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Some of the Morphological Parameters of Arabica Coffee Cultivars Seedlings as Affected by Planting Density and Fertilizer Rate

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Abstract

Morphological parameters of Arabica coffee are affected by competition for common resources. The objective of the study is to evaluate the effect of planting density and fertilizer rate on some of the morphological parameters of Arabica coffee cultivars seedlings. It was conducted at Jimma Agricultural Research Center in 2018. The experiment was conducted by using a completely randomized design with three replications. The treatments consisted of four population densities (one, two, three, and four plants per polythene tube) of cultivar-74110 and 75227, and three compound NPK fertilizer rates (control, 5 and 10g of NPK) were used. The result revealed that plant height, the absolute growth rate in terms of height, stem girth, taproot length, and leaf area was significantly ($P < 0.05$) affected by population density, fertilizer rate, and their interaction. PH (15.11cm), AGR (0.062cm), SG (2.91mm), and LA (89.43cm^2) were more enhanced at population density2, whereas maximum value of 18.40cm for TRL was obtained from population density3 in cultivar-74110. Similarly, the highest value of 17.97, 0.081 and 19.19 cm, and 116.9 cm^2 for PH, AGR, TRL, and LA were obtained from population density3, whereas the maximum value of 2.89cm for SG was obtained from population density1 in cultivar-75227, respectively. Therefore, the highest plant height, the absolute growth rate in terms of height, stem girth, taproot length, and leaf area were obtained from high population density which was treated by 5g of NPK fertilizer rate in both cultivars.

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Keywords

Coffee cultivars, Fertilizer rates, Morphology, Population density.

Introduction

The coffee plant is more suited for a high planting system and the productivity of densely planted is generally much greater than that of traditional plantings (DaMatta, 2004). It has been also reported that a closely planting space favors the individual coffee plant to utilize the environmental resources such as light, moisture, and nutrients throughout the growing period (Taye *et al.*, 2001). Plants adapt to constructing environment by bringing in some morphological and physiological changes. Plants respond to changing light conditions by adjusting a suite of morphological and physiological traits (Wubishet *et al.*, 2020).

The morphological parameters: plant height, stem diameter, root system, and leaf area have a good correlation with productivity and are very important components for coffee yield (Sakai *et al.*, 2013). Leaf area is one of the important parameters and it plays a determinant role in a light interception and, as a consequence, in processes such as vegetative growth,

development rates, photosynthetic efficiency, evapotranspiration, the use of nutrients and water, and even the response to fertilizers and productivity potential of the plant (Williams and Martinson, 2003; Blanco and Folegatti, 2005; Koester *et al.,* 2014). A dense planting system increases coffee seedling height and leaf area (Akunda *et al.,* 1979). In addition to this, coffee roots develop deeper so that they take up water and nutrients from lower soil horizons (Cassidy and Kumar, 1984). Therefore, the objective of the study is to evaluate the effect of planting density and fertilizer rate on some of the morphological parameters of Arabica coffee cultivars seedlings.

Materials and Methods

The study was carried out at the nursery site of Jimma Agricultural Research Centre (JARC) in Southwest Ethiopia in 2018. The study was carried out using a completely randomized design (CRD) with three replications. The treatments consisted of four population densities (one, two, three, and four plants per polythene tube) of cultivar 74110 and 75227 and three compound NPK fertilizer described by (Wubishet *et al.,* 2020) with rates of (control, 5 and 10g of NPK) were used for each cultivar. All pre-and post-sowing operations including mulching, water, shading, and weed control were applied as recommended (Tesfaye *et al.,* 2005). Data including plant height (PH), the absolute growth rate in terms of height (AGR) it was measured at two and six pairs of leaves from two plants (Reford, 1967), stem girth (SG), taproot length (TRL), and leaf area (Yakob *et al.,* 1998) were recorded. All relevant data were summarized and subjected to analysis of variance (ANOVA) using SAS 9.0 version (SAS, 2011). Treatment means separation was done by least significant difference (LSD) at a 5% probability level.

Results and Discussion

Plant Height and Absolute Growth Rate in terms of Height

The results revealed that PH and AGR in terms of height were significantly ($P < 0.05$) affected by population density, fertilizer, and interaction effect in both cultivars (Table1 and 2). PH and AGR in terms of height were more enhanced for the interaction effect of high population density (2 and 3) and application of 5g of NPK fertilizer in cultivar 74110 and 75227, respectively (Table2) and similar for population density and fertilizer (Table1). This might be related to competition for common resources, especially for light. As the intensity of shading increased due to high population densities, the plant tended to grow taller due to competition. The tendency for increasing height by shade adapted species for better use of light. In addition, densely shaded coffee plants undergo competition for sunlight and other growth factors, resulting in an increase in height. Other similar results have been reported, where the highest plant height was obtained from under shade conditions, due to adaptation mechanism to maximization of light interception by individual leaves (Biruk, 2018). This result was in agreement with the findings of Bote *et al.,* (2018a) who reported that Arabica coffee plants grown under shade level (70%, 50%, and 30%) including control, where 70% shade level was given highest plant height. Similar findings were reported that the high population density increases plant height due to competition among each other on Faba bean (Thalji, 2010); Maize (Brekke *et al.,* 2011b).

