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Comparison of indices of plant water status in two (*Celosia argentea* L. and *Amaranthus dubius* Mart. ex Thell) tropical leaf vegetables.

Resumen. Se estudió la relación entre los índices de contenido de humedad foliar conocida como contenido de humedad relativa (RWC), potencial osmótico, potencial de humedad foliar y la resistencia a la difusión de vapor de agua en la hoja (LDR). Las comparaciones entre índices se hicieron entre *A. dubius* y *C. argentea* creciendo la humedad de campo (lujuria) y humedad restringida (inadecuada).

Las relaciones fueron diferentes entre hojas jóvenes (superiores) y maduras (inferiores) y entre las dos hortalizas creciendo a diferentes contenido de humedad.

El potencial de humedad foliar en las hojas jóvenes es menor que en las maduras de *A. dubius*, proceso inverso cuando la planta crece con poca agua. Las hojas de *C. argentea* presentan un comportamiento similar, cuando crecen a capacidad de campo, incrementando significativamente en las hojas jóvenes bajo humedad restringida. Por cada unidad de descenso en el RWC en ambas especies, *A. dubius* sufrió una pérdida mayor en el potencial de humedad foliar que *C. argentea*

Para un valor dado de RWC, el LDR en plantas creciendo a humedad de campo mostró ligeros aumentos en *A. dubius* y ninguno en *C. argentea* tanto en hojas jóvenes como maduras. El LDR fue mayor en las hojas jóvenes de ambas especies sometidas a déficit de humedad.

Several researchers (5, 6, 7, 8, 12, 13), have studied the effect of plant water status on physiological processes. Four indices of water status are often used: leaf relative water content (RWC), sap osmotic potential (π), leaf tissue water potential (Ψ), and leaf water vapour diffusion resistance (LDR).

Shepherd (6, 7, 8), reported that the relationships between the indices and transpiration are not simple. However, it is worthwhile trying to elucidate the relationships because of their relevance to study of water movement in plants, plant growth analysis and modelling, and resistance to drought.

This paper compares the response of two tropical leaf vegetables, *Amaranthus dubius* and *Celosia argentea*, grown under conditions of field capacity and at limited water supply. The comparisons of relationships between the indices are made within and between the plant species.

Material and methods

Seeds of *A. dubius* and *C. argentea* were sown in sandy clay loam soil (20.6% clay) at the University of Ife Agricultural Farm, Ile-Ife.

The indices of plant water status considered are:

– leaf relative water content (RWC), which is the moisture content as a percentage of the fully saturated moisture content, was estimated according to Barrs (1);

– sap osmotic potential and leaf tissue water potential were determined using a simple termocouple psychrometer as described by Shepherd (8); and

– leaf water vapour diffusion resistance (LDR) was measured between 0900-1600 hours on young (upper) and old (lower) leaves attached to the parent plant, using an aspirated diffusion prometer as described by Byrne *et al* (2).

The first three indices were determined at 0900 and 1200 hours each day; and at two other times on three days per week on detached leaves. Each determination was carried out on young (upper) and old (lower) leaves, excluding damaged and senescent ones.

The experimental period for both species extended from the first week to the tenth week after germination, when the plants were harvested.

The two species were supplied with water at two levels. The treatments were imposed on two replicates of each species. One replicate of each species was watered so that the soil was approximately kept at field capacity, which will be referred to as 'luxury' plants. The other replicate was supplied water at one week intervals, resulting in frequent wilting, which will be referred to as 'inadequate' plants

Linear regression analysis was used in fitting straight line relationships, and curves were fitted by inspection since this paper is concerned with their relative locations rather than with their shapes.

Results

The relationships of RWC to sap osmotic potential and leaf water potential

For a given RWC in *A. dubius*, osmotic potential was significantly lower for young than for old leaves of the luxury plants ($P < 0.01$) with means -25 and -19 bars respectively. The difference was not significant in the inadequate plants, although the osmotic potential was slightly lower for younger leaves than for older leaves. The corresponding leaf water potential values (Figures 1a and 1b) were significantly lower in young leaves than in old ones in the luxury plants ($P < 0.01$), whereas the reverse is true for the inadequate.

