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Evaluation of Arabica coffee germplasm for clean coffee yield and caffeine content under Southern hill zone of Karnataka

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Abstract
The present research was conducted for evaluating different Arabica coffee genotypes for yield and quality parameters during the year 2020-21 and 2021-22 at Central Coffee Research Institute, Balehonnur, Karnataka, India which in turn help in identifying high yielding varieties in *Coffea arabica* L. About 41 arabica coffee genotypes were used comprised of 39 exotic collections along with two check varieties such as Cauvery and Chandragiri (CCRI, selections). Results from the experiments revealed that significant variation among the genotypes were observed for clean coffee yield and caffeine content. Clean coffee yield was ranged from 418.42 to 474.18 kg/ha (2020-21) and 268.98 to 627.63 kg/ha (2021-22), similarly caffeine content was ranged from 0.56 to 1.05 per cent. Genotypes S.2724, Chandragiri, S.2532, S.1655, S.2608, S.2725, S.2502 and S.1482 established higher clean coffee yield per ha, while the genotypes S.1477,S.2602, S.1573, S.2532 and S.1655 revealed low caffeine content. Therefore these genotypes can be selected as these genotypes will serve as resource for further crop improvement programmes like breeding for high yield combined with low caffeine content.

Keywords: Arabica coffee, caffeine content, clean coffee yield, evaluation and HPLC

Introduction
Arabica coffee is botanically known as *Coffea arabica* L. belongs to family Rubiaceae originated from Ethiopia. It is the only self-fertile species in the genus *Coffea*. Arabica is allo-tetraploid (2n = 44) whereas all the remaining species including robusta are cross pollinating diploids (2n = 22). The contribution of arabica coffee to global coffee production is around 70 per cent, while robusta coffee is 30 per cent. According to coffee board of India data base (Anon, 2022), the area share of arabica coffee was 70 per cent while rest of the area was under robusta coffee during 1950's. Off late, the area under arabica coffee is decreasing more rapidly, which is replaced by robusta coffee gradually. Currently, both arabica and robusta coffee shared almost equal area share of 51 and 49 per cent, respectively in India. In spite of the commercial importance and the appropriate environmental conditions, the drastic reduction of arabica coffee area in India is might be due to the lack of adaptable cultivars for each ecological zone of the region, susceptibility to major pests and diseases like white stem borer and leaf rust, respectively and increased cost of production coupled with low productivity (470 kg clean coffee/ha) compared to that of robusta coffee. Therefore evaluation and selection of high yielding genotypes coupled with superior quality parameters (caffeine content) would be essential to address the issues and the information generated on various characters particularly yield and quality would be most useful in planning the breeding programme. Hence, keeping all these views the research work was conducted for evaluating different arabica coffee genotypes with the objectives of assessing arabica coffee genotypes for clean coffee yield and caffeine content at Central Coffee Research Institute (CCRI), Balehonnur, Karnataka, India during 2020-2021 and 2021-22.

Materials and Methods
In my present study, 41 arabica coffee genotypes (Table 1) were collected from World collections (14 No.), Ethiopian collection (10 No.), Costa Rica collections (15 No.) and CCRI check varieties (2 No.) maintained in germplasm block at CCRI were evaluated for yield and cup quality traits. The experiment was conducted in randomized complete block design (RCBD) with two replications (Plate 1). Four randomly selected plants from each replication

were tagged for recording observations on yield and quality parameters (Plate 2 and 3). In addition, the regular calendar of operations like weeding, fertilizer application, harvesting and processing were carried out during the course of investigation. The soil of the experimental plot was medium sandy loam to lateritic in nature. In order to assess the fertility status, the soil samples were collected from the depth of 0-30 cm in randomly selected areas of the block. The soil was analyzed for pH, electrical conductivity, organic carbon, phosphorus and potassium. Results revealed that pH of the experimental plot was slightly acidic (5.63) and low in electrical conductivity (0.17 dS/m), while the organic carbon content was 2.48%. Similarly, nutrient status of the soil was medium in available phosphorus (26.21 kg/ha) and high in available potassium content (277.48 kg/ha). The soil analysis data is furnished in Table 2.
Observations recorded on clean coffee yield and caffeine content were discussed here under

1. Clean coffee yield (kg/plant)
Matured and ripe fruits were harvested manually from the individual plants during the month of December. The harvested fruits were subjected to processing like pulping, drying and hulling to get the clean coffee bean. The clean coffee yield was derived by standard out turn ratio of 6:1 (fruit to clean coffee).

