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Response of Coffee Genotypes (Coffea Arabica) for Moisture Stress Condition at Tepi, South West of Ethiopia

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Abstract: *Shortage of moisture affected coffee production in South West of Ethiopia. However, little or no research has been done on the response of diverse coffee genotypes to moisture stress. The study was conducted at Tepi for two yearstargetingon identification of the growth responses of ten Coffea arabica varieties collected from Tepi, Bench Maji and Gambella areas. The seedlings of those genotypes were left to 30 days of moisture stress period followed by 15 days of re-watering. The experiment was conducted under rain shelter by arranging in a randomized complete block design with three replications. The plant growth responses to moisture stress was evaluated by measuring morphological characteristics and growth rate after stress and re-watering. A combined analysis showed that there is a significant difference among coffee genotypes on tap root length, total dry biomass, root to shoot ratio and specific leaf area. From the coffee accessions,74110 and 7454exhibited higher tap root length, total dry biomass and low specific leaf area, whereas as, the lowest total dry biomass and specific leaf area was observed fromAug-97. It is relevant to select 74110 and 7454 coffee varieties for their better resistance to moisture stress at early stage and cultivation at the recommended growing regions.*

Keywords: *Coffea arabica, Genotype, Moisture stress, Morphological characters, southwest*

1. INTRODUCTION

Coffee has a substantial source of income for the Ethiopian growers as well as world market contributing (Worku and Astatkie, 2010). The coffee market fluctuation in the international trade has been affected by the low production of coffee and its quality (ITC, 2010). South-West Ethiopia is well known for tropical humid and lowland crop cultivation including coffee. The area receives an annual average of 1500mm precipitation. However, the presence of erratic rainfall has created moisture stress during the critical period of coffee cultivation and the yield has been severely reduced.

Proper coffee plant growth and bean production requires sufficient moisture in addition to healthy environment. Drought at modest and extended period can abort flowering, diminished vegetative growth, bean yield, and plant death (Tesfaye et al, 2013). Moreover, the biochemical composition of coffee beans would also be modified by drought and erratic rainfall (Vineky et al, 2016).

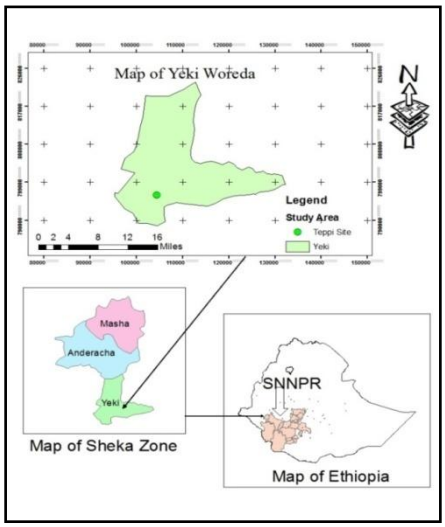
Researchers have been conducted in the area on improvement of coffee productivity and quality. Several promising coffee cultivar sin the area are identified but there is no information on the resistance of moisture stress among the identified coffee cultivars. DaMatta (2004) described that varieties which are more tolerant to drought generally differ on morphological characters and/or physiologically with mechanisms that allow them to produce comparable yield under limited water supply. For instance, genotypes with deeper root system enabled them to gain greater access from the bottom and maintain sufficient moisture. Most of the time, drought resistant plants are characterized by deep and vigorous root systems (Pinheiroet.al, 2005). Hence, identifying the best morphological and physiological characteristics of different coffee cultivars against moisture scarcity will lead to selection of potential coffee varieties for better coffee production and quality.

Hence, it is relevant to identify and cultivate moisture resistant coffee varieties in order to increase production and productivity of coffee while reducing the effect of climate change. Hence, the objective of this study is to identify drought resistant coffee varieties at early stage for increased coffee production.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The experiment was undertaken at Tepi National Spices Research Center (TNSRC). The center is found South-West of Ethiopia, located at 7.18^0N latitude and 35.42^0 longitudes E.It is 611Km far from Addis Ababa and have an altitude of 1200meter above sea level(masl). The mean maximum and minimum monthly temperature is 29.85^0C to 18.01^0C. The area is categorized as hot to warm humid and sub-humid low lands and receives an average annual rainfall of 1500mm.



