EFFECTS OF SOIL TYPES ON THE VEGETATIVE CHARACTERISTICS OF SORGHUM (*Sorghum bicolor* L.)

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Abstract:
Sorghum (Sorghum bicolor L.) is an important food crop in Africa and the fifth most important cereal grown in the world. The potential for sorghum to be the driver of economic development in Africa is enormous and continuous focused fundamental and applied research is essential to unleash sorghum's capacity to be the cornerstone of food security. Hence, the objectives of this paper are to estimate the effect of soil types on the vegetative characteristics of sorghum and to evaluate the differences in the vegetative characteristics of sorghum, to project the agronomical significance of the effect of soil types on sorghum production. This experiment was conducted in the Research farm of the Department of Crop, Soil and Pest Management of The Federal University of Technology, Akure, Ondo – State. The 5 treatments used are different soil types which are Loam, Sand Clay, Clay Loam, Sandy Loam and Sand Clay Loam replicated three times. The Improved seeds of sorghum were secured from IITA Ibadan, and a pot experiment was laid out in Completely Randomized Design (CRD). Seeds were sown, the irrigation and weed control were done manually. The data collected on sorghum plants are height at flowering, stem thickness, number of nodes peer plant, length of leaf per plant, number of inflorescences per plant, number of diseased leaves and leaf area. The data obtained were subjected to Analysis of Variance (ANOVA) using SPSS version 21 package and means were separated using Duncan's Multiple Range Test (DMRT). Sandy Loam appears optimal for sorghum cultivation, balancing vegetative and reproductive growth while minimizing disease. Loam supports vegetative growth but may require management to encourage flowering and reduce disease. Sandy Clay is least suitable, highlighting the need for soil amendments or alternative crops in such conditions.

Keywords: Soil types, Vegetative characteristics, Sorghum (Sorghum bicolor L.)

Introduction

Sorghum (*Sorghum bicolor* L.) is an important food crop in Africa, Central America and South Asia. It is the fifth most important cereal grown in the world, along with Wheat, Rice, Maize and Barley. It originates in Africa, domesticated in North Africa, possibly in the Nile or Ethiopian region around nearly 1000BC (Igwebuike et al., 2013) Sorghum bicolor is a monocot belonging to the family Poaceae, sub-family Panicoideae, and tribe Andropogoneae (Attala, 2002)

Sorghum (*Sorghum bicolor*) is the fifth most important world cereal crop after maize, wheat, rice and barley (FAO 2019) Sorghum is a staple crop in sub-Saharan Africa and Asia (Ajeigbe et at., 2017). The 5 biggest producers of sorghum bicolor in the world are United State (25%), India (21.5%), Mexico (11%), China (9%) and Nigeria (7%). Sorghum ranks among the top three most important grains in the country while its industrial demand is increasing particularly in beverage, food and livestock feed industries.

There is always a concern about where to cultivate sorghum across ecological zones, mainly for the soil types and climatic conditions (Aba et al., 2005). The potential for sorghum to be the driver of economic development in Africa is enormous and continuous focused fundamental and applied research is essential to unleash sorghum's capacity to be the cornerstone of food security (George et al., 2022).

Hence, the objectives of this study are to estimate the effect of soil types on the vegetative of sorghum and to evaluate the differences in the vegetative characteristics of sorghum, so as to project the agronomical significance of the effect of soil types on sorghum production.

Materials and Methods

This experiment was conducted in the Research farm of the Department of Crop, Soil and Pest Management of The Federal University of Technology, Akure, Ondo – State. The 5 treatments used are different soil types which are Loam, Sand Clay, Clay Loam, Sandy Loam and Sand Clay Loam replicated three times. These soil samples collected from the sampling pit were air dried, sieved and analyzed, following laboratory procedure of Canadian society of soil science (carter, 2003) used in determination of soil physical and chemical properties. The Improved seeds of sorghum were secured from IITA Ibadan, and a pot experiment was laid out in Completely Randomized Design (CRD). Seeds were sown, the irrigation and weed control were done manually. The data collected on sorghum plants are height at flowering, stem thickness, number of nodes peer plant, length of leaf per plant, number of inflorescences per plant, number of diseased leaves and leaf area. The data obtained were subjected to Analysis of Variance (ANOVA) using SPSS version 21 package and means were separated using Duncan's Multiple Range Test (DMRT).