The osmotic potential of *C. argentea* young leaves at all times was generally about 1 bars lower in the old leaves for both the luxury plants ($P < 0.01$) and the inadequate plants ($P < 0.01$). The corresponding values of leaf water potential (Figures 1c and 1d) were similar for the young and old leaves of the luxury plants, whereas in the inadequate plants the values were significantly higher ($P < 0.01$) for young leaves as compared to old leaves. As with *A. dubius* plants, reversal of the relationships of osmotic potential and leaf water potential to RWC was greater for the inadequate than for the luxury plants.

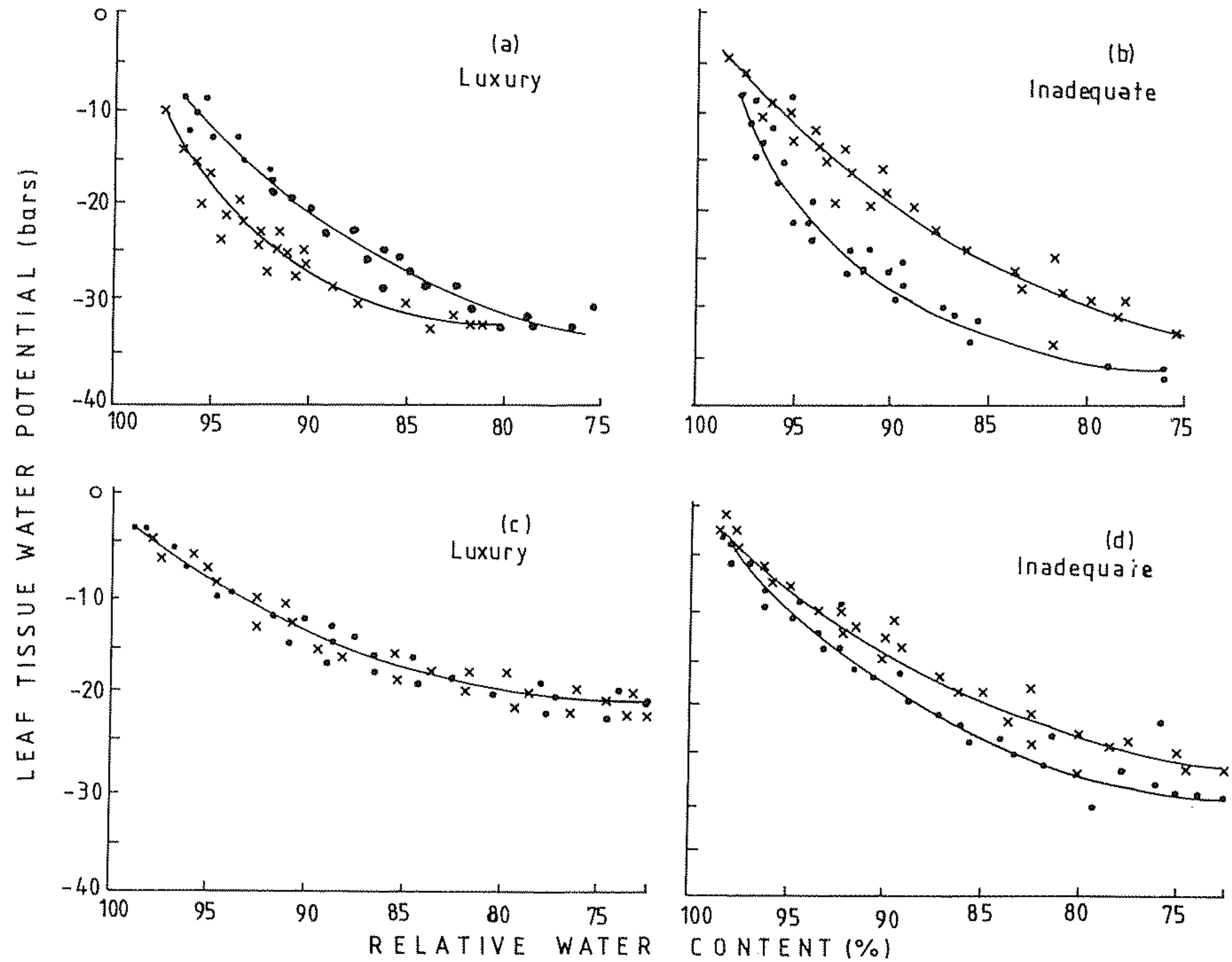

Fig. 1 Relations between RWC and leaf tissue water potential for younger (x) and older ( ) leaves (a) and (b) *Amarantus dibius*, (c) and (d) *Celosia argentea*

The relationships of RWC to leaf water vapour diffusion resistance (LDR)

In the luxury *A. dubius* plants, at a given RWC, the LDR of the young leaves was less than for the old leaves ($P < 0.01$), whereas in the inadequate plants, LDR was greater for the young leaves (Figures 2a and 2b).

In *C. argentea* at a given level of RWC, the values of LDR for young and old leaves were similar in the luxury and inadequate plants, but the LDR was greater for young than for old leaves of the inadequate plants (Figures 2c and 2d).

Discussion

Although the water potential of a cell at a given transpiration rate is directly determined outside its boundaries (by upstream resistances) each cell does directly determine its corresponding turgor pressure through the concentration of the free solution in its vacuole and cytoplasm. Movement of water within plant tissues is normally along gradients of decreasing leaf water potential. Therefore, since transpiration is mainly from the more exposed parts of the plants. lower leaf water potential might be expected in the younger leaves. In the 'luxury' *C. argentea* plants (Figure 1c). there was no difference between the leaf water potential of young and old leaves for a given RWC; whereas in the luxury *A. dubius* plants (Figure 1a), the leaf water potential was lower in young leaves than in old ones for a given RWC. On the other hand, in the inadequate *A. dubius* and *C. argentea* plants. a decrease in leaf water potential from old to young leaves occurred only if the RWC of the young leaves was appreciably lower than that of the old leaves (Figures 1b and 1d). Thus the requirement for lower RWC of young (upper) leaves to ensure the gradient of leaf water potential necessary for transpiration, appeared to be more stringent in inadequate plants. In Figure 2a and b, smaller values of LDR were observed in young (upper) than in lower (old) leaves at corresponding RWC, in luxury *A. dubius* but