(Source: Muktar and Yigezu, 2016)

Figure1. *Map of Working Area*

2.2. Experiment Procedures

The study was undertaken for two consecutive years. The experimental treatments include a combination of coffee varieties and water application. Ten coffee varieties were used in the study. The seed of coffee varieties was obtained from coffee accession maintained at Tepi National Spices Research Center (TNSRC) which was collected from Benchimaji, Tepi, and Gambella zones. The experiment was laid in a randomized complete block design and three replications. The seeds were sown in cylindrical black polythene bag under rain shelter condition to prepare recommended coffee seedlings. The experimental plot had nine pots and for each pot one coffee plant was allowed to grow. Uniform water amount was applied until the seedlings produce eight pair of true leaf for the selected genotypes. The seedlings were transplanted to the growing media containers having a size of 0.3m diameter with 0.40m depth under rain shelter condition. The growing media was composed of recommended mixture of forest soil (70%) and sand (30%) in volume basis. Water was supplied through water can at two days interval and all the nursery management were done based on the recommendation provided from TNSRC until eight pair of true leaves per plant produced. Then the seedlings of each genotype were subjected to two watering conditions including well-watered (control) and water stress.

2.3. Data Collection and Analysis

2.3.1. Stress Scoring

Coffee genotypes response to moisture stress was assessed visually at two-day-intervals since the first wilting symptom was observed. The degree of leaf folding or wilting was scored using 1 to 5 during morning and noon score at 1:00 pm and at 8.00am respectively. Each plant in a plot was assessed and the plot was given a mean stress score value.

2.3.2. Rate of Recovery

After the coffee varieties exposed for moisture stress for 30 days, they were re-watered at every three day intervals for two weeks. Then the number of plants producing new growths, recovered and died was counted to estimate genotypic differences during recovery period.

2.3.3. Plant Vegetative Parameters

Non- destructive plant growth parameters such as plant height, leaf area (Photoelectric Leaf Area Measure GDY-500), stem girth, number of nodes, number of leafs were recorded from a central parts of each plot. In addition, destructive plant growth parameters such as fresh and dry stems roots and leaves weight; root to shoot ratio, length of tap roots and lateral roots, and total dry matter were recorded by selecting from each plots. The oven drying plant tissues was done at 72 degree Celsius for 72 hours.

Specific Leaf Area: Drought and water stress have varying effects on specific leaf area. It is calculated as the ratio of leaf area to total dry matter.

SLA (m^2/Kg) = Leaf Area (m^2)/Total biomass (Kg)

2.3.4. Statistical Analysis

The collected data were analyzed using statistical analysis system (SAS) software version 9.0 using the general linear model (GLM). Significant differences between treatment means were tested by the F-tests, at P ≤005.

3. Result And Discussion

3.1. Plant Agronomic Parameters

3.1.1. Plant Height (Ph), Stem Girth (Gr), and Number of Nodes (NN)

Plant height was significantly affected by coffee genotypes and watering conditions (Table 1) at 5% significance level. The highest and shortest plant height was 65.73cm and 29.25cm measured from 7440 (well-watered) and Gesha (water stress) respectively as shown in Table (1). The widest stem girth was measured from 2097 genotype (8.22cm) under well-watered condition and the thinnest was J-21(4.09cm) from the water stressed condition. However, there is no statistical difference between genotypes on stem girth under water stress condition at 5% probability level. There was a significant variation of coffee genotypes between well watered and water stress condition on the number of nodes per plant. The maximum number of nodes were 12.0 from J-21 genotype under well- watered condition and a relatively few number was counted from Aug-97 genotype (8.0) under water stress condition.

Table1. *Plant height, Stem Girth, and Number of nodes*

Variety	Ph_cm		Gr_cm		NN	
	Ws	Ww	Ws	Ww	Ws	Ww
Gesha	29.25k	44.95e-g	4.12d	6.67b	9e-g	11a-e
J_21	30.00jk	44.23e-h	4.09d	6.61b	10c-g	12a
J-19	32.20i-k	45.45d-g	4.44d	6.84b	9fg	11a-d
2097	40.33f-i	58.92ab	4.78d	8.22a	9d-g	11a-d
Aug-97	40.58f-i	54.15bc	4.19d	6.38b	8g	10b-f
2079	36.25h-k	56.75bc	4.45d	6.34b	9e-g	11a-f
7454	38.40g-j	50.68b-e	4.58d	6.44b	11a-f	12ab
7440	42.98e-h	65.73a	4.14d	6.71b	10e-g	11a-d
74140	38.50g-i	58.25ab	4.90d	6.83b	10b-f	11.3a-c
74110	48.68c-f	53.38b-d	5.19cd	6.16bc	11a-f	12ab
LSD 5%	8.43		1.14		1.81	
CV	16.2		17.8		15.4	

