Early Agronomic Performance of Some New and Existing Arabica Coffee Varieties in Kenya

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Summary

The primary goal of plant breeding is to improve yield, quality and disease resistance. However, majority of reported work on coffee breeding primarily concerns agronomical improvement that directly impinges on either coffee quality or yields. The main objective of this study was to compare the agronomic traits of new Arabica coffee varieties with existing commercial cultivars in Kenya. Field recording of cherry yield and disease infection was done during the cropping seasons of 2007 and 2008. Artificial inoculation for both Coffee Berry Disease (CBD) and Coffee Leaf Rust (CLR) were done in respective screening laboratories using Completely Randomized Design (CRD). Significant variations in yield and disease resistance were observed among the genotypes. There were significant negative correlations between disease scores (both CBD and CLR) and cherry yield.

Introduction

Coffee is an important export crop and a major foreign currency earner for Kenya (Gichimu and Omondi, 2010). In Kenya, the coffee industry has been the leading foreign exchange earner since independence. However, its performance has been on the decline as evident from the drop in coffee exports, coffee quality and yields (Condliffe *et al.*, 2008). It has since been overtaken by other sub-sectors and now ranks fourth after tourism, tea, and horticulture. Currently, it is estimated that 170,000 ha of Kenyan land is under coffee and that the sector supports approximately five million Kenyans. The industry contributes about 8% of the country's foreign exchange earnings, a drop from a 40% contribution in the good years of 1980's (Coffee Board of Kenya, 2010).

Coffee production in Kenya is seriously constrained by diseases across the coffee growing areas especially the two fungal dieseases; Coffee Berry Disease (CBD) caused by *Colletotrichum kahawae* and Coffee Leaf Rust (CLR) caused by *Hemileia vastatrix* (Omondi *et al.*, 2001). CBD mainly affects the berries. This is also the infection of highest economical importance, especially on green immature fruits, a stage in which it can cause up to 80% crop loss if not controlled and conditions are favourable (Masaba and Waller, 1992). On the other hand, CLR is a disease of foliage that causes premature leaf fall, yield loss and even death of the tree in severe cases. Disease control in susceptible coffee varieties is by intensive spray programmes that accounts for up to 30% of the total cost of production and is a major constraint to economic coffee production especially to the small-holders who find the use of pesticides beyond their financial and technical capabilities (McDowel and Wolffenden, 2003).

In view of the economics and to minimise the chemical input for disease management, the development and cultivation of tolerant cultivars is the most effective and viable option. A Kenyan Arabica coffee hybrid cultivar, Ruiru 11, developed by Coffee Research Foundation, Ruiru, Kenya, and released to growers in 1985, combines resistance to CBD and leaf rust with high yield, fine quality and compact growth amenable to high density planting (Omondi *et al.*, 2001). In addition, the Foundation has recently developed and released three true-breeding Arabica coffee varieties namely Batian 1, Batian 2 and Batian 3 that are also resistant to CBD and CLR. The main objective of this study was to compare the early agronomic traits of the new Arabica coffee varieties with existing commercial cultivars.

Materials and Methods

Study site: The field trial was carried out at Tatu Estate of Socfinaf Co. Ltd. The site is located within the upper Midland 2 agro-ecological zone at latitude 1^o 05'S and longitude 36^o 54'E and is approximately 1623m above the sea level. The area receives a bimodal mean annual rainfall of 1063mm and mean annual temperature is 19^{o}C. The soils are classified as a complex of humic nitisols and plinthic ferrasols. The soil pH ranges between 5 and 6.

Experimental Materials and Layout: The test materials included three new true-breeding Arabica coffee varieties namely Batian 1, Batian 2 and Batian 3, which were evaluated alongside two commercial Arabica cultivars, SL28 and Ruiru 11. The site was laid out in a Randomized Complete Block Design (RCBD) with twenty trees per plot planted on a spacing of 2M x 1.5M and replicated three times. Field establishment was done in March/April 2005. Cherry yield for 2007 and 2008 was recorded in kilograms per tree from all the twenty trees per plot. CBD infection was recorded by counting the percentage number of infected berries from five tagged branches per tree and then calculating the mean infection per replicate. A similar method was applied for CLR where percentage number of infected leaves from five tagged branches per tree was used to calculate the mean percentage of CLR infection per replicate.

Laboratory inoculation tests: Laboratory experiments to evaluate resistance to CBD and CLR through artificial inoculations were set up in Completely Randomized Design (CRD) with three replications. Evaluation for CBD was conducted through hypocotyl inoculation tests using the method of Van der Vossen *et al.*, (1976). After three weeks, the seedlings were scored individually on a scale of 1 (no visible symptoms), to 12 (whole seedling dead). Evaluation for leaf rust resistance was carried out using leaf disk inoculation tests (Eskes, 1982). A scale of 1-100 was used to score the CLR infection based on percentage sporulation as follows: 0-20% = highly resistant; 21-40% = resistant; 41-60% = moderately resistant/susceptible; 61-80% = susceptible; and 81-100% = highly susceptible.

Data Analysis: The data was subjected to analysis of variance (ANOVA) using COSTAT software and effects declared significant at 5% level. A combined analysis of variance was performed on yield and disease data for both years. Least Significance Difference ($LSD_{5\%}$) was used to separate the means. Linear correlation and regression analysis was performed using SAS Version 9.1 and Ms Excel respectively to compare the relationship between disease resistance and cherry yield.

