Crop Protection 70 (2015) 28–39

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

Testing local cocoa selections in three provinces in Sulawesi: (i) Productivity and resistance to cocoa pod borer and Phytophthora pod rot (black pod)

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ARTICLE INFO

Article history:
Received 8 June 2014
Received in revised form
27 December 2014
Accepted 2 January 2015
Available online 8 January 2015

Keywords:
Multi-location
Cocoa selections
Clones
Resistance
Bean quality
Cocoa pod borer
Phytophthora pod rot (black pod)

ABSTRACT

Trials were established on smallholder cocoa farms in three provinces in Sulawesi to assess productivity and constitutive responses of local cocoa clones to cocoa pod borer (CPB) and Phytophthora pod rot (Ppr) in different environmental situations. Twelve clones per trial (local farmer-assisted selections or clones produced by hybridisation programs in East Java and Malaysia) were tested in the districts of Pinrang, Polewali-Mandar and North Kolaka, including four standards common to the trials: the Malaysian clone, PBC123, and three selections from Sulawesi farms. The clones were evaluated from the time they started fruiting in 2010 (about two years after planting) for two years during which time chemical pesticides were not applied. Otherwise farms were managed according to recommended practices, including harvesting each fortnight, fertiliser application and heavy and light pruning, depending on the season. Butter fat content was generally lower than 50% but was higher in three local selections in Pinrang, M04, RB and Panimbu Red. While strongly dependent on genotype, fat and shell content and pod values in the common standards showed some variation between sites. The bean size and fat content of PBC123 was low, but this clone yielded better than most of the clones tested. For the common standards, yield estimates obtained from average yield per tree were higher in Pinrang (735–1100 tons/ha/annum) than in N. Kolaka (342–894 ton/ha/annum) or Polewali-Mandar (485–899 tons/ha/annum) indicating a marked site-effect. The number of flowers produced was higher in the common standards in Pinrang. Soil parameters including pH and exchangeable calcium, magnesium and potassium were higher in Pinrang than in Polman, although both sites were deficient in soil nitrogen and organic carbon. Lower average CPB infestation rates in ripe pods for the two-year evaluation period occurred in Pinrang (48–66%) and Polewali-Mandar (19–68%) than in N. Kolaka (77–80%). In most of the clones, total and severe CPB incidence decreased during the high pod season but some selections, such as M04 and TR01, maintained a low total and severe CPB incidence in both the low and high pod seasons, indicating partial resistance. In the ripe pods of common standards, the highest average Ppr incidence (ranging from 10 to 14%) occurred in N. Kolaka, which had a higher annual rainfall than the other sites. In ripe pods in the Pinrang trial, Geni J, M06 and Panimbu Red had a low Ppr incidence (4.4–4.8%) while M04 was Ppr-susceptible (23%). Incidence of *Helopeltis* spp. was high in the immature pods of some clones (exceeding 30% of the total harvest in M01 and Geni J in Pinrang). The results show that the performance of clones is affected by the locality in which they are grown, as well as their genotype, indicating the importance of testing clones under different environmental conditions. While the trials confirmed the efficacy of farmer-assisted selection, they also indicated that clones resistant to CPB, were susceptible to Ppr or other pests/diseases, and vice versa. For example, local selection, M04, was highly susceptible to Ppr, yet

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http://dx.doi.org/10.1016/j.cropro.2015.01.001

resistant to CPB. Therefore, the results indicate the importance of efforts to screen the progeny of hybrid crosses that combine resistance and yield traits.

1. Introduction

In Indonesia, cocoa (*Theobroma cacao*), originating in South America, has a long history of various introductions with the Celebes (or Sulawesi) being the first island in which cocoa, brought by Spanish sailors via the Philippines, was planted (Durand, 1995). However, it is only relatively recently (beginning in the early 1980s) that cocoa production has expanded to global proportions in Sulawesi (Ruf and Yoddang, 2000, 2004a). This expansion, due to a boom in smallholder production, has led to the island contributing to over 60% of the total production of Indonesia (currently the world's third largest cocoa producer). Following an early 'honeymoon' period, relatively free of pests/diseases and with sufficiently fertile soils (Keane, 1992; Ruf and Yoddang, 2000, 2004b), farmers, processors and exporters of cocoa in Indonesia are now facing a decline in productivity and in bean quality, an issue addressed by the 6th Indonesian International Cocoa Conference[1]. The decline can be accounted for by a number of factors, including decreasing soil fertility and organic matter content and an increased incidence of pests/diseases. Cocoa bean quality in Sulawesi is compromised by infestation by cocoa pod borer (CPB), *Conopomorpha cramerella*, now widespread in Indonesia. A large proportion of beans in infested pods becomes unusable and with heavy infestation the whole pod must be discarded. Losses also are incurred by *Helopeltis* spp. although attack is more localised. In addition, during the wet season the incidence of Phytophthora pod rot (Ppr) or black pod caused by *Phytophthora palmivora* (Guest, 2007) rises markedly so that losses of 50% and above may occur during periods that are particularly wet. If Ppr incidence is high in the main harvest season this can become the most serious pest/disease problem for farmers. Diseases impacting on vegetative plant parts, especially vascular-streak dieback (VSD), also incur major losses. These problems are currently driving Indonesian farmers to replace cocoa with other crops, particularly oil palm.