Note: Figures followed by same letters with in a column are not significantly different at P ≤ 0.05

Ws referred to water-stressed and Ww refers to well watered condition

3.1.2. Number of Leaf(NL), Tap Root Length (TRL), and Leaf Area (LA)

As shown in Table (2), there was a significant difference on number of leaf due to genotype difference. There is also significant difference of coffee genotypes due to watering condition at P=5% level. The highest number of leaf was 49.8observed from 2079 genotype under well-watered condition. During water stress condition, most of the genotypes losses their leaf but Genotype 74110 showed better leaf count (24.0) while Aug-97remained with the least number of leaf per plant (12.0).

As shown in Table (2), both the TRL and leaf area has shown a statistical variation between genotypes at P=5%. Although the TRL was the longest in Gesha genotype (21.82cm) under well-water condition, the shortest TRL also measured from this itself (11.25cm) which revealeditsweakness to withstand moisture stress situation. Among water-stressed genotypes, genotype 74110(18.5cm) has elongated its root system to resist the soil moisture stress situation and has enabled to uptake deep soil's moisture.

The widest leaf area was observed from 7440genotype (70.75cm^2). However, under water stress condition, most genotypes decrease their surface leaf area. Genotype 2097has scored the smallest leaf area (33.11cm^2) but it has produced larger number of leaf.

From the above two vegetative parameters, genotype-74110 (37.09cm2) has increased its root length for better water uptake and reduce its leaf area to keep lesser plant moisture release. Drought resistant coffee genotypes tends to increase their root lengths to uptake deep soil moisture water through their deep root system and reduce their leaf area for improving plant water status (Poorter et al., 2012; Kufa and Burkhardt, 2011).

Table2. *Number of leaf, Tap root length, and Leaf area*

Variety	NL		TRL_cm		LA_cm^2	
	Ws	Ww	Ws	Ww	Ws	Ww
Gesha	17de	46.17ab	11.25h	21.82a	42.40e-g	61.46ab
J_21	21de	41.67ab	13.13f-h	14.95d-h	37.71fg	59.59a-c
J-19	20de	43.50ab	12.82gh	20.72ab	43.54d-g	64.21ab
2097	16de	41.50ab	14.97d-h	20.27a-c	33.11g	55.04b-e
Aug-97	12e	26.17dc	15.38c-h	17.77a-f	41.76fg	62.47ab
2079	19de	49.83a	16.13b-h	17.02a-g	35.87fg	55.76b-d
7454	20de	45.33ab	16.62b-g	18.68a-e	42.07fg	62.04ab
7440	17de	36.00bc	15.68c-h	19.85a-d	48.17c-f	70.75a
74140	23de	42.00ab	13.97e-h	17.18a-g	36.03fg	47.67c-f
74110	24d	40.67ab	18.50a-e	17.27a-f	37.09fg	44.53d-g
LSD 5%	11.53		4.94		12.91	
CV	33.5		25.8		23	

Note: Figures followed by same letters with in a column are not significantly different at P $\leq$ 0.05

Ws referred to water-stressed and Ww refers to well watered condition

3.2. Plant Dry Biomass

3.2.1. Shoot Dry weight(SDW), Root weight(RDW)

The shoot dry weight and root dry weight was highly affected by genotype difference under well watered condition at P=0.05 as shown in Table (3). However, both the SDW and RDW weren't statistically different between coffee genotypes to water-stress unlike genotypes kept under well-watered condition. The highest SDW was recorded from genotype2097 (23.78gram) under well-watered condition. The smallest SDW was measured onAug-97 (4.34gram) under water-stress condition and it has produced few numbers of nodes. The highest dry root mass was 5.42gram obtained from 2097genotype under well-watered condition but there is no significant difference between coffee genotypes with in water-stress edge no types though Gesha variety provides the least root dry matter (0.88gram).