2. Caffeine content (%)
The procedure was used for estimation of caffeine content in Arabica coffee genotypes developed by Shrestha *et al.* (2016). A total of 41 green coffee samples weighing 150 gm each were collected from experimental plot for estimation of caffeine content in Arabica coffee genotypes. The coffee samples were kept at room temperature throughout the analysis. All the glassware were properly cleaned, then rinsed with HPLC water before use. The chemicals and reagents used in this study were HPLC grade methanol, ultra-pure water and MgO (Magnesium oxide). Later caffeine content can be determined by using HPLC method. During caffeine determination, coffee samples were first grounded to powder and about 1 g of grounded coffee samples were taken into 250 ml conical flasks. Then 200 ml of distilled water was added along with 5 gm of MgO (Magnesium oxide) into the conical flask and placed over hot water bath (90^0 C) for 20 min, proper mixing was done with occasional shaking. Then the solution was cooled, volume maintained to 250 ml water in a 250 ml volumetric flask and allowed solid particles to settle. The supernatant solution was taken and filtered through 0.45 micron filter. First few ml of supernatant solution was discarded and later used for HPLC analysis. Caffeine content was calculated in per cent on dry basis.

Plate 1: General view of the experimental block

Plate 2: Tagging the plants

Plate 3: Recording observations

Results and Discussion
The data on *per se* or mean performance of 41 arabica coffee genotypes for clean coffee yield during the year 2020-21 and 2021-22 is presented in table 3. Results revealed that clean coffee yield (kg/plant) and clean coffee yield (kg/ha) had shown significant difference among the 41 arabica coffee genotypes studied. During 2020-21, clean coffee yield per plant and per ha was ranged from 0.14 to 0.25 kg and 418.42 to 474.18 kg, respectively. Among the 41 arabica coffee germplasm collections, genotype S.2724 (Costa Rica collection) recorded significantly highest clean coffee yield of 0.25 kg/plant and 747.18 kg/ha which was on par with genotype Chandragiri (Check), S.2532 and S.1655 recorded 0.23 and 687.40 kg clean coffee yield each per plant and per ha, respectively and S.2608, S.2725, S.2502 and S.1482 registered 0.22 and 657.51 kg clean coffee yield each per plant and per ha each, respectively. While lowest clean coffee yield of 0.14 kg per plant and 418.42 kg per ha was observed in genotype S.1565, S.2511 and S.2660 each, respectively.

Table 1: Details of the Arabica coffee genotypes used for present study

Sl. No.	Name of the genotypes	Source
1.	S.1477	World collections
2.	S.1482	
3.	S.1484	
4.	S.1493	
5.	S.1495	
6.	S.1496	
7.	S.1497	
8.	S.1500	
9.	S.1502	
10.	S.1561	
11.	S.1565	
12.	S.1572	
13.	S.1573	
14.	S.1655	
15.	S.2501	Costa Rica collections
16.	S.2502	
17.	S.2503	
18.	S.2504	
19.	S.2505	
20.	S.2506	
21.	S.2507	
22.	S.2508	
23.	S.2509	
24.	S.2510	
25.	S.2511	
26.	S.2529	
27.	S.2532	
28.	S.2724	
29.	S.2725	
30.	S.2601	Ethiopian collections
31.	S.2602	
32.	S.2606	
33.	S.2608	
34.	S.2613	
35.	S.2616	
36.	S.2659	
37.	S.2660	
38.	S.2671	
39.	S.2672	
40.	Cauvery - Check	CCRI, selections
41.	Chandragiri - Check	

