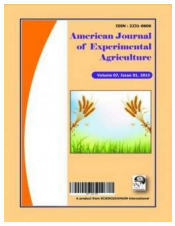

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Cacao Developmental Pattern, Soil Temperature and Moisture Variation as Affected by Shade and Dry Season Drip Irrigation

Idowu B. Famuwagun[1*]

[1]*Department of Crop Soil and Pest Management, Federal University of Technology, Akure, Nigeria.*

Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

Field experiments were conducted in Akure and Oda communities in Ondo state within the rain forest zone of Nigeria between 2010 and 2012. Single and combined effects of shade and irrigation were investigated on soil temperature, soil moisture variations and cacao seedling development and establishment on the field. The treatments involved included plantain shade alone, dry season irrigation alone, plantain shade + dry season irrigation and the control. Seedling vigor in terms of plant height, number of leaves and basal stem girth were significantly higher under no shade + irrigation compared to those obtained in the control plots. No significant difference in the basal stem girth of the cacao seedlings and the number of leaves produced between no shade +irrigation and shade + irrigation at the first nine months of the experiment. Soil temperature was significantly higher in the unshaded plots compared to other treatments. Shade alone and the combination of shade + irrigation was found to significantly reduce soil temperature and enhanced seedling survival compared to the non-shaded control plots. The results indicated a significant difference between the irrigated plots with shade and the unshaded control. Shaded plots + irrigation enhances soil temperature maintenance within the range of 26-32ºC throughout the four months of dry season and also improve percentage seedling establishment from less than 61.5% under the control plots to 99.12% under irrigation alone and irrigation + shade. Percentage seedlings survival was highest under irrigated plots with no record of stand mortality as they suffer less of moisture stresses during the dry season as recorded under non irrigated plots.

**Corresponding author: E-mail: ibfamuwagun@futa.edu.ng;*

Keywords: Establishment; root; seedling; shade; temperature.

1. INTRODUCTION

Effective shade management was the key factor pointed out by [1,2] on which the survival of transplanted tree crop seedlings depends. But with the current trend of changing weather and its deleterious effect on the aquiver, its negative impact on cropping systems especially in the area of available water during active crop growing season is calling for an effective soil water management (irrigation) especially during the dry season to achieve the goals of improved field survival and establishment in cacao. Cacao plantation establishment have been facing a lot of problems ranging from unavailability of improved planting materials, pest and diseases, high production cost, and low percentage survival after transplanting which is as a result of rainfall distribution pattern and the length of dry season that follows the season of transplanting [3,4,5]. Other factors included change in rainfall distribution pattern, increase soil and atmospheric temperature, extended dry season duration which are all the result of changing climate and other problems of field management [6]. Research reports have recommend the use of temporary shade plant in aiding cacao seedling survival on the field after transplanting but the best result from this if well managed was about 65-75% survival of the transplanted seedling [7]. This trend has in a long way discouraged the farmer leading to a sharp fall in the level of production in the continent especially in Nigeria. Therefore it is a worthwhile effort researching into ways of regulating the weather factors like soil and air temperature and soil moisture conditions as it affects cacao growth, development, survival and establishment on the field. The objective of the research is to evaluate the effect of single and combine application of plantain shade and irrigation on cacao seedling establishment, vigour of growth, root development, survival and soil temperature variation on the field.

2. MATERIALS AND METHODS

The field experiments were conducted at the Teaching and Research Farm of the Federal University of Technology, Akure and in Oda community (about 40 km from Akure) both in the rain forest zone of Nigeria between May, 2010 and May, 2012. The experiments were carried out to evaluate the effects of plantain shade and irrigation on cacao seedling establishment, vigour of growth, root development, survival and soil temperature variation on the field. The treatments are plantain shade alone, irrigation alone, irrigation + plantain shade and the control. The treatments were replicated three times in a completely randomized design.

Cacao seedlings were raised between January and May, 2010 in the nursery and were transplanted to a manually cleared forest land with two month's old established plantain suckers (for shade treatments) at a spacing of 3 x 3 meters on the two sites. Drip irrigation lines were laid out on the field at the base of the cacao seedlings (irrigated treatments) at the beginning of dry season (December 2010 and 2011) to enhance adequate moisture supply during the dry season. Water was applied once per week at two liters per plant for the four months of dry season. The shade plant (Plantain) were transplanted on the field at the ratio of one stand of plantain to one stand of cacao seedling. Growth and development of the seedlings, soil and air temperature of the experiment site and soil moisture variation both in the wet and dry season were monitored starting from the onset of the dry season for five consecutive months. The data collected include: plant height, stem girth, number of leaves, number of branches, taproot length, and number of lateral root, length of lateral root, % seedling survival and leaf area. The soil moisture was monitored with the use of tensiometer, while temperature with soil thermometer at about 14.00 - 15.00 pm at the depth of 15cm below the surface. The collected data were subjected to analysis of variance (ANOVA) and the means separated using Tukey test.