Most of the cocoa in Sulawesi has been derived from parent material introduced from seed gardens established in Sumatra and Java, or from Malaysia brought back to Sulawesi by returning itinerant labourers. This has led to a moderately genetically diverse population on farms as well as considerable diversity in productivity, quality and pest and disease resistance. Therefore, the diversity of the cocoa currently planted in smallholdings is a sound basis for local selection and hybrid crossing for pest/disease resistance and improved yield and quality. With the techniques of side- and top-grafting, now widely adopted in Sulawesi, there is a great potential to select improved genotypes and propagate them clonally. Potentially, employing improved planting material and selection of genotypes that are suitable for particular environments (with input and cooperation from local farmers) could help to address the decline in productivity and quality, and discourage farmers from turning to crops with higher nutrient requirements, such as maize, or crops that are less environmentally sustainable, such as oil palm. In an Australian Centre for International Agricultural Research (ACIAR) project conducted jointly with Mars Inc. this approach was tested in different locations in southern Sulawesi using a range of local selections from Sulawesi, clones from hybrid crosses conducted in Jember by the Indonesian Coffee and Cocoa Research Institute (ICCRI) and two Malaysian clones, PBC123 and BR25, which are now planted widely in Sulawesi.

To test genotypes identified as promising for particular characteristics by smallholder farmers, trials were established on cocoa smallholder farms in three provinces in Sulawesi. The main objective of this research was to identify local genotypes suited to propagation in Sulawesi under local conditions of natural pest/disease infestation. Data obtained could be used to recommend selected clones as farmers' planting material or for using as parental material in hybrid crosses. An additional aim of the trials was to provide more information about the performance of selected clones in different geographical locations. Here we report on the performance of the selected clones, in particular their pod and bean properties and variations in response to CPB and Ppr. A wide range of responses was found between the different clones indicating an urgent need to combine promising characters in breeding programs. Site-specific effects were also evident pointing to the necessity of testing promising material *in situ* since genotype

Table 1
Clones, their origin (district in Sulawesi or region outside Sulawesi), purpose of selection and the districts in Sulawesi in which they were tested: Pinrang (Tiroang), North Kolaka (Tiwu) and Polman (Anreapi). i, included in trial; r, resistance; PBC, Prang Besar clone (PBC123 is known locally as Sul1, Sulawesi1); M, Muhtar; Geni J, Genin Jasi; Pan R, Panimbu Red; DRC, Djati Roenggo clone; RB, Rahim Burau; TR, Torea; ICCRI, Indonesian Coffee and Cocoa Institute; PCK, Puang Caddik; KKM, Klon Koko Mardi; NR, Nasir Rauf; PwPg, Polewali-Pinrang; ILH, Ilham; BR, Balong River (BR25 is known locally as Sul2, Sulawesi 2); KW, Kaliwining.

Clone	Pod colour	Trial site			Origin	Selected for
		Pinrang	N. Kolaka	Polman		
PBC123 (Sul1)	Red	i	i	i	Malaysia	Yield
M01	Green	i	i	i	N. Luwu	Yield
M05	Pale Red	i	i	i	N. Luwu	VSDr
Geni J	Red	i	i	i	E. Luwu	VSDr
Pan R	Red–orange	i	i		N. Luwu	Yield
M04	Green	i			N. Luwu	Yield/quality
M06	Red–yellow	i	i		N. Luwu	Yield
DRC15	Pale green	i			E. Java	VSDr
RB	Orange	i			E. Luwu	Yield
Tr01	Red–orange	i			N. Luwu	Yield
ICCRI04	Green	i			E. Java	Yield
PCK	Green	i			Mamuju	Yield
KKM22	Yellow–red		i		Malaysia	Yield
Nasir Rauf	Green		i	i	Soppeng	Yield
Muhtar	Yellow–red		i	i	Soppeng	Yield
PwPg	Red–orange		i		Pinrang	Yield
Darno	Green –yellow		i		Soppeng	Yield
ILH	Green –yellow		i	i	Soppeng	Yield
BR25 (Sul2)	Red			i	Malaysia	Yield
KW617	Red			i	E. Java	Yield
KW523	Reddish green			i	E. Java	PPRr
KW516	Green			i	N.Sumatra	Yield
Husbitori	Green			i	Bone	Quality

[1] The 6th Indonesian International Cocoa Conference: Empowering smallholders for a sustainable cocoa industry, Askindo, May 15–16, 2014, Nusa Dua, Bali, Indonesia.