Results

This section displays the results.

Table 1: Physical and Chemical Properties of the soil types

Soil properties	Loam	Sandy clay	Clay loam	Sandy loam	Sandy clay loam
pH	6.32	5.15	5.34	5.35	5..86
Organic carbon (%)	2.15	2.00	2.28	0.67	0.42
Organic matter (%)	3.70	3.43	2.21	1.16	0.72
Phosphorus (ppm)	0.74	0.02	0.03	0.06	0.45
Exchangeable cations (cmolkg^{-1})					
Ca^{2+}	14.30	16.00	11.60	14.40	11.20
Mg^{2+}	16.00	11.50	8.00	9.50	6.70
Na^{+}	0.51	0.30	0.39	0.34	0.50
K^{+}	0.34	0.12	0.19	0.14	0.34
Particle size (%)					
Sand	71.52	60.40	62.40	67.68	58.40
Silt	8.72	12.00	11.28	6.00	12.00
Clay	19.60	27.60	26.32	25.60	29.60

Table 2: Mean Performance of soil types on sorghum

Soil types	Height at flowering	Stem thickness	Number of node per plant	Length of internodes	Number of leaves per plant	Number of inflorescence per plant	Number of disease leaves
Loam	91.40ab	1.18a	10.00a	8.38ab	13.00a	0.00b	3.40a
Sandy clay	72.20b	0.69b	7.20bc	8.07ab	9.60c	0.00b	3.20b
Clay loam	73.40b	0.97ab	7.00c	8.89a	10.60bc	0.20a	2.40d
Sandy Loam	97.20a	0.96ab	9.00ab	9.01a	12.20ab	0.20a	2.40d
Sandy Clay Loam	76.60ab	0.98ab	8.00bc	7.41b	11.00abc	0.20a	2.80c

Means within a column followed by the same letter are not significantly different at P<0.05 according to Duncan's Multiple Range Test

Discussion

Table 2 above shows that for Height at Flowering, Sandy Loam (97.20cm) and Loam (91.40cm) soils produced the tallest plants, with Sandy Loam being significantly taller than Sandy Clay (72.20cm) and Clay Loam (73.40cm). Hence Sandy Loam and Loam likely offer optimal drainage and nutrient retention, promoting vigorous growth. Sandy Clay and Clay Loam may restrict root development or nutrient uptake due to compaction or poor drainage in line with the study of Ogunniyi (2017).

For Stem Thickness, it is revealed that Loam (1.18cm) had the thickest stems, significantly outperforming Sandy Clay (0.69cm). Other soils (Clay Loam, Sandy Loam, Sandy Clay Loam) were intermediate (0.96–0.98cm). The Thickness of the stems in Loam suggests better structural support and nutrient transport, possibly due to balanced soil properties. Sandy Clay's poor performance may reflect nutrient deficiencies or physical constraints as stated by Schapel et al. (2023).

As for Number of Nodes per Plant, Loam (10.00) had the highest node count, significantly more than Clay Loam (7.00) and Sandy Clay (7.20). Sandy Loam (9.00) and Sandy Clay Loam (8.00) were intermediate. More nodes indicate better branching and potential yield. Loam's superiority highlights its suitability for sorghum, while Clay Loam's compactness may limit node formation.

