Indian J. Plant Physiol., Vol XXVII, No. 2 pp. 190—200 (April 1984)

SOME ASPECTS OF GROWTH OF *ADANSONIA DIGITATA* L.

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SUMMARY

The effects of three nitrate sources on the growth as well as the effects of water stress and the antitranspirant, Vapor Gard (VG), on transpirational water loss and on the growth of *Adansonia digitata* were investigated. All three sources of nitrate, potassium nitrate (KNO_3), ammonium nitrate (NH_4NO_3) and magnesium nitrate ($Mg(NO_3)_2$) significantly enhanced shoot heights with NH_4NO_3 giving the highest growth at an application rate of 175 kg ha^{-1}. Only KNO_3 significantly enhanced root growth when it was applied at 100, 125 or 150 kg ha^{-1}. The highest dry weight values for both below-and above-ground tissues were obtained with KNO_3 application at 200 kg ha^{-1} followed by NH_4NO_3 at 125 kg ha^{-1}.

The oldest leaves of all plants subjected to water stress senesced and abscised while the remaining leaves showed acute symptoms of wilting and transpired less towards the end of each stress cycle. In contrast, plants which were sprayed with VG before being water-stressed did not shed their leaves, showed only minor symptoms of wilting and transpired much less. However, untreated plants and plants which were sprayed with VG but which were well watered had higher fresh and dry weights than the former two treatments. The application of KNO_3 or NH_4NO_3 as a nitrogen source in raising young plants of this species is recommended and the foliage treatments with VG during periods of water stress will prolong their survival in the field.

INTRODUCTION

In an earlier study (Etejere and Osatimehin, 1983), it was found that the low population density of *Adansania digitata* in the field might be primarily due to the dormancy of its seeds. Since many factors contribute to the successful development of plants to maturity, the authors decided to look at some aspects of the growth of this species.

Growth of many plants may be limited more often by a deficiency of nitrogen in the soil. One reason for this is the large requirement of nitrogen by plants. Viets (1965) calculated that plants contain more atoms of nitrogen than any other element except hydrogen derived from soils. The ploughed layer of the majority of cultivated soils contains between 0.2-0.4% N by weight. Application of nitrogen to soils is therefore, of major importance in fertilizing plants. Wilson (1975) also reports that under favourable conditions there is a linear response to the applied levels of N up to 180 kg N ha^{-1} in tea plants.

The potential for water conservation through transpiration reduction is of great importance because at least 99% of the water absorbed from the soil by a plant is transpired into the atmosphere (Gale & Hagan, 1966). Gale & Hagan (1966), Zelich (1969) and Etejere (1982) have shown that transpiration may be reduced by the application of chemical compounds that increase leaf resistance to diffusion of water vapour. Such chemical compounds that have been referred to as antitranspirants. The potential use of antitranspirants to decrease transpiration in crops thereby increasing growth through more efficient use of soil moisture in semi-arid regions has received considerable attention (Paljakoff-Mayber & Gale, 1972; Olofinboba, Kozlowski and Marshall, 1974 and Slatyer & Bierhuizen, 1964).

This study therefore, aims at determining the growth response of *A. digitata* when supplied with various sources of nitrogen and also the effects of water stress and the antitranspirant Vapor Gard (VG) on its growth and on its transpirational water loss. Vapor Gard forms a thin film or coat on the surfaces of leaves after its application. Information from these investigations would be of importance in the formulation of nitrogen fertilization, and water requirement programmes matching the requirement of the crop at the critical early of its growth.

MATERIALS AND METHODS

Effects of Nitrate Sources on Plant Growth

Three different sources of nitrate were investigated. These were potassium nitrate (KNO_3), ammonium nitrate (NH_4NO_3) and magnesium nitrate ($Mg(NO_3)_2$). *Adansonia digitata* acid-scarified seeds were sown in loamy soil contained in 20 cm plastic pots at a depth of 3 cm (Etejere & Osatimehin, 1983). Emerging seedlings were thinned down to one per pot. After the expansion of two cotyledonary leaves, a nitrate salt was applied evenly to the surface of the soil in the pot at rates of 100, 125, 150, 175 and 200kg ha^{-1}. Subsequent watering of the soil enabled the salt to percolate into the soil. In order to simulate field conditions, the pots were transferred to an open field. Control pots had no nitrate source. All plants were watered daily. All treatments were replicated five times.