3. RESULTS AND DISCUSSION

3.1 Effects of Shade and Irrigation on Cacao Root and Shoot Development

From Tables 1 and 2, dry season irrigation alone significantly influenced higher plant height development, number of leaves produced, wider stem girth of seedlings and the number of branches developed compared with other treatments in the two locations. Treatment of shade + irrigation were lower in plant height, number of leaves and stem girth development compared with irrigation alone but was higher significantly over the shade alone and the control treatments. The lowest means were recorded

under the control treatments in terms of height, leaf production, stem girth development and number of branches produced.

In the 2010 experiment, cacao tap root was higher significantly compared with irrigation alone and irrigation + shade treatments. But in the 2011 experiment, irrigation alone treatment and combination of irrigation with shade showed no significant difference between each other but were higher significantly in tap root development compared with other treatments. Lateral root number and length, percent survival and leaf area development were enhanced by irrigation treatments (irrigation alone and combination with shade) which were significantly higher compared with those in shade alone and the control in both sites for the two experiments (Tables 1 and 2).

3.2 Effects of Shade and Irrigation on Soil and Air Temperature Variation within Cacao Canopy

Shade treatments significantly influenced soil temperature reduction within the cacao plantation as a significantly higher soil temperatures were recorded under irrigation alone and no-shade treatments compared to those in shade alone and shade + irrigation treatments. No significant difference between the two treatments involving shade, so also those with no shade were not differ significantly (Fig. 1). Fig. 2 showed the effects of shade and irrigation on air temperature within the cacao canopy. From the chart, it was indicated that shade enhanced air temperature reduction significantly compared with the treatments of no-shade as indicated in Fig. 2.

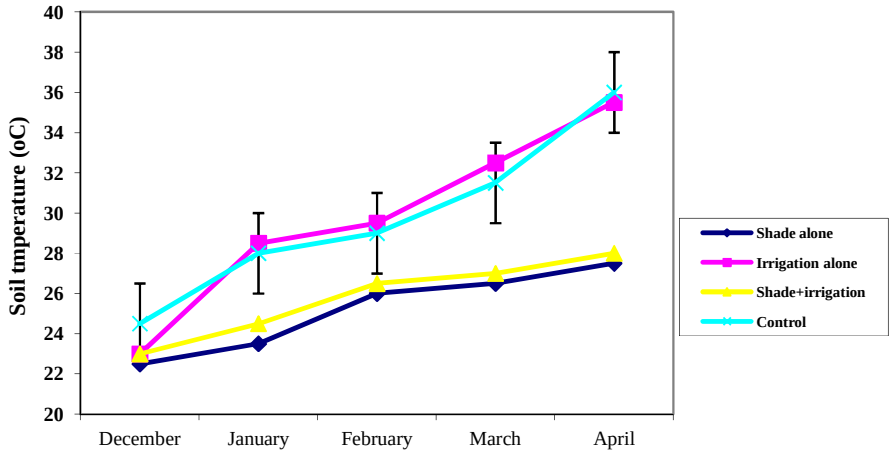

Fig. 1. Effects of shade and irrigation on soil temperature variation within cacao plantation

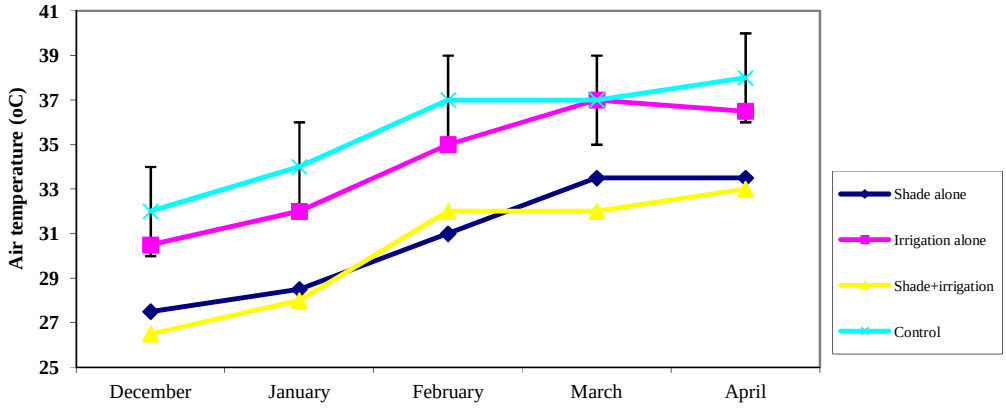

Fig. 2. Effects of shade and irrigation on air temperature variation within cacao canopy

Table 1. Effects of shade and irrigation on cacao shoot and root development (2010 experiment)

