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WATER DEFICIT ON SEEDLING GROWTH OF THREE VARIETIES OF KENAF (*Hibiscus cannabinus* L.)

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ABSTRACT

The effect of water deficit on the seedling growth of derived values of three certified improved varieties of kenaf (*Hibiscus cannabinus* L.) was investigated. The plants were grown in the Agricultural Garden at Imo State University, Owerri. The crop plants were subjected to three irrigation regimes representing well-watered control, moderate stress, and severe water stress. Each watering treatment was replicated three times in a split-plot design with irrigation treatments as the main plots and the varieties as the sub-plots. Water deficit profoundly reduced all aspects of vegetative growth including plant height, collar diameter, and leaf dry matter production as revealed by agromorphological parameters. The moderate stress attained an average height of 77.45cm and severe stress 68.58cm thus reduced height by 24% and 33% of the control that attained a mean height of 101.67cm respectively. Collar diameter growth of severely stressed plants was reduced by 33% of the control having a basal diameter of 7.06mm, moderate stress retarded growth by 26% and the plants reached a radial diameter growth of 7.80mm when compared with the control that recorded a basal diameter growth of 10.55mm. Holistic assessment of agromorphological parameters showed that water deficit significantly retarded growth resulting to 47.61% performance for the severely stressed plants, 66.67% for the moderately stressed plants and 100% for the control.

KEYWORDS: Seedling Growth, Agromorphological & Plants

INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.) is a non-woody fiber crop that belongs to the family Malvaceae. It is a fast-growing herbaceous annual crop with slender straight stems. Kenaf originated from East Central Africa where it is traditionally cultivated for cordage. It is an important crop source of textile fibers all over the world for the production of twines, ropes, burlap bags and rug backing (Wilson*et al.*,1965). Only the bast or outer bark fibers are used in the manufacture of these products. Kenaf is frequently grown as a vegetable in some countries where the tender upper leafy portion of the plant is used for food. The crop has become an important jute fiber substitute.

Research has shown that kenaf is a crop plant with the potential to supply fiber for the production of paper pulp (Clark *et al.*, 1969; Muchow, 1981). As a non-woody plant, the stem contains two distinct fiber types the bast or the outer bark fibers (Comparable to softwood fibers), and the inner core of short wood fibers (comparable to hardwood fibers), both of which may be utilized in pulp production (Francio *et al.*, 1992). It is a fast-growing crop plant and can reach an average height of 3.5 meters in 150 days. Economic analysis of kenaf production shows that company land capable of growing the plant would produce raw material at roughly half the price of producing pulpwood and 3-5 times as much as pulpwood per hectare could be produced annually. In addition, Kenaf also competes well with major crops like corn, cotton, and soybean with yields of 10 to 15 metric tones per hectare (Moore *et al.*, 1976).

Drought is a regular feature of most plants of sub-Saharan Africa and water deficit has been found to decrease the yield of Kenaf (Ogbonnaya*et al.,*1997a). However, the resulting decreases in fiber dimensional properties brought about favorable changes in coefficient of flexibility and Runkel ration indicating that the paper produced will have good strength properties (Ogbonnaya*et al.*,1997b). Water deficit is known to affect every aspect of plant growth, modifying its anatomy, morphology, physiology, and biochemistry (Hsaio, 1973; Enukwesi, *et al.*,1986). Ogbonnaya*et al.*,1992) studied the effectof water stress on *Gmelina arborea* and found that although water deficit reduced the volume of wood produced and changed wood fiber properties, the quality of pulp and paper produced were not significantly affected.

Water deficit is not always injurious to plants. Although it reduces vegetative growth, it sometimes improves the quality of plants products (Kramer, 1983). Mild stress has been found to increase the rubber content of guayule and desirable aromatic properties of Turkish tobacco (Wolf, 1962). From these observations, Ogbonnaya *et al.*, (1997b) suggested that some level of water deficit may actually be required to improve the qualities of fiber crops. However, the level of water deficit that will improve the seedling growth and will not adversely affect the establishment and proper development has to be determined for each crop species.

MATERIALS AND METHODS

Certified seeds of kenaf (*Hibiscus cannabinus* L.) were collected from the National Root Crops Research Institute, Umudike, Abia State, Nigeria. Three cultivars namely: Tainung #2, SF 459 and Everglades 41 were used for the study. These varieties were chosen on the basis of their high seedling growth establishment and disease resistance. This experiment was conducted at the Agricultural garden, Imo State University, Owerri, Imo State, Nigeria; situated at latitude 5^0 10^1N and $6^0 0^1$N and longitude $6^0 35^1$E and $7^0 0^1$N in the southern eastern zone of Nigerian, on a deep loam sandy soil. The experiment was based on a split-plot design replicated 3 times. The three irrigation regimes constituted the main-plots and three kenaf varieties as the sub-plots. The three watering treatments were replicated three times to give a total of 27 experimental units.

The experimental field was uniformly irrigated to field capacity by watering and allowed to drain before seeding. The seedlings were subjected to uniform irrigation at weekly intervals from sowing to 21 days after sowing. This was to ensure uniform seedling establishment before the imposition of the treatment. The watering treatments were manually applied to the plots using a watering can of 10 liters capacity as a measuring device. It was applied manually due to the non-functional sprinkler irrigation system. Water deficit treatments were imposed on the test plants three weeks after germination when they had attained four-leaf stage. The standard rain gauge was mounted in the field in order to measure the quantity of water added to the plants through rainfall. Outlined below were the three levels of irrigation regimes the experimental plots were subjected to:

- **Control (L1):** The plants received a total of 650mm of irrigation during the growth period to serve as the control. Under this regime, the crop plants received 20.3mm of irrigation twice weekly throughout the experimental period.