Growth of the plants was evaluated 8 weeks after treatments. Growth analysese we performed by measuring the heights of the main shoot. Thereafter the soil with the plant was carefully removed from each pot minimising root destruction. The plants were washed in running tap water to remove all traces of soil particles adhering to the plant roots. The length of the primary roots was measured and the plants separated into above-and below-ground tissues. They were dried in an oven at 60°C to constant weight in order to obtain the dry weights of above-and below-ground tissues. All data were subjected to Duncan's Multiple Range Test (Ducan, 1955).

Effect of water stress and Vapor Gard on transpirational water loss and plant growth

Eight-week old plants (1 plants pot^{-1}) were raised in pots as previously described. The plants were divided into four groups A, B, C and D, each group containing five plants. All the plants were then watered and the following morning to prevent weight loss by evaporation from the soil surface, each pot was completely wrapped with aluminium foil, thus leaving the stem and the leaves of the plants exposed to the atmosphere.

Group A plants were then weighed on a Mettler balance(PC440) to obtian initial weight of each pot plus plant. The plants were then subsequently weighed daily at 10.00 a.m. and the amount of water lost during the previous day was added to the soil through a needle mounted on a syringe. Group B plants were subjected to the same treatments exept that they were water-stressed by with-holding water until the plants showed signs of wilting. The plants were then watered by gradually replacing the total amount of water lost during the stress period and then repeating the stress cycle. Periods between watering averaged ten days. Group C plants had similar treatments like Group A plants except they were initially sprayed on the foligage with Vapor Gard (VG)* at a rate of 2.58 kg ha^{-1} by using a spray-eze-atomiser. Group D plants were treated exacty like Group B plants except that they were initially sprayed with 2.58 kg ha^{-1} VG. At the end of the determination for each day, the total leaf area of each plant was determined by using and Aristo Planimeter (Aristo 1130 EL)**. Transpirational water loss was determined as water loss 100 cm^{2-1} leaf surface. All the plants were maintained in an environment with a twelve hour day and alternating 30 ± 3°C day and 24 ± 2.5°C night temperatures. Plants were harvested at the end of thirty days and growth determined as previously described.

RESULTS

Effects of nitrate sources on growth

Plant shoot height was significantly enhanced by the application of

*Pinolene formulation

**Aristo-Werke, Dennert & Pape K.G., Hamburg, Germany.

nitrates to the soil. Ammonium nitrate gave the highest value of 46 cm for shoot height when it was applied at 175 kg ha^{-1} but decreased to 38 cm at 200 kg ha^{-1} (Fig. 1). Although $Mg(NO_3)_2$ and KNO_3 gave lower values when compared with NH_4NO_3, they also significantly enhanced the growth of the shoots in all the rates of application that were tested.