Table 2: Initial soil physical and chemical properties of experimental site

Particulars	Content
I. Physical properties	
P^H	5.63
EC (dS m^{-1})	0.17
II. Chemical analysis	
Organic carbon (%)	2.48
Available Phosphorus (kg ha^{-1})	26.21
Available Potassium (kg ha^{-1})	277.48
Available Calcium (mg kg^{-1})	539.40
Available Magnesium (mg kg^{-1})	250.91
Available Sulphur (mg kg^{-1})	13.68
Available Zinc(mg kg^{-1})	2.06
Available Ferrous (mg kg^{-1})	39.11
Available Copper(mg kg^{-1})	16.92
Available Manganese (mg kg^{-1})	37.32
Available Boron (mg kg^{-1})	0.97

Table 3: Performance of arabica coffee genotypes for clean coffee yield (kg/ha)

Genotypes	2020-21		2021-22	
	CCY (kg/plant)	CCY (kg/ha)	CCY (kg/plant)	CCY (kg/ha)
S.1477	0.15	448.31	0.11	328.76
S.1482	0.22	657.51	0.18	537.97
S.1484	0.20	597.74	0.16	478.19
S.1493	0.15	448.31	0.13	388.53
S.1495	0.20	597.74	0.17	508.08
S.1496	0.15	448.31	0.09	268.98
S.1497	0.15	448.31	0.11	328.76
S.1500	0.15	448.31	0.09	268.98
S.1502	0.18	537.97	0.14	418.42
S.1561	0.19	567.85	0.16	478.19
S.1565	0.14	418.42	0.09	268.98
S.1572	0.17	508.08	0.14	418.42
S.1573	0.16	478.19	0.14	418.42
S.1655	0.23	687.40	0.19	567.85
S.2501	0.21	627.63	0.18	537.97
S.2502	0.22	657.51	0.18	537.97
S.2503	0.19	567.85	0.16	478.19
S.2504	0.19	567.85	0.17	508.08
S.2505	0.18	537.97	0.16	478.19
S.2506	0.20	597.74	0.16	478.19
S.2507	0.19	567.85	0.17	508.08
S.2508	0.15	448.31	0.14	418.42
S.2509	0.17	508.08	0.14	418.42
S.2510	0.19	567.85	0.15	448.31
S.2511	0.14	418.42	0.10	298.87
S.2529	0.23	687.40	0.20	597.74
S.2532	0.19	567.85	0.16	478.19
S.2724	0.25	747.18	0.21	627.63
S.2725	0.22	657.51	0.18	537.97
S.2601	0.18	537.97	0.17	508.08
S.2602	0.16	478.19	0.15	448.31
S.2606	0.16	478.19	0.16	478.19
S.2608	0.22	657.51	0.16	478.19
S.2613	0.20	597.74	0.17	508.08
S.2616	0.15	448.31	0.10	298.87
S.2659	0.16	478.19	0.15	448.31
S.2660	0.14	418.42	0.13	388.53
S.2671	0.16	478.19	0.13	388.53
S.2672	0.16	478.19	0.14	418.42
Cauvery - Check	0.20	597.74	0.17	508.08
Chandragiri - Check	0.23	687.40	0.19	567.85
Mean	0.18	537.97	0.15	448.31
S.Em±	0.01	29.89	0.01	29.89
C.D. @ 5%	0.04	119.55	0.03	89.66