Treatment	Plant height (cm)		Number of leaves		Stem girth (cm)		Number of branches		Tap root length (cm)		Number of lateral root		Lateral root length (cm)		% survival		Leaf area (m^2)	
	FUTA	Oda	FUTA	Oda	FUTA	Oda	FUTA	Oda	FUTA	Oda	FUTA	Oda	FUTA	Oda	FUTA	Oda	FUTA	Oda
Shade alone	65.12c	69.16bc	45c	36c	2.3b	2.5b	19b	24b	60.06a	53.25b	26c	31c	45.1b	47.3b	53.4b	55.0b	1.84b	1.82b
Shade + Irrigation	75.33b	80.04ab	64b	59b	2.9b	2.9b	17b	20b	51.35b	49.04c	39b	45ab	52.1a	54.8a	95.7a	96.5a	2.88a	3.15a
Irrigation alone	90.12a	93.35a	79a	93a	3.6a	3.4a	29a	33a	50.58b	42.31c	43a	49a	55.6a	59.9a	97.4a	99.1a	3.12a	3.05a
Control	56.08d	60.34d	35d	31d	1.5c	1.8c	6c	8c	75.16a	71.81a	24c	22d	35.4c	36.6c	13.5c	14.2c	1.41c	1.38c

Table 2. Effects of treatments on plant shoot and root parameters (2010 experiment)

Treatment	Plant height (cm)		Number of leaves		Stem girth (cm)		Number of branches		Tap root length (cm)		Number of lateral root		Lateral root length (cm)		% survival		Leaf area (m^2)	
	FUTA	Oda	FUTA	Oda	FUTA	Oda	FUTA	Oda	FUTA	Oda	FUTA	Oda	FUTA	Oda	FUTA	Oda	FUTA	Oda
Shade alone	204.5b	217.5b	89.2ab	107.6b	4.6a	4.4ab	29.3b	34.1b	58.6b	52.3b	49b	52b	41.1b	42.2b	73.4b	74.6b	1.6b	1.52ab
Shade + Irrigation	255.3a	262.9a	103.1a	129.4a	4.9a	5.2a	37.8b	47.2a	85.1a	80.7a	57b	61ab	56.6a	58.8a	93.7a	91.5a	1.9b	1.54ab
Irrigation alone	285.7a	289.6a	101.8a	143.3a	6.3a	6.7a	56.4a	50.8a	80.2a	77.5a	81a	78a	61.9a	62.9a	96.4a	98.6a	4.4a	2.87a
Control	120.3c	141.7c	69.4c	60.2c	2.7b	2.7c	21..1c	17.5c	59.7b	57.3b	47bc	50b	38.1b	36.2b	61.5c	62.0c	0.97c	0.86c

The results showed that sole application of dry season irrigation and the combinations of dry season irrigation + plantain shade (ratio 1:1 of cacao and plantain stands) positively enhanced seedlings growth, extablishment and survival in most of the parameters measured during the experiment. The significantly taller plants, wider basal stem girth, and higher number of leaves produced under plots with sole dry season irrigation (No shade) was traced to un-hidered growth during the wet season due to direct acess to sunlight, sufficient soil moisture form irrigation during the dry season and continuous asymilate production both in wet and dry season for development which all give rooms for continuous growth and development throughout the period of experiment. Also, the effects of shade provided by the broad plantain leaves also help in reducing the impact of direct sunlight on the soil thereby reducing water loss due to evapration, soil temperature reduction, and reduction of moiture loss from the cacao leaves to evapotranspiration which was the reason for broader leaf area recorded under shaded + dry season irrigation plots. The above result was supported by [8] and [9], that application of dry season irigation enhance plant hiegth and leaf area development in pepper, plantain and cassava in a separate research. The significant decrease in the air and soil temperatue under the shaded cacao was in conformity with the findings of [10] that use of shade plant reduced evapotranspiration rate from cacao leaves thereby leading to a broader broader leaf area development.

The significantly high differeces recorded between irrigation + shade and the use of plantain shade alone implies that the traditional culture of depentding on shade alone for cacao seedling establishment on the field is no more giving the required result as the percentage survival decreases from about 98% to less than 65%. Moreso, the rate of shoot and root development was with a marked differences in the two trials indicating that the ability of the two sets of plant (shade+irrigation and shade alone) to withstand unforseen harsh weather condition will vary depending on their level of root development. This facts further coroborate the findings of [11,2] and [3] that extensive root development is a key factor to cacao seedling survival and establihment on the field. Marked significant difference recorded in the number of branches and number of lateral root produced between irrigated+shade and other treatments was as a result of abundant assimilate production which was patitioned to various parts of the plant for growth and development.

[12] reported that lateral root population was positively correlated to tree crop seedling survival and in a related experiment, [13] proved that the use of plantain shade promote root development and better seedling establishment in tree crops. With the current trend of changing climate, it is highly essential to adopt a proactive measure that is all encopasing in facing the chalenges of establishment of tree crops thrugh the use of natural shade plant and irrigation to forestore the rising soil temperature which is detrimental to root development and survival.

4. CONCLUSION

It is therefore concluded that incorporating drip irrigation with plantain shade enhances soil temperature maintenance within the range of 26-32ºC within cacao canopy during the months of dry season and also improve percentage seedling establishment. More so, seedlings survival under irrigated plots reduced cacao seedlings mortality to zero as they suffer less of moisture stresses during the dry season as recorded under non irrigated plots.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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