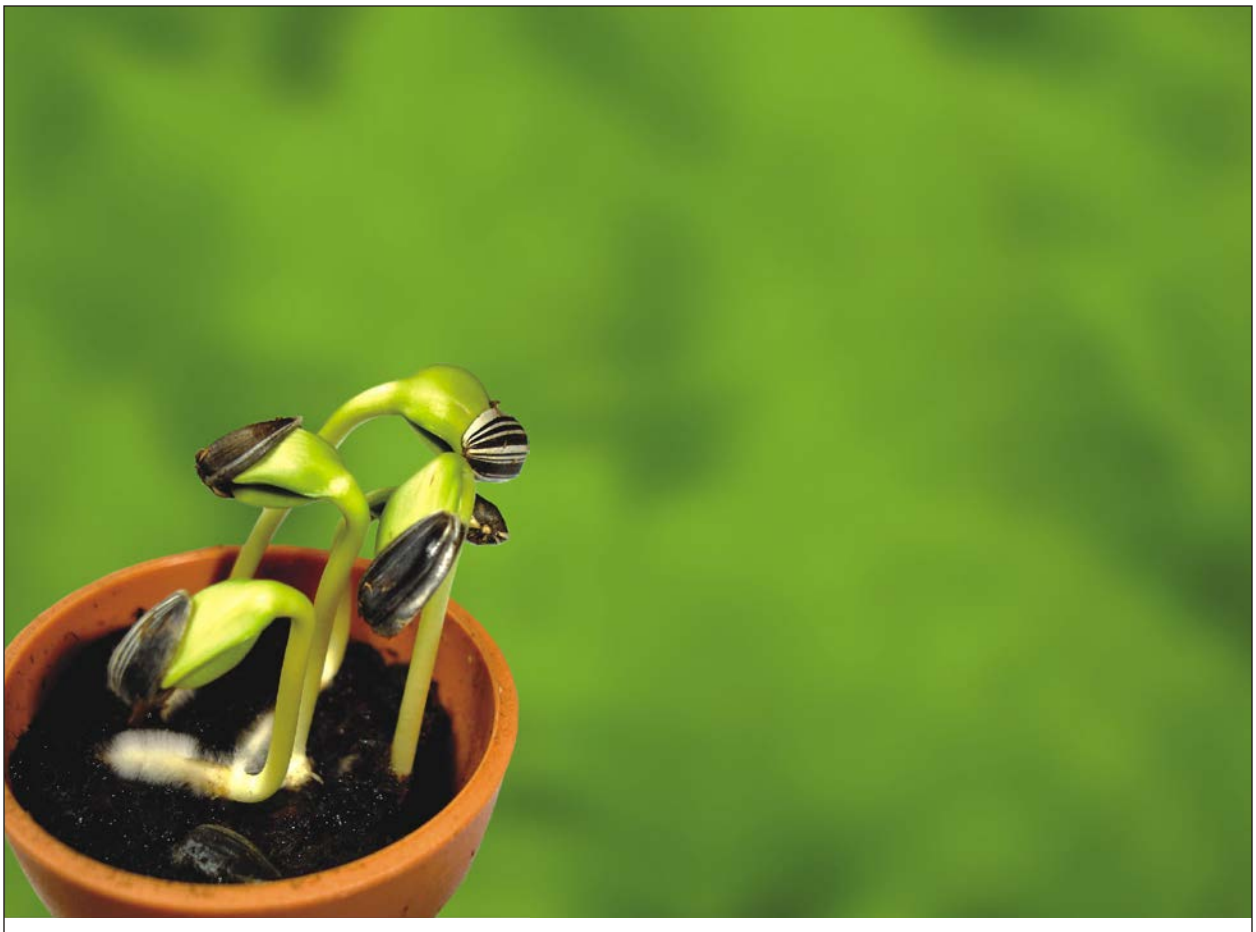

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A Study of *Coffea racemosa* x *Coffea canephora* var. *robusta* Hybrids in Relation to Certain Critically Important Characters