Results and Discussion

The genotypes were evaluated for cherry yields over a two year period. The three new varieties recorded similar or higher mean cherry yields than the existing commercial cultivars. Batian 1 performed significantly ($p<0.05$) better than Batian 2 and Batian 3 whose yields were not significantly ($p>0.05$) different from SL28 which was the least yielding (Table 1). These results were in agreement with findings of similar work that was carried out in Western (Kitale) and Eastern (Meru) Kenya on the adaptation trials of the new varieties (Gichimu and Omondi, 2010).

Disease pressure was low under field conditions for both CBD and CLR. However, artificial inoculation with both *C. kahawae* and *H. vastatrix* pathogens demonstrated significant ($p<0.05$) differences among the genotypes. SL28 was therefore an escape in the field experiment and would have been mistaken as resistant if laboratory experiment was not done. Batian 1 was highly resistant (1-3) to CBD while SL28 was highly susceptible (10-12). The rest including Ruiru 11 were resistant (4-6). Resistance to CBD in Ruiru 11 and the new varieties is mainly controlled by the R gene from Rume Sudan and the T gene from Catimor either directly or introgressed through Hibrido de Timor (Gichimu and Omondi, 2010).

On the other hand, Ruiru 11 and the three new varieties were resistant to CLR while SL28 was susceptible (Table 1). The three new varieties (Batians) are selections from male parents of Ruiru 11 which are useful in imparting resistance to CLR into Ruiru 11. It is therefore expected that the Batians, are also resistant to CLR.

Table 1: Variation in yield and disease resistance

Genotypes	Cherry Yield (Kg/tree)	**FIELD DISEASE SCORES**		**LAB DISEASE SCORES**	
		% CBD Score	% CLR Score	CBD Score	% CLR Score
Batian 1	2.96a	0.53b	1.02b	3.08c	3.33b
Batian 2	2.03b	0.72b	0.86bc	3.96b	8.67b
Batian 3	2.14b	0.70b	0.71cd	4.28b	6.00b
Ruiru 11	1.90b	0.54b	0.50d	4.15b	0.33b
SL28	1.71b	1.06a	2.36a	10.36a	92.33a
LSD (5%)	0.60	0.33	0.24	0.60	13.07
CV%	23.13	35.11	18.35	6.84	36.44

Combined mean cherry yields were more than three times higher in 2008 (3.38 kg/tree) than in 2007 (0.91 kg/tree). Gichimu and Omondi (2010) reported that for newly established coffee plants, when all the other variables are held constant, growth and yield characters are expected to increase almost exponentially up to a certain threshold above which the limits are determined by the management practices applied. Wamatu *et al.* (2003) also reported that for established coffee trees, biennial bearing phenomenon is common and coffee yields fluctuates from year to year. The level of CBD infection was not significantly ($p>0.05$) different over the two years but there was significantly ($p<0.05$) more CLR infection in 2008 than in 2007 (Table 2).

Table 2: Seasonal effects on berry yields and disease infection

Year	Mean Cherry Yield (kg/tree)	Mean CBD Infection (%)	Mean CLR Infection (%)
2007	0.91^{b}	0.73	0.02^{b}
2008	3.38^{a}	0.69	0.16^{a}
LSD (5%)	0.38	NS	0.22
CV%	23.13	38.24	18.35

There was significant negative correlation between cherry yields and both CBD (-0.62) and CLR (-0.56) indicating that yields increased with increase in resistance to both diseases. Regression analysis also revealed negative relationship between cherry yields and both CBD and CLR infection (Figure 1). This was an indication of how major coffee diseases can lower coffee yields even in potentially high yielding but susceptible varieties. Gichimu and Omondi (2010) reported that production of resistant coffee cultivars is the most economical and sustainable control strategy.

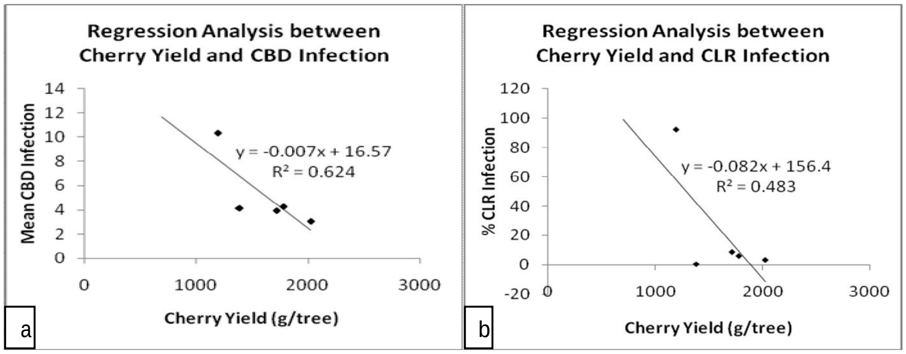

Fig 1: Regression analysis between cherry yields and (a) CBD infection; (b) CLR infection

Conclusions

The study demonstrated that the three new varieties have a higher yield potential than the two existing commercial cultivars, Ruiru 11 and SL28. The lines also possess good resistance to CBD and leaf rust comparing well to the improved commercial cultivar, Ruiru 11. The study also revealed that growing resistant coffee varieties can contribute greatly in yield improvement especially where no disease control is applied

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