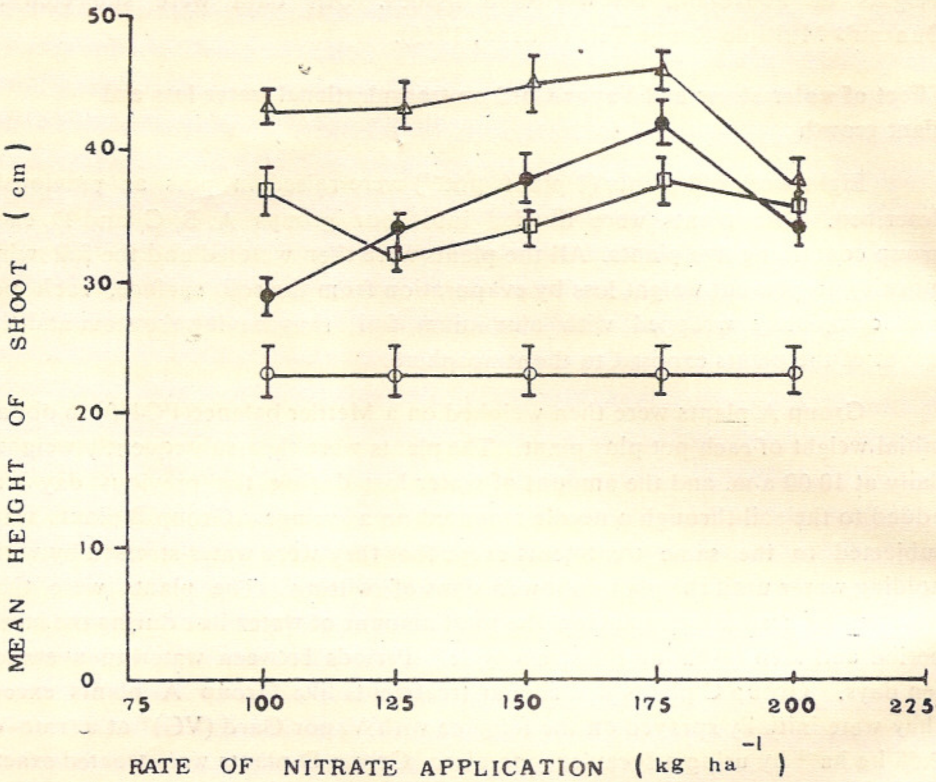

Fig. 1. Effect of various sources of nitrate on shoot height of *A. digitata*. Shoot height was measured 8 weeks after nitrate application. O. Control, ● Mg $(No_3)_2$, □ KNO_3, △ NH_4 No_3.

Plant root length was also significantly enhanced by the application of KNO_3 especially at 100, 125 or 150 kg ha^{-1}. The other two nitrate sources had no significant effects (Fig. 2.).

The three sources of nitrates significantly increased dry weight of above-ground tissues but had no significant effect on dry weight of below-ground tissues (Fig. 3). Ammonium nitrate at 100 or 125 kg ha^{-1} enhanced dry weigh of above-ground tissues up to 3.1 g while higher rates of 150, 175 or 200 kg ha^{-1} decreased dry weight even though these rates enhanced shoot height. In contrast, KNO_3 and $Mg(NO_3)_2$ at low rates of 100 or 125 kg ha^{-1} decreased dry

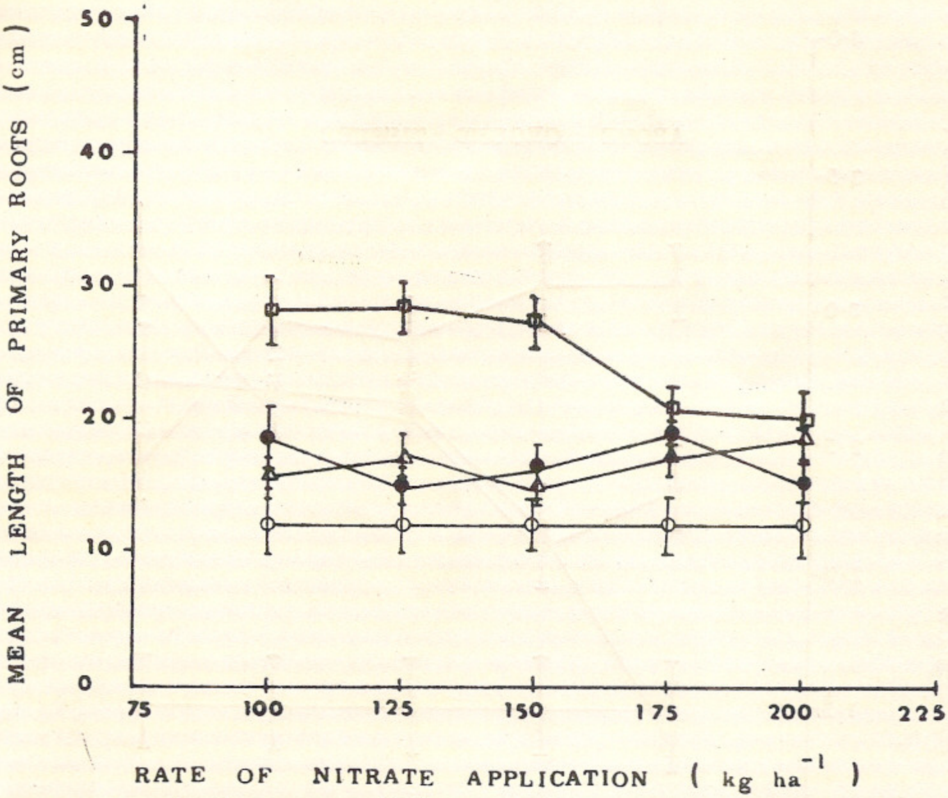

Fig. 2. Effect of various sources of nitrate on primary root length of *A. digitata*. Root length was measured 8 weeks after nitrate application. O Control ● Mg $(No_3)_2$ □ KNO_3, △ NH_4NO_3.

weight of above-ground tissues but enhanced the dry weight at higher rates of application (Fig. 3). Potassium nitrateg ave the greatest dry weight of 3.2 g at 200 kg ha^{-1}.

