Co.V. for genotypes and environments effects. Among the genotypes that showed significant difference was (*P= 0.001*) with 20.8%. Genotypes versus environment and locations did not show significant differences at *P= 0.36* and *0.24*, respectively. The highest Co.V. was at Hipolito, Luis, Almeida and Lucio's on-farm trials with 2.2, 2.3, 2.3 and 2.5, respectively from the mean value (2.7). The lowest Co.V. was Arjuna at Lucia and Lucio's on-farm trials with 4.0 and 3.5, respectively from the mean value. Meanwhile, the lowest rate was at Lucia's on-farm trial.

Summary

The result of the first cycle of NAI showed outstanding performance with high Co.V., and Dr.Mt. In Lospalos, the first cycle of NAI yielding 2.2 for Co.V. and 21.3 t/ha^{-1} at Hipolito's on-farm. This evidence indicated that some dominance genes may effect the Dr.Mt. Expression of additive gene action in this breeding was determined by the heterosis effect of genotypes at each demonstration field. Ear to row (ETR) procedure selection was an effective in changing gene frequency for highly heritable characters. Hallauer (1986) stated that the proportion of the additive genetic variance expressed among testcross families or

involved in covariances of testcross means is independent of the choice of tester, but is dependent on the inbreeding level in the population prior to crossing to the tester.

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