CCY – Clean coffee yield per plant

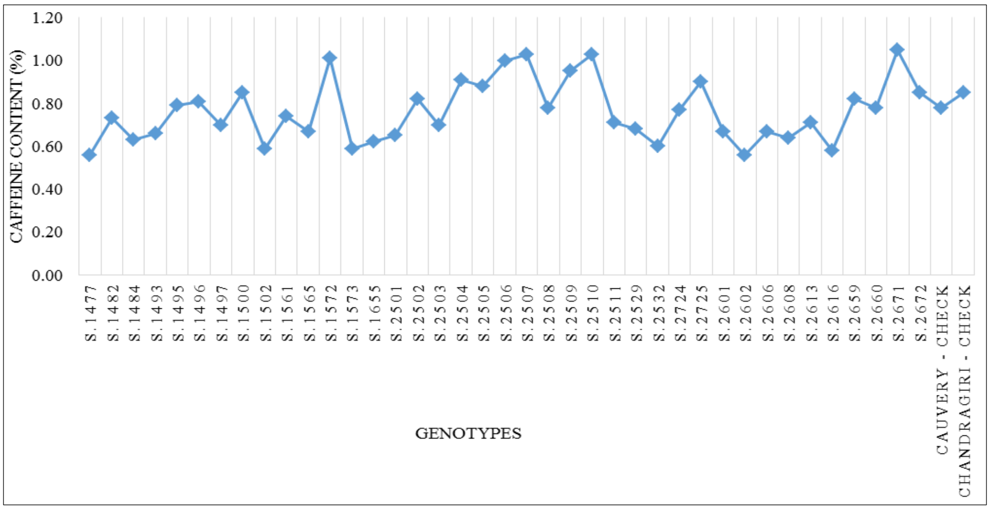

Fig 1: Performance of arabica coffee genotypes for caffeine content (%)

Data from table 3 during 2021-22 established similar results with respect to clean coffee yield per plant and per ha. Clean coffee yield per plant and per ha had shown significant difference among the 41 genotypes studied. Clean coffee yield per plant and per ha was ranged from 0.09 to 0.21 kg and 268.98 to 627.63 kg, respectively. Data from table 3 indicated that, significantly highest clean coffee yield per plant (0.21) and per ha (627.63) was displayed by genotype S.2724 which was on par with S.2529 (0.20 kg/plant and 597.74 kg/ha), Chandragiri (0.19 kg/plant and 567.85 kg/ha), S.1482, S.2501, S.2502 and S.2725 (0.18 kg/plant and 537.97 kg/ha, each respectively). Whereas, the genotypes S.1496, S.1500 and S.1565 demonstrated least clean coffee yield per plant (0.09) and clean coffee yield per ha (268.98), respectively. The values indicate the existence of large amount of variations among the genotypes. So, there is scope for considerable improvement in this crop through the characters studied and which shows the possibility to select best and exploit through selection. The significant difference observed for measured quantitative traits in this study are in agreement with the finding of earlier authors who reported considerable genetic variability within the Arabica coffee genotypes (Gichimu and Omandi, 2010, Olika *et al*., 2011, Atinafu and Mohammed, 2017, Kusolwa *et al.*, 2019 [5], Donkor *et al.*, 2020 and WeldeMichael *et al.*, 2020) [4, 6, 2, 3, 8].

Caffeine content (%) was showed significant difference among the genotypes (Fig 1) during the course of investigation. Caffeine content was ranged from 0.56 to 1.05 per cent. Significantly lowest caffeine content of 0.56 per cent was observed in genotype S.1477 and S.2602 which was on par with S.1573 (0.59%), S.2532 (0.60%) and S.1655 (0.62%) and it was followed by the genotypes S.1484 (0.63%), S.2501 (0.65%) and S.2608 (0.64%). While the genotypes S.2506 (1.00%), S.2507 (1.03%), S.2510 (1.03%) and S.2671 (1.05%). Similar findings were observed by Gichimu and Omandi (2010) [4], Olika *et al*. (2011) [6], Atinafu and Mohammed (2017) [2], Kusolwa *et al.* (2019) [5], Donkor *et al.* (2020) [3] and WeldeMichael *et al.* (2020) [8].

Conclusion

Significant variation was observed in the studied materials (arabica coffee) with respect to clean coffee yield and caffeine content (%) during both years of study 2020-21 and 2021-22. Selection of high yielding genotypes combined with low caffeine content genotypes would help for development of high yielding and good quality varieties by employing different breeding strategies.

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