Effects of water stress and Vapor Gard on water loss and growth

Water loss

All the groups of treated plants significantly reduced water loss through their surfaces (Fig. 4). Water-stressed plants transpired more water after replenishment of the soil moisture and transpired less towards the end of each stress cycle. Similar observation was also made for plants which were sprayed with VG before being water-stressed, although this was more pronounced with the former group. Plant which were sprayed with VG and which were well watered significantly reduced water loss on the average during the 30-day period by approximately 15.8% when compared with the control plants. Water loss by this group of plants was significantly reduced during the fiirst 16 days afteɹ

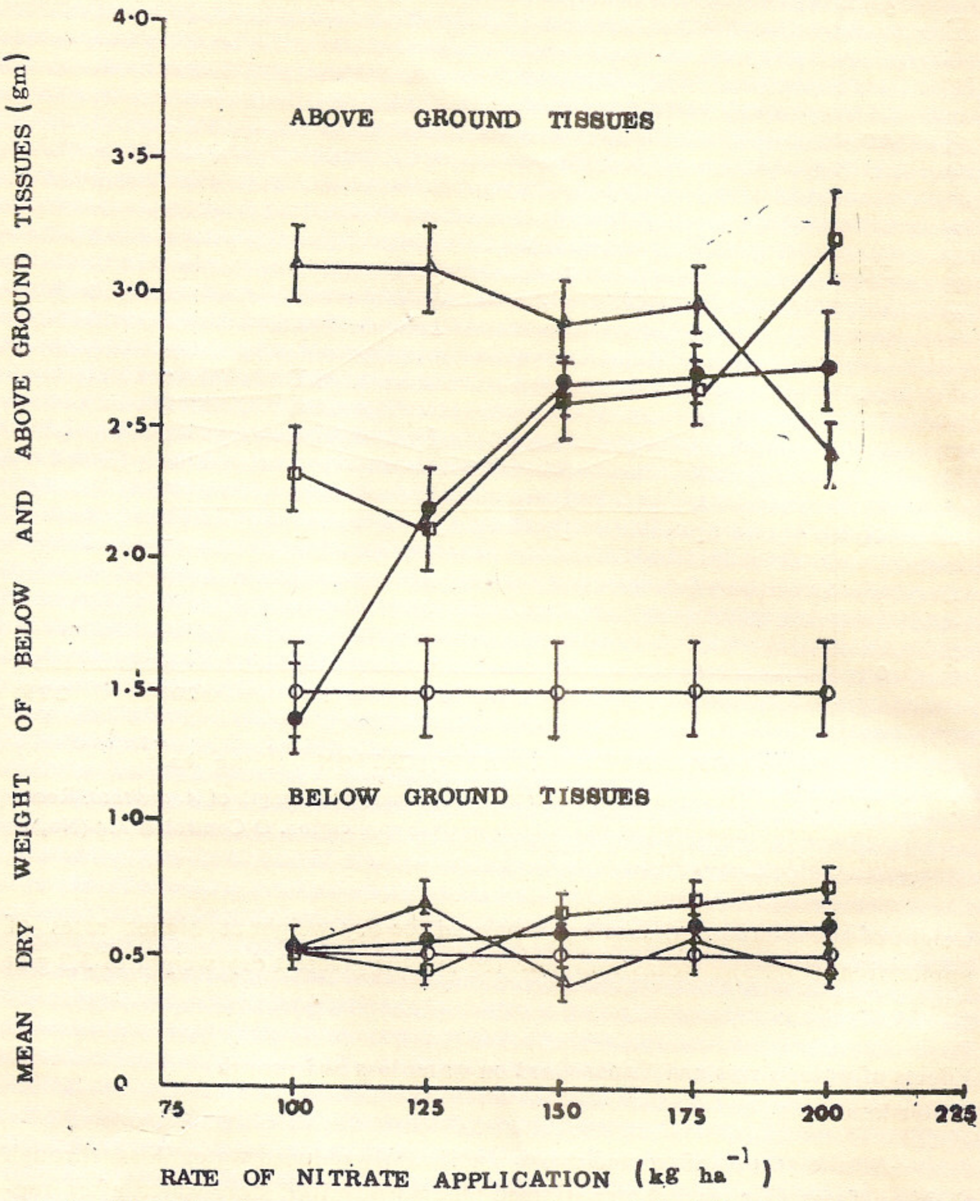

Fig. 3. Effect of various sources of nitrate on dry weight of above-and below-ground tissues of *A. digitata*. Data were obtained 8 weeks after nitrate application. O Control ● $Mg(NO_3)_2$, □ KNO_3, △ NH_4NO_3.