Stem Girth

The result showed that there was significant ($P < 0.05$) difference was observed among treatment for population density, fertilizer rate, and its interaction effect on both cultivars (Table1 and 2). High planting density (population density2) combined with the application of 5g of NPK resulted in higher stem girth for cultivar 74110, whereas one seedling per hole was higher in cultivar 75227 (Table1). The highest values of 3.78 and 3.49mm of SG were obtained from the interaction effect of population density 2 and 1 which was treated with 5g of NPK in cultivar- 74110 and 75227, respectively (Table2). This result is in line with the previous report on stem girth showed that there is a significantly affected on spacing or population density as well as nutrients (Sakai *et al.,* 2013; Musagomba, 2019; Santos *et al.,* 2020).

Taproot Length

Taproot length was significantly ($P < 0.05$) affected by population density, fertilizer rate, and its interaction effect on both cultivars (Table1 and 2). High planting density combined with the application of 5g of NPK resulted in a higher taproot length of cultivar 74110 than that of 75227 (Table1 and 2). Growth of the taproot length was more enhanced in cultivar 75227, probably because of genetic differences. In line with this, it has been reported that these cultivars were different in root growth nature; cultivar 74110 with shallow root while cultivar 75227 with deeper root growth nature (Behailu *et al.,* 2008).

Table.1 Effect of population density and fertilizer rate on PH, AGR, SG and TRL on both coffee cultivars

Factors		Cultivar-74110				Cultivar-75227			
		PH (cm)	AGR (cm)	SG (mm)	TRL (cm)	PH (cm)	AGR (cm)	SG (mm)	TRL (cm)
PD	1	12.87b	0.05c	2.78a	14.81b	16.23b	0.075b	2.89a	18.06b
	2	15.11a	0.062a	2.91a	18.32a	15.64b	0.065c	2.61b	18.86a
	3	13.51b	0.052bc	2.42b	18.40a	17.97a	0.081a	2.47b	19.19a
	4	13.58b	0.056ab	2.36b	18.28a	16.06b	0.060c	2.43b	19.09a
LSD (5%)		**1.22**	**0.01**	**0.26**	**1.13**	**1.09**	**0.01**	**0.23**	**0.79**
FR	0	13.84b	0.05b	2.89b	18.54b	16.95b	0.072b	2.96b	19.79b
	5	18.05a	0.09a	3.36a	19.99a	20.63a	0.109a	3.28a	22.29a
	10	9.41c	0.02c	1.61c	13.83c	11.84c	0.029c	1.56c	14.32c
LSD (5%)		**1.06**	**0.01**	**0.23**	**0.98**	**0.95**	**0.005**	**0.19**	**0.69**
CV (%)		**9.06**	**14.55**	**10.32**	**6.64**	**6.82**	**7.55**	**8.99**	**4.33**

Where, PD and FR are population density and fertilizer rate, respectively. Figures followed by same letters within a column for each factors are not significantly different at a 5% probability level.

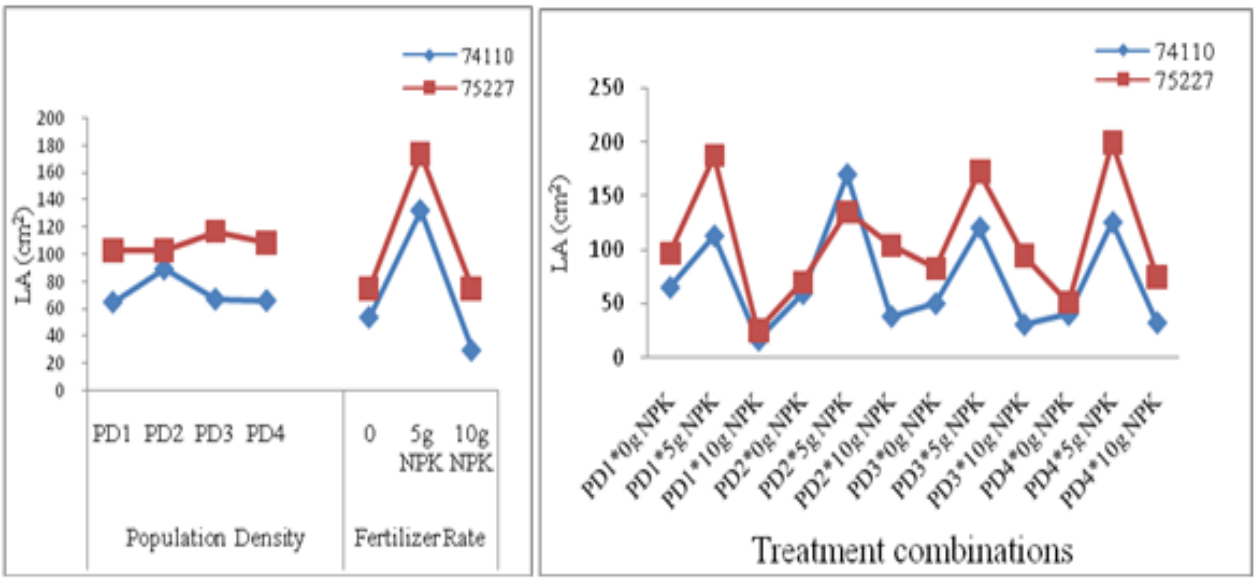
Table.2 Interaction effect of population density and fertilizer rate on different morphological parameters of coffee cultivars seedlings