  The quantity of water (liter) applied was obtained from the relationship.

  1mm of irrigation/rainfall = 1litre/m^2.

- **Mild Water Deficit (L2):** The plants receive 14.1mm of irrigation twice a week giving rise to a sum total of 450mm of irrigation for the two months period.

- **Severe Water Deficit (L3):** The plants under this regime were mostly stressed by subjecting them to 7.8mm of irrigation two times a week which amounted to a total of 250mm of irrigation for the two months duration.

Three plants were randomly harvested at each sampling session from the experimental plots. The plants were cut at ground level and the following growth parameters measured: Plant height, collar diameter, dry matter production, plant water relation, and transpiration rate.

DISCUSSION OF RESULTS

Growth

Plant height, stalk diameters, and dry matter production were the parameters employed in assessing growth.

The study revealed that height growth was significantly reduced by water deficit in all the varieties. That drought reduces plant height and vigour is well known. Water stress and salt stress are the most severe environmental stresses to which plants may be subjected. Kramer (1963) reported that the alteration witnessed by growth parameters under water stress is due in part to the role of water in turgidity maintenance necessary for cell enlargement. Physiological studies indicate that both photosynthetic capacity and carbohydrate metabolism are altered in response to stresses.

Growth in plants may be defined as the irreversible increase in volume, which is brought about by the activities of cell division and cell enlargement at the apical and lateral meristems. Cell division has been shown to decrease as water deficit increases since cells apparently must attain a certain size before they can divide (Doley and Leyton, 1968). Studies by earlier researchers have confirmed that water deficits adversely affect all aspects of plant growth including plant height and rot-collar diameter (Kramer, 1983; Enukwesi *et al*, 1986 and Ogbonnaya *et al.*, 1997).

The performance of any plant in terms of dry matter production is directly dependent on the pattern of its leaf area development in response to solar energy and carbon dioxide perception. This means that the amount of light intercepted for any given location and growth duration is primarily dependent on leaf area development, which has been shown to be directly linked with leaf turgor (Bunce, 1977; Wenkert *et al.*, 1978). Leaf growth is the most vulnerable of plant processes to water stress and is regularly inhibited in field crops (Hsaio, 1973; Schulze and Mathew, 1993). Different plants develop different strategies for environmental stress adaptation. In this study, kenaf was observed to adopt the mechanism of 'leaf rolling' and stomatal closing to avoid/limit water loss. Though this was an efficient way of managing stress in terms of water loss, however, it was disadvantageous to the plant in the sense that it leads to a decline in photosynthetic capacity due to a decrease or complete stoppage of carbon dioxide assimilation (Muchaw *et al.*, 1986; Nwalozie and Annerose, 1996). Water deficit drastically reduced the leaf area, and leaf dry matter of kenaf leading to poor leaf expansion and defoliation. This was found pronounced among the plants that were severely starved of soil moisture.

Plant Water Relations

Leaf Gaseous Exchange

Kenaf like other plants requires flux of CO_2 and water vapor via the stomates for its normal metabolic activities. One of the commonest strategies adopted by kenaf in response to water stress isstomatal closure, which interferes with the flux of CO_2 as well as water vapor. It was observed in this experiment that kenaf plants in the stressed plots rolled their leaves as soil moisture stress intensifies. These two mechanisms exercised by kenaf could be described as drought avoidance by Levitt (1980).

Stomatal conductance showed an initial increase with maturity. This increase was dramatic in the severely stressed plants of two varieties – Tainung #2 (V1) and SF 459 (V2). This initial increase was followed by a sharp decline at the10th week of growth in all the levels of the treatments (Fig 4.5 a-c). The dramatic rise in stomatal conductance observed by these two varieties could be attributed to the nature of their roots or even to the palmate or divided nature of their leaf shape suggesting that either the plants obtain enough water through the roots to withstand drought conserve water owing to the reduced surface area of the leaves characteristics of these varieties.

Transpiration rate in kenaf decreased with age in contrast to stomatal conductance, but the response was rather erratic. Low transpiration rates were recorded by the varieties with palmate (divided) leaves and the severely stressed plants scored the least when compared with Everglades 41 with cordate (undivided) leaves. Also noticed in this study was the sharp increase in the rate of transpiration experienced by nearly all the treatment levels at the 10th week of growth following irrigation.

Kenaf has been described as desiccation tolerant (Fransois *et al*., 1992). Cowpea is another crop plant that shows a similar response (Hall and Schuize, 1980; Nagarajah and Schuize, 1983). This response enables plants to avoid dehydration by maintaining leaf water potential at relatively high levels. This ability might be due to membrane resistance or osmotic adjustment mechanisms triggered when water stress arises above the critical point of -0.5 MPa among desiccation tolerant plants with this strategy, kenaf could, therefore, be described as opportunistic in relation to water availability, high rate of stomatal conductance and transpiration when soil water is readily available but with markedly reduced leaf conductance and transpiration rates when water is limited. This assertion contrasts with some crops, for example, wheat, which utilizes water sparingly when it is available but has an only a gradual decrease in photosynthesis as water deficits set in (Hensen*et al.,* 1989).

CONCLUSIONS

Studies have shown that water stress is not always destructive because even though it retards vegetative growth, it sometimes enhances the quality of plant product (Kramer, 2005). Following the findings of this study and that of other researchers, it can be generally concluded, therefore, that some level of water deficit is needed to improve seedling growth and qualities of crop plants. Hence moderate water stress is recommended for the cultivation of kenaf for fiber production.

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