treatment but water loss increased at the 18th day reaching approximately 94% of controls on the 28th day. The greater reduction of water loss of approximately 64.6% and 70.4% respectively by water-stressed plants and plants sprayed with VG before being water-stressed may be due to (a greater extent) the scarcity of

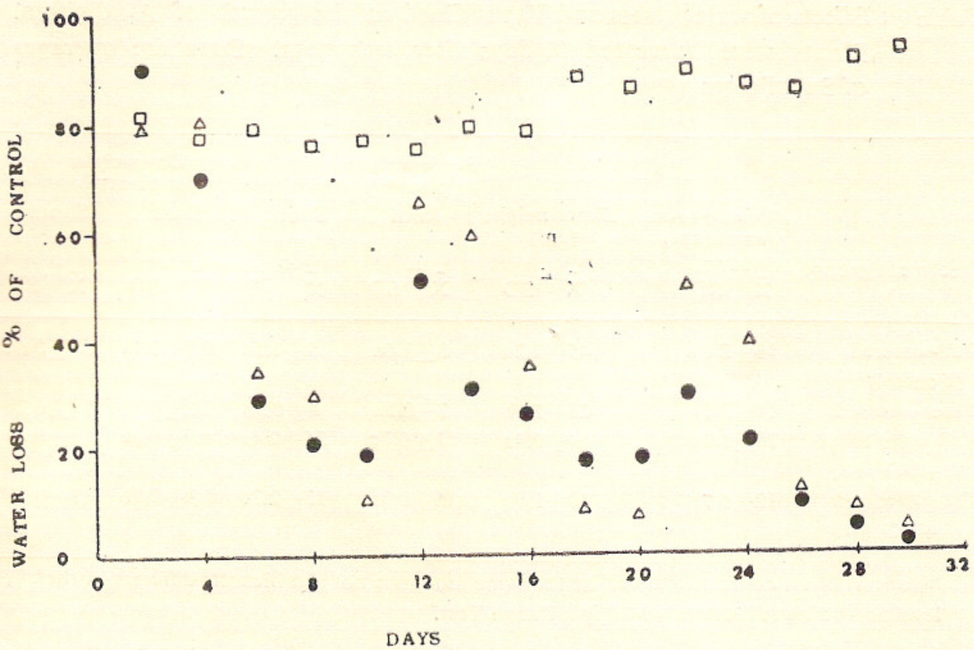

Fig. 4. Water loss from plants of *A. digitata* subjected to water stress and Vapor Gard (VG) treatment. Data are averages of 5 replicates. ● Water stressed + VG. □ Well watered + VG, △ Water-stressed.

water. Water-stressed plants showed severe symptoms of wilting and their oldest leaves senesced and abscised during the 2nd and 3rd stress cycles. Plants which were sprayed with VG before being water-stressed showed only minor symptoms of wilting especially towards the end of the 2nd and 3rd stress cycles; and did not shed their leaves. The latter group of plants showed a higher rate of recovery than the former when their soils were replenished with water.

Growth

Water-stressed plants produced longer primary roots although these roots were tiny in structure (Table I). No significant differences were observed in root length between control and the two other groups of plants. Except for plants which were sprayed with VG and which were well-watered, all the groups of treated plants had their shoot height significantly different from control plants (Table 1). The fresh weight of roots and shoots of all the treated groups was also significantly different from control plants except the fresh weight of roots of plants sprayed with VG before being water-stresed. Plants which were sprayed with VG and which were well-watered had the greatest fresh root and shoot weight while water-stressed plants had the lowest weight (Table 1). Although plants which were sprayed with VG and which were well-watered had

Table I : Effects of water stress and Vapor Gard on the growth of A. digitata. Plants were harvested 30 days after treatment. Data are averages of 5 replicates

Treatment group	Primary root lengh (cm) $\bar{x} \pm$ SD	Shoot height (cm) $\bar{x} \pm$ SD	Fresh weight ($g\ plant^{1-}$) Root $\bar{x} \pm$ SD	Fresh weight Shoot $\bar{x} \pm$ SD	Dry weight ($g\ plant^{-1}$) Root $\bar{x} \pm$ SD	Dry weight Shoot $\bar{x} \pm$ SD
Well-watered (Control)	14±2.6a	45±2.2a	8±1.0a	19±1.5a	0.7±0.1a	2.9±0.6a
Water-stressed	18±3.1b	23±2.1b	2±0.5b	8±0.9b	0.2±0.1b	0.9±0.2b
Well-watered +VG	15±1.3a	44±0.4a	12±0.7c	24±2.4c	0.7±0.3a	2.7±0.5a
Water-stressed +VG	12±1.7a	38±1.9c	6±0.9a	13±2.2d	0.3±0.3b	1.1±0.8b

Means within a column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

significantly different fresh root and shoot weight, their dry weights were not significantly different from that of controls. The dry weight of roots and shoots of the other two groups of treated plants was however significantly different from those of control plants.