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Abstract: The present experiment has been carried out to study a hybrid germplasm of *Coffea racemosa* x *Coffea canephora* var. *robusta* F_1 for crop duration, caffeine content and some other important morphological characters. Caffeine content in robusta coffee is comparatively high. Recent life style trends demand coffee with low caffeine content. Crop duration also is more in robusta compared to other cultivated species. *Coffea racemosa* is a wild species with desirable characters like low caffeine content, short duration and resistance to leaf rust. A hybrid population of *Coffea racemosa* and *Coffea canephora* var. *robusta* has been analyzed presently for caffeine content, leaf rust resistance and other growth and yield characters so as to explore the possibility of selecting hybrid plants that may prove useful in future breeding programmes to develop robusta based varieties with short duration, low caffeine content and high resistance to leaf rust. The hybrid plants showed improvement over the mid parent values, but improvement over the better parent was shown in the case of a few agronomic characters only. However, flower to harvest duration was reduced; caffeine content and leaf rust incidence were considerably low in the hybrid plants. This indicates the feasibility of racemosa x robusta protocol for the production of more desirable hybrids from robusta coffee plants.

Key words: *Coffea canephora* var. *robusta*, *Coffea racemosa*, hybrids, caffeine content, crop duration, leaf rust

INTRODUCTION

Coffee is one of the most important non alcoholic beverages of the world and it is obtained from the processed beans of two species of the genus *Coffea* namely *Coffea arabica* and *Coffea canephora* var. *robusta. Coffea arabica* is a highland species grown at altitudes ranging from 500 m in subtropics to 2500 m near equator whereas *Coffea canephora* is a low land coffee suited for cultivation at an elevation ranging from 500-1000 m above sea level (Willson, 1999). The three top produces of coffee in the world are Brazil, Vietnam and Colombia and these countries contribute around 55% of global production (Venkatachalam, 2005). India is sixth in position in production (Anonymous, 2007).

Coffea canephora var. *robusta* is a large shrub when compared to *Coffea arabica* with broad large and pale green leaves. Flowers are borne in axillary fascicles and are white,

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fragrant and born in large clusters. In the study area (latitude 13° 22'N and longitude 75° 28' E) the buds initiate from November to February and the flowers open in February-March when a shower of rain, the blossom shower becomes available. This species of coffee is self sterile and cross pollination is necessary for fertilization. The fruits mature in 10-11 months. Though *Coffea canephora* var. *robusta* is a little inferior in quality compared to *Coffea arabica*, it is tolerant to major pests and diseases. The fruits of this species become generally ready for harvest two months later than arabica (Wellman, 1961; Anonymous, 2003). The beans of this species contain more caffeine, ranging from 1.5 to 3.8% (Texeira and Fazouli, 1975). *Coffea racemosa* is a small profusely branching shrub about four feet tall. The leaves are small, leathery, undulating and flowers subterminal in erect bracteate racemes. Fruits are subglobose, small, red and watery when ripe having two hemispherical seeds. Fruit set to ripening duration is significantly short in this species (Haarer, 1962). Mean caffeine content is 0.83% which is lower when compared to both arabica and robusta coffee (Lopes and Herminda, 1972). Changing life style trends of man has currently resulted in increased demand for coffee with low caffeine content and hence breeding coffee varieties and hybrids with low caffeine content has become the need of the day. Hybridization of cultivated species of coffee with wild species with low caffeine content is a method to produce coffee varieties with low caffeine content. The present study is an effort to analyze a hybrid population of coffee produced by *Coffea racemosa* x *Coffea canephora* var. *robusta* crosses and maintained in the experimental garden of Regional Coffee Research Station, Chundale, Wayanad, Kerala, India in terms of crop duration, caffeine content and some other important morphological characters.

MATERIALS AND METHODS

With an objective of carrying out interspecific crosses between different coffee species, germplasms of different species of coffee were established in the field gene bank of Regional Coffee Research Station, Chundale, Wayanad, Kerala, India which is a regional research station of Central Coffee Research Institute, Chikmagalur, Karnataka, India starting from 1970s. Crosses between *Coffea racemosa* (female parent) and *Coffea canephora* var. *robusta* (male parent) were made in 1989 using *Coffea canephora* planted in 1978 and *Coffea racemosa* planted in 1983. Both the parents were well established and mature. The inflorescence were emasculated and bagged at the appropriate time and hand pollination was effected after eliminating chances of self pollination. Hybrid seeds were collected and nine F1 plants could be raised from the cross. The interspecific hybrids evolved from the above cross have been analyzed presently in relation to their parents based on 30 characters including growth, yield and physical quality characters, caffeine content and leaf rust resistance (Table 1). Observations were made in 2005 when the hybrid progeny also matured and started flowering and fruiting. The hybrids and parents were analyzed for caffeine content using ISO 4052-1983 method (Anonymous, 1983) and for leaf rust resistance by visual scoring.