3.2.2. Total Dry Biomass (TDB)

The TDB was significantly affected by genotype difference at P=0.05 as shown in Table (3). Although the largest dry mass of coffee genotype was measured ongenotype-2097 (29.2gram) under well watered situation, the TDB was very low due to its susceptibility to moisture stress. The smallest TDB was observed from Aug-97 genotype (5.27gram). The resistance for moisture stress among test genotypes, genotype-74110 has shown maximum dry mass (10.21gram). The highest shoot and root dry biomass is a result of better resistance to moisture stress and a similar result was attained from a study done by Robel et.al (2018).A more comparable TDB under water stressed genotype were seen from 74110-variety whereas most of coffee genotypes including 2097, 7440, Gesha, J-21, and 2079 has shown very low mass in comparison to the control treatment.

3.2.3. Root/Shoot Ratio(RSR)

The root/shoot ratio with in genotypes was highly affected by genotype differences at P=0.05 as shown in Table (3). The highest RSR was gained as 0.25 from control treatment of 74110 and the least RSR fraction was 0.13 recorded from Geshavariety under water stressed condition. Under moisture stress condition, higher RSR was exhibited by Aug-97 but its total dry biomass was very low as shown in Table (3). However, Genotype-74110 has attained significant and best RSR in addition to better total dry biomass.

3.2.4. Specific Leaf Area (SLA)

As shown in Table (3), the SLA was considerably affected by moisture and genotype variation at 5% significance level. The higher leaf area per kilogram dry mass of plant was attained from Aug-97 genotype (0.84m2/kg) under water stress condition which implied that the genotype has the least tolerance to moisture stress according to Aspelmeier and Leuschner (2006). Inversely the smallest SLA was obtained fromgenotype-74110 (0.39m2/kg) under water stress condition telling that the genotype has better adaptation to moisture stress condition. In addition, moisture stressed genotype-74110 has more comparative SLA with controlled treatment than the rest of water stressed coffee varieties

Table3. *Shoot dry weight, Root dry weight, Total biomass, Root/Shoot, and Specific leaf area*

Variety	SDW_g		RDW_g		TBM _ g		Root/Shoot		SLA _m^2/Kg	
	Ws	Ww	Ws	Ww	Ws	Ww	Ws	Ww	Ws	Ww
Gesha	6.60f	23.02a	0.88d	4.37a b	7.48e	27.38a	0.13c	0.18a-c	0.61bc	0.29 e-g
J_21	6.46f	20.98a	1.10d	4.71a	7.56e	25.69ab	0.17a-c	0.22ab	0.51cd	0.26 g
J-19	7.13ef	19.61a -c	1.14d	3.89a b	8.26e	23.49a-c	0.18a-c	0.20a-c	0.58b-d	0.28 fg
2097	5.85f	23.78a	1.14d	5.42a	6.99e	29.20a	0.187a-c	0.24a	0.56cd	0.21 g
Aug-97	4.34f	13.28c -e	0.93d	2.89b c	5.27e	16.17cd	0.22ab	0.20a-c	0.84a	0.47 e-f
2079	6.84ef	21.17a	1.09d	4.72a	7.93e	25.89a	0.175a-c	0.21a-c	0.49c-e	0.25 g
7454	7.17ef	19.92a b	1.04d	3.84a b	8.21e	23.76a-c	0.15bc	0.19a-c	0.51cd	0.29 e-g
7440	5.77f	21.39a	0.97d	3.84a b	6.74e	25.22ab	0.176a-c	0.19a-c	0.77ab	0.29 e-g
74140	6.04f	18.95a -c	1.17d	4.31a b	7.21e	23.26a-c	0.178a-c	0.23a	0.52cd	0.22 g
74110	8.55d-f	14.29b -d	1.65c d	3.76a b	10.21d e	18.05bc	0.188a-c	0.25a	0.39d-g	0.28 fg
LSD 5%	6.52		1.69		7.8		0.08		0.2	
CV	43.6		43.6		36.2		55.7		43.4	

Note: Figures followed by same letters with in a column are not significantly different at P ≤ 0.05

Ws referred to water-stressed and Ww refers to well watered condition

4. Summary And Conclusion

Arabica Coffee is one of the most economical crops to Ethiopian as well as for the world. Coffee production in Ethiopia especially in South-West Ethiopia is dependent on rainfall. Several researches have been conducted on coffee productivity and quality improvement. However, information on the moisture stress resistance is not identified for the coffee cultivars grown around Benchimaji, Tepi, and Gambellaareas of the South West Ethiopia region. For this reason, ten Arabica coffee cultivars were evaluated to their moisture stress resistance characteristics. The study has started in Tepi National Spices Research Center under rain-shelter condition, when the plant produced 8 pair of true leaves. The response for moisture stress between coffee genotype plant parameters was statistically affected at significance level of 5%.