Furthermore, Length of Internodes in Clay Loam (8.89cm) and Sandy Loam (9.01cm) had the longest internodes, significantly longer than Sandy Clay Loam (7.41cm). Loam (8.38cm) and Sandy Clay (8.07cm) were intermediate. Longer internodes in Clay Loam and Sandy Loam suggest rapid vertical growth, possibly due to better water retention or aeration. Sandy Clay Loam's shorter internodes may indicate stress.

The Number of Leaves per Plant in Loam (13.00) had the most leaves, significantly more than Sandy Clay (9.60). Sandy Loam (12.20) and Sandy Clay Loam (11.00) were intermediate. Leaf count correlates with photosynthetic capacity. Loam's high leaf number suggests optimal growing conditions, while Sandy Clay's low count may reflect water or nutrient stress (Ismail & Ozawa, 2007).

The Number of Inflorescences per Plant in Sandy Loam, Clay Loam, and Sandy Clay Loam (all 0.20) had inflorescences, while Loam and Sandy Clay (0.00) had none. Inflorescence production is critical for grain yield. The absence in Loam and Sandy Clay could stem from imbalanced nutrients or delayed flowering due to excessive vegetative growth (Loam) or stress (Sandy Clay).

The noticed higher incidence of diseased leaves in Sandy Clay (3.20) and Loam (3.40) soil especailly suggest that the soil type may create conditions favourable to pathogen spread. Loam soils, characterized by a composed mixture of clay, sand and silt,, offer optimum moisture holding and nutrient accessibility beneficial for the growth of plant, but can likewise favour the existence and activities of some soilborne pathogens when the soil is not properly managed. Also, Sandy Clay soils, which have the highest content of clay, can preserve moisture more efficiently, making it potentially liable to waterlogged conditions that foster diseases such like Fusarium root rot disease (Yan & Nelson, 2022)

On the contrary, lower disease incidences detected in Clay Loam and Sandy Loam soils (2.40) may be credited to their better aeration and drainage features. Sandy Loam soil, with higher sand content, aids better water permeation and diminish moisture levels that are favourable for the development of pathogen. Clay Loam soils, while retentive to moisture, may have a structure that restricts pathogen survival and movement, thereby minimising incidence of diseases.

The results of this study are consistent with earlier studies that have demonstrated the effect of soil texture on disease expression. For example, Ghorbani et al. (2008) emphasized the importance of soil physical properties in suppression, with soils that have intermediate texture properties able to support the development of beneficial microbial communities that would outcompete pathogens. Conversely, soils that are extreme in texture, such as pure sands or clays, may drain too rapidly or hold too much moisture, either of which may interfere with the microbial composition and favor disease epidemics (Ghorbani et al., 2008).

Additionally, the relationship between soil texture and environmental factors like moisture and temperature has been demonstrated to influence the severity of diseases. Research has suggested that particular pathogens flourish under certain temperature and moisture conditions, which are determined by soil type. As a result, it is essential to comprehend the intricate interactions between soil characteristics and environmental elements for successful disease management.

To conclude, the varying rates of disease occurrence related to different soil types highlight the necessity of factoring in soil texture and structure when developing disease management approaches. Implementing strategies like optimizing soil drainage, revising irrigation timings, and increasing organic matter content can alter soil conditions to create an environment that is less conducive to pathogen growth, ultimately decreasing disease rates and enhancing plant well-being.

Conclusion and Future Works

Sandy Loam appears optimal for sorghum cultivation, balancing vegetative and reproductive growth while minimizing disease. Loam supports vegetative growth but may require management to encourage flowering and reduce disease. Sandy Clay is the least suitable, highlighting the need for soil amendments or alternative crops in such conditions. Further research could explore soil specific nutrients or water interventions to improve performance in suboptimal soils.

It is therefore recommended that sandy loam is the best soil for sorghum but monitoring of soil health, appropriate irrigation and adopting proper measures to control disease are required in order to experience maximum productivity. Also, precision agricultural approach is required in further research so as to ascertain sorghum production in different soil types in terms of water efficiency and accurate fertilizer rate.

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