Treatment Combinations	Cultivar-74110				Cultivar-75227			
	PH (cm)	AGR (cm)	SG (mm)	TRL (cm)	PH (cm)	AGR (cm)	SG (mm)	TRL (cm)
PD1*0g NPK	14.33cd	0.06cd	2.97bc	16.4de	17.17bc	0.079c	3.04ab	20.3bc
PD1*5g NPK	16.00c	0.067c	3.26b	18.23bcd	20.83a	0.122a	3.49a	23.67a
PD1*10g NPK	8.27e	0.016g	2.11d	9.80f	10.7e	0.022f	2.15c	10.22f
PD2*0g NPK	13.87d	0.045de	2.88bc	20.20ab	17.43bc	0.075c	2.95b	18.83c
PD2*5g NPK	21.47a	0.125a	3.78a	20.22ab	18.4b	0.087c	3.26ab	23.42a
PD2*10g NPK	10.003e	0.017g	2.07d	14.53e	11.1e	0.032ef	1.63d	14.33e
PD3*0g NPK	14.27cd	0.049de	2.97bc	19.58abc	17.7b	0.078c	2.83b	19.9bc
PD3*5g NPK	16.23c	0.073c	3.21b	20.82a	22.33a	0.123a	3.24ab	20.65b
PD3*10g NPK	10.03e	0.035ef	1.08e	14.8e	13.87d	0.041e	1.34d	17.02d
PD4*0g NPK	12.9d	0.041ef	2.72c	17.98cd	15.50cd	0.054d	3.02ab	20.14bc
PD4*5g NPK	18.5b	0.098b	3.18bc	20.68a	20.97a	0.104b	3.15ab	21.41b
PD4*10g NPK	9.33e	0.029fg	1.18e	16.17de	11.7e	0.023f	1.13d	15.71de
LSD (5%)	**2.12**	**0.015**	**0.48**	**2.41**	**2.063**	**0.013**	**0.51**	**3.089**
CV (%)	**9.06**	**14.55**	**10.32**	**6.64**	**6.82**	**7.55**	**8.99**	**4.33**

Figures followed by the same letters within a column are not significantly different at a 5% probability level.

Fig.1 (a) effect of population density and fertilizer rate on leaf area, LSD (5%) =13.59 and 8.2 for PD, 11.77 and 7.11 for FR, and CV (%) = 19.29 and 7.78 for cultivar-74110 and 75227, respectively, and **(b)** interaction effect of population density and fertilizer rate on leaf area, LSD (5%) =30.01 and 21.8 and CV= 19.29 and 7.78 for cultivar-74110 and 75227, respectively.

a ***b***



A similar report showed that coffee roots develop deeper in dense planting systems and they take up nutrients and water from lower soil horizons (Classidy and Kumar, 1984). In agreement with the present result, it has also been found that coffee root length is varying with plant density, genotype, and cultural practices (Cavatte *et al.*, 2008). In another study closely planted coffee results in better uptake of available soil nutrients by denser rooting (Van der Vossen, 2005).

Leaf Area

Leaf area was significantly ($P < 0.05$) affected by population density, fertilizer, and interaction effect in both cultivars (Figure1a and b). The highest LA (89.43 and 116.9 cm^2) was obtained from population density2 and 3 in cultivar 74110 and 75227, respectively, whereas the lowest (65.09 and 103.15 cm^2) was obtained from population density1 in both cultivars.

In addition to this, the highest LA (132.26 and 174.04 cm^2) in 5g of NPK and the lowest (29.84 and 74.76 cm^2 LA) in 10g of NPK were obtained from cultivar74110 and 75227, respectively (Figure1a). The highest values of 169.81 and 200.06cm^2 LA were obtained from population density2 and 4 which were treated by 5g of NPK in cultivar 74110 and 75227, respectively. However, the lowest LA was obtained from the interaction effect of population density1 with 10g of NPK (Figure1b). The result showed that a higher leaf area was obtained from high population density. A similar report showed that leaf area is more enhanced at high population density (Akunda *et al.*, 1979). The productivity potential of the plant is determined by the leaf area available for carbon assimilation (Pandey and Singh, 2011).

Plants adapt to constructing environment by bringing in some morphological changes. It was observed that population density and fertilizer rates, as well as their interactions, enhanced plant height, the absolute growth rate in terms of height, stem girth, taproot length, and leaf area. PH, AGR, TRL, and LA were more enhanced at high population density in both cultivars and a similar finding was observed for stem girth in cultivar-74110. In addition to this, 5g of NPK rate showed higher results for all parameters. It is advisable to consider the population density and nutrient management for a high coffee planting system.

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