The genotypes were selected for their best response during water stress condition. The highest tap root length was attained from genotype 74110 and 7454taken from moisture stress condition. The greater total dry biomass tested at moisture stress condition was exhibited by genotype-74110 and J-19 but genotype J-19 has given the least tap root length during stress. The best specific leaf area attained during water stress condition was by 74110 and 2079 but genotype 2079 has given relatively low total dry biomass during water stress condition.

It will be relevant to conclude that from the test coffee genotypes that have shown better result on tap root length/system, total dry biomass, and specific leaf area could have a greater influence on reducing moisture stress effect. Therefore, based on the above discussion, genotype 74110 and 7454 are the selected coffee genotypes in order to resist the effect of moisture stress at early stage of cultivation for a place where the crop grows at Tepi, Bench Maji and Gambella areas.

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REFERENCES

[1] DaMatta FM 2004. Eco-physiological constraints on the production of shaded and unshaded coffee: A review Field Crops Research 86: 99–114.

[2] F. Vinecky[1], F. Davrieux[2], A. C. Mera[3], G. S. C. Alves[1], G. Lavagnini[3], T. Leroy[4], F. Bonnot[5], O. C. Rocha[3], G. F. Bartholo[6], A. F. Guerra[6], G. C. R odrigues[7], P. Marraccini[1,4], and A. C. Anrrade[6,8]; 2016. Controlled irrigation and nitrogen, phosphorous and potassium fertilization affect the biochemical composition and quality of Arabica coffee beans. Journal of Agricultural Science, Cambridge, p.1-17, 2016 (online first doi:10.1017/S0021859616000988)

[3] International Trade Centre (ITC), 2010. Climate Change and the Coffee Industry Geneva: ITC. vi, 28 pages (Technical paper).

[4] Kufa T, and Burkhardt J., (2011).Stomatal characteristics in Arabica Coffee Germplasm Accessions under contrasting environments at Jimma, Southwestern Ethiopia. International Journal of Botany 7 (1): 63-72.

[5] Mohammed Worku and T. Astatkie, 2010.Growth responses of arabica coffee (Coffea arabica L.) varieties to soil moisture deficit at the seedling stage at Jimma, Southwest Ethiopia. Journal of Food, Agriculture & Environment Vol.8 (1):195- 200.

[6] Muktar BY, Yigezu TT (2016) Determination of Optimal Irrigation Scheduling for Maize (Zea Mays) at Teppi, Southwest of Ethiopia. Irrigation Drainage System Engineering 5: 173.doi: 10.4172/2168-9768.1000173

[7] Poorter, H., Niklas, K. J., Reich, P. B., Oleksyn, J., Poot, P., & Mommer, L. (2012). Biomass allocation to leaves stems and roots: Meta-analyses of interspecific variation and environmental control. New Phytologist, 193, 30–50. https://doi.org/10.1111/j.1469-8137.2011.03952.x

[8] Pinheiro HA, DaMatta FM, Chaves ARM, Loureiro ME, Ducatti C (2005). Drought tolerance is associated with rooting depth and stomatal control of water use in clones of Coffeacanephora. Annals. Bot., 96: 101-108.

[9] Robel A., Tesfaye S., Minda T., Addisu A., 2018. Growth Response of Hararghie Coffee Accessions to Soil Moisture Stress at Seedling Stage at Jimma, South West Ethiopia. Journal of Natural Sciences Research, ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online), Vol.8, No.9.

[10] Tesfaye S.G., Mohd R. I., Kausar H., Marziah M. and Ramlan M.F., 2013 Plant water relations, crop yield and quality(coffea Arabica L.) as influenced by supplemental deficit irrigation International Journal of Agriculture and Biology ISSN Print:1560-8530 ISSN Online: 1814-9596

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