RESULTS

The hybrid plants showed positive variation in the case of most of the characters when compared to the mid parent values (Table 1). However, fruits per node and yield per plant

Table 1: Observations on the *Coffea racemosa* x *Coffea canephora* var. *robusta* hybrids and their parents

Characters	Female parent *Coffea racemosa*	Male parent *Coffea canephora* var. *robusta* (S.274)	Hybrid	Segregation based on the mid parent value	Segregation based on the better parent value
Stem girth (mm)	62.1-85.92	96.62-115.4	25.3-106.7	+	-
No. of secondary branches per primary	8.5-10.5	4.5-6.7	1.5-12.5	+	+
Girth of primary branches (mm)	12.52-28.28	58.5-82.4	6.0-41.0	+	-
Length of primary branches (cm)	174.28-264.0	170.5-178.0	79.5-203.0	+	-
Internodal length (cm)*	2.02-2.45	5.81-6.42	1.95-3.72	+	+
Bush spread (cm)*	270-352	344-391	97-371	+	+
Leaf length (cm)*	4.65-5.05	14.95-27.30	6.9-10.65	+	-
Leaf breadth (cm)*	1.6-2.6	5.73-11.0	2.6-4.25	+	-
Leaf area (cm^2)*	5.49-8.93	73.94-192.53	12.19-30.20	+	-
Crop duration (days)*	80-90	310-315	160-170	+	-**
Fruits per node	1-4	17-24	1-3	-	-
Fruit length (mm)	12.54-13.63	12.82-14.58	15.30-16.43	+	+
Fruit breadth (mm)	11.57-13.63	12.05-14.57	9.05-13.28	+	-
Fruit thickness (mm)	9.57-11.89	10.80-13.89	9.69-12.15	+	-
Fruit volume (mm^3)	722.01-1099.74	867.57-1214.43	156.19-1333.22	+	+
100 fruit wt. (fresh) (g)	84.5-135.53	94.72-142.13	61.25-150.97	+	+
100 pea berry wt. (fresh) (g)	58.0-80.5	57.6-89.9	43.67-104.13	+	+
100 fruit wt. (dried) (g)	22.0-22.86	35.7-62.0	13.24-29.49	+	-
100 pea berry wt. (dried) (g)	13.0-20.0	23.4-34.4	11.33-24.9	+	-
Bean length (mm)	5.77-6.99	7.11-8.68	5.81-8.61	+	-
Bean breadth (mm)	3.07-3.48	6.65-6.72	4.56-5.79	+	-
Bean thickness (mm)	3.07-3.45	4.21-4.44	3.31-4.63	+	+
Bean volume (mm^3)	36.95-46.1	121.42-157.98	58.36-131.37	+	-
100 bean wt. (g)	6.0-7.8	9.8-15.2	9.21-12.97	+	-
100 bean wt. (pea berry) (g)	5.0-7.0	9.0-13.5	7.5-13.0	+	-
Yield per plant (kg)	0.05- 0.5	7.43-15.31	0.05-1.00	-	-
Out turn (%)	17.59-26.04	37.69-43.62	15.67-25.24	+	-
% of floats*	0	0	0-70	-	-
Caffeine content (%)*	0.38	1.76	1.47	*	-**
Incidence of leaf rust (%)*	0	30	9	+	-**

*: Lower values are desirable in coffee, **: Superior when compared to the cultivated variety used as parent

were lower than the mid parent values in the case of the hybrids. When compared to the better parent values, the number of secondary branches per primary, internode length, bush spread, fruit length, fruit volume, 100 fruit weight (fresh), 100 pea berry weight (fresh) and bean thickness showed positive variation. In the case of the other characters which include characters like stem girth, girth and length of primary branches, fruits per node, dried fruit weight, bean volume and yield per plant, the hybrid population has been found to be inferior to the better parent. Some floats have also been observed in the case of the hybrid plants. The crop duration in the case of the hybrid population was 160 to 170 days and it was 310-315 days in the case of *Coffea canephora* var. *robusta*. Caffeine content in the case of the hybrid population was 1.47% where as it was 1.76% in the case of robusta coffee in the present experiment. The incidence of leaf rust in the case of robusta coffee was 30% and it was 9% in the hybrids.