DISCUSSION

It has been clearly demonstrated with mature stands of wheat (Croy & Hageman, 1970) and maize (Zieserl, Rivenbark and Hageman, 1963) that addition of nitrate to the soil enhances the level of leaf protein. In *A. digitata*, the plants supplied with nitrates were found to have higher growth and produced more dry matter when compared with control plants (Figs. 1-3). There was a general increase in dry matter production of above-ground tissues with increase in $Mg(NO_3)_2$ or KNO_3 applications while there was a decrease with increase in NH_4NO_3 application (Fig. 3). The non-significant effect on dry matter production of below-ground tissues with nitrate application shows that nitrates applied to the soil tend to be more effective in the dry matter production of above-ground tissues, especially since these are the sites of food manufacture. Thomas & Thorne (1975) and Thorne & Blacklock (1971) have also reported similar results on stiff-strawed varieties and on short varieties of wheat plants, respectively. It has also been suggested by various workers that the rate of ion uptake is influenced by the nature and level of counter ions present in the nutrient medium or soil (Claassen & Wilcox, 1975; Cox & Reisenauer, 1973, and White, 1973). Several investigations also indicate that non-toxic additions of NH_4^+ to the nutrient media can inhibit uptake of NO_3^- by roots of higher plants, although the inhibition does not always occur (Haynes & Goh, 1978). However, Rufty, Jackson and Raper, (1982) found in all their experiments that root NO_3^- reduction was restricted by the presence of ambient NH_4^+. Since a number of studies show that increased rates of ion uptake may be associated with higher dry weights (Hatrick & Bowling, 1973), it could be inferred that NO_3^- from NH_4NO_3 is best taken up by *A. digitata* roots at application rates lower than 150 kg ha^{-1} while NO^-_3 from KNO_3 is better taken up above 175 kg ha^{-1}. However, the reaction of plants to different nitrate forms as reflected in this study, could also be partly due to pH changes in the soil medium (Bigg & Daniel, 1978).

The results shown in Figure 4 clearly show that transpirational water loss is relatively proportional to the amount of water present in the soil. The plants from all the treatments transpired more water when the water content of the soil was high and transpired less when the soil water was low. The 15.8% reduction in transpirational water loss by plants sprayed with VG and which were well-watered was due to the presence of VG. The antitranspirant VG which forms thin films on the surfaces of leaves cover up a high proportion of stomatal pores thus reducing the diffusion of water vapour to the atmosphere. These observations have also been reported by various workers (Slayter & Bierhuizen, 1964; Olofinboba *et al.*, 1974). Thus the slight increase in water loss beginning from the 18th day may be caused by the degeneration of the thin film of VG on the leaf surfaces thus exposing more stomatal pores to the atmosphere. The significant difference between control plants and stressed groups of plants was largely caused by the stress conditions. The available water to the stressed plants seem to be used to saturate water-starved cells leaving little amounts to be transpired. The application of VG to reduce water loss and thus prolonging the survival of plants under stress conditions may be very useful in the field. This is better appreciated when one considers that the plants which were sprayed with VG and subjected to stress conditions retained their leaves, showed only minor symptoms of wilting and generally looked more heatly than unsprayed stressed plants. The former group of plants also had higher fresh and dry weight than the latter group (Table 1). Although plants which were sprayed with VG and then well-watered had higher fresh weight than control plants, the latter group showed a higher amount of dry matter production. This suggests that although conservation of water through the use of antitranspirants may lead to expansion growth of the plant tissues, such treatments may not necessarily lead to the production of dry matter. It should also be realized that film forming antitranspirants inhibit photosynthesis by covering stomatal pores, a pathway for atmospheric carbon dioxide (CO_2) entering the leaf tissue. The application of NH_4NO_3 or KNO_3 as a nitrogen source in raising young plants of

A. digitata in the field is encouraged. Similarly, regular foliage treatments of this species with more effective concentrations of VG during periods of high temperatures or water stress will prolong the survival of the young plants.

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