DISCUSSION

Characters like number of secondary branches per primary, internode length, bush spread, fruit length, fruit volume, 100 fruit weight (fresh), 100 pea berry weight (fresh) and bean thickness showed positive variation when compared to the better parent values and other agronomic characters showed positive variation when compared to the mid parent values in the case of the hybrids and this amounts to transgressive segregation towards the favourable side. However, in the case of the other morphological characters, the hybrid population has been found to be intermediate in behavior and hence it requires further improvement.

But, it can be seen that the hybrids show considerable reduction in crop duration, caffeine content and incidence of leaf rust when compared to the cultivated species used as parent in the present cross. This observation is very significant since robusta based coffee plants suitable for low elevations with shorter crop duration, lower caffeine content and low incidence of leaf rust are highly desirable to overcome the drawbacks of robusta cultivars.

Fruit development in coffee, which covers the time between anthesis and full ripening, takes between 2 to 3 months in *C. racemosa*, 6 to 8 months in arabica and 9 to 11 months in robusta (Sondahl and Baumann, 2001). Certain efforts have been made to develop early maturing coffee plants by earlier workers. An early maturing (180 days from flower to fruit) somaclonal population selected from arabica-racemosa hybrids have been developed by Sondahl *et al*. (1997). Interspecific hybrids between *Coffea racemosa* x (CxR) coffee with early maturing habit have been reported by Suresh-Kumar *et al*. (2004).

The reduction in crop duration in the case of the hybrid can be exploited scientifically and utilized for the effective reduction of crop duration in coffee so that, coffee beans of this type of plants can be harvested earlier and the plants get a gap period before the onset of the next flowering period and hence it can replenish its potential for the next crop in a better way.

Development of robusta varieties with lower caffeine content has been a thrust area in robusta coffee research right from the beginning of organized research in robusta coffee. Arabica coffee has got caffeine content of about 1 to 1.5% and robusta has got caffeine content of about 2 to 3% (Willson, 1999). Interspecific hybridization has been proposed as a method to develop varieties with low caffeine content in robusta coffee. Narasimhaswamy and Vishveshwara (1961, 1967) have conducted hybridization experiments in coffee with the objective of obtaining materials with good quality. Capot (1972) reported an arabusta material (*Coffea canephora* x *Coffea arabica*), which is both self-fertile and intercompatible with a caffeine content ranging from 1.5 to 2%. Rabemiafara *et al*. (1997) developed a family of three way hybrids of coffee, named Ratelo, through a *Coffea eugenioides* x *Coffea canephora* cross and chromosome doubling and subsequent crosses with *Coffea arabica* followed by selfing and intercrossing. The hybrids were smaller trees of reduced height, compact habit, partial autogamy and heavy flowering and the hybrid was expected to combine the adaptability of *Coffea canephora*, low caffeine content of *Coffea eugenioides* and flavour characteristics of *Coffea arabica*. Mazzafera and Carvalho (1991) have reported hybrids between *Coffea eugenioides* and *Coffea salvatrix* with very low caffeine content. Seeds of tetraploid hybrids of *Coffea arabica* x *Coffea salvatrix* and *Coffea arabica* x *Coffea eugenioides* also showed lower caffeine content. Texeira and Fazuoli (1975) developed *Coffea canephora* x *Coffea eugenioides* hybrids with intermediate caffeine content. Sreenath *et al*. (1992) have also attempted crosses between *Coffea canephora* and wild coffee species to combine the agronomic properties of *Coffea canephora* with some useful characters of the wild species especially the low caffeine content.

Interspecific hybridization of coffee has resulted in plants with general inferiority but with certain superior traits in certain earlier works also (Capot, 1972; Texeira and Fazuoli, 1975; Rabemiafara *et al*., 1997; Mazzafera and Carvalho, 1991; Sreenath *et al*., 1992; Sondahl *et al*., 1997; Suresh-Kumar *et al*., 2004). Some of them have developed superior hybrids from them through different techniques like back crosses and sib mating and selection (Capot, 1972; Texeira and Fazuoli, 1975; Rabemiafara *et al*., 1997; Mazzafera and Carvalho, 1991).

As the crop duration has been reduced and caffeine content also is low in the interspecific hybrids studied, the present study has been successful in suggesting a breeding protocol for the production of better coffee hybrids with robusta base suitable to low elevation areas. However, the hybrids have to be improved tremendously by subjecting them to selection cycles and back cross breeding so as to make them more productive maintaining their short crop duration, low caffeine content and high resistance to leaf rust. The present findings can be used to refine a protocol to develop better coffee varieties with robusta base.

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