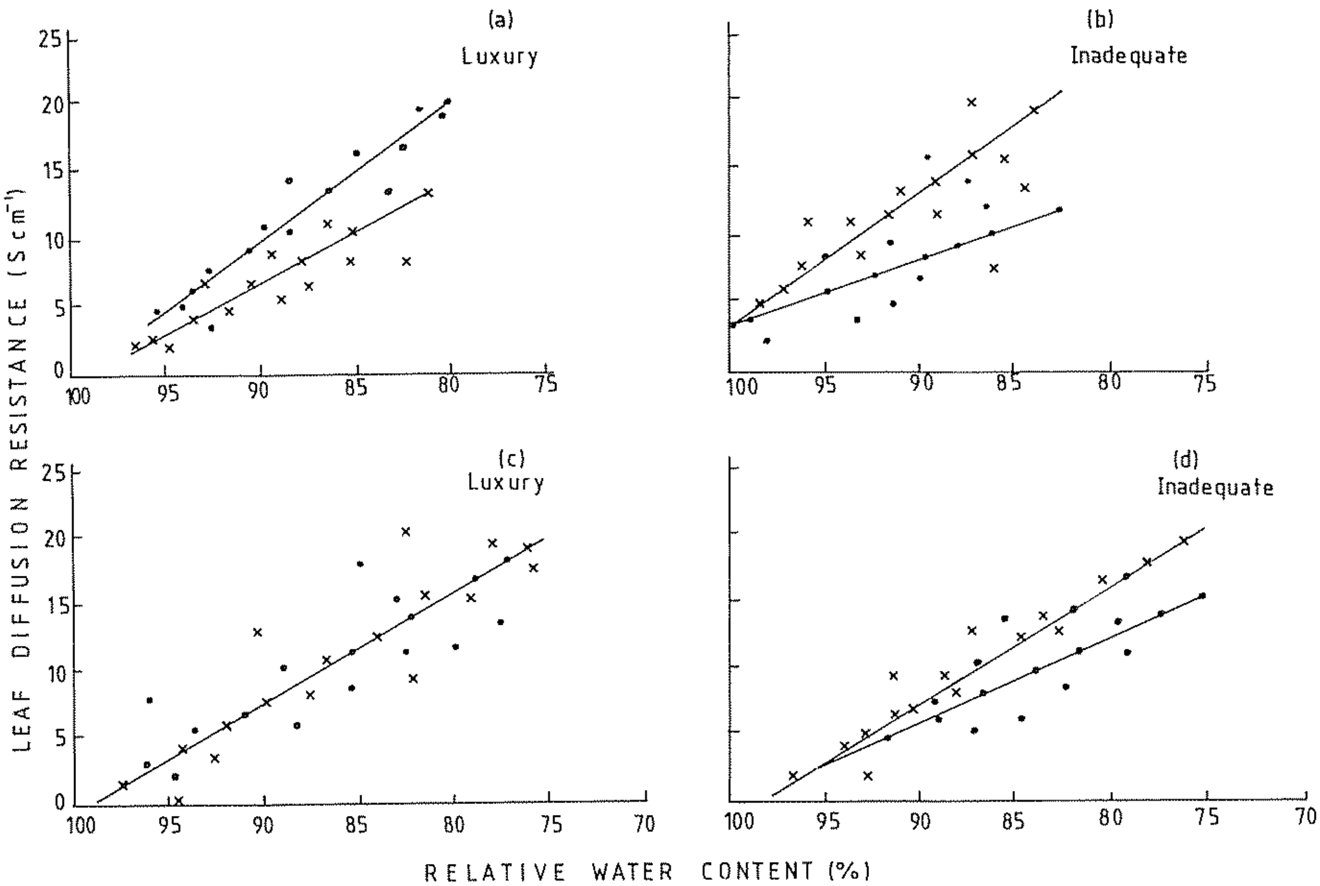

Fig 2 Relations between relative water Content and Leaf diffusion resistance for younger (x) and older (*) Leaves (a) and (b). *Amarantus dubius*: (c) and (d) *Celosia argentea*

not in inadequate *A. dubius* Similarly, with the inadequate *C argentea* the young leaves had higher LDR values than the old ones at the same RWC, although this effect might only be sufficient to nullify the generally smaller LDR of the old leaves of the inadequate *C argentea*, compared with the luxury plants (Figures 2c and d).

Per unit decrease of RWC in the two species, *A. dubius* recorded greater decrease of leaf water potential than *C argentea* plants (Figure 1). Several researchers (3, 4, 9, 11, 12, 13) have claimed that larger decreases of leaf water potential per unit decrease of RWC, as observed in *A dubius* and *C argentea*, confer drought resistance. Warren Wilson (10), Wenkert *et al* (13) and Wenkert (12) suggested that the loss of cell wall elasticity, which could promote this relationship, is likely to result from drought conditions. Wenkert (12) went further to suggest that water loss in conjunction with an increase in replacement of water volume with insoluble compounds could lead to large changes in leaf water potential without changes in the elastic modulus and total volume of the cell And that, this may be the mechanism for the decreased leaf water potential as per unit decrease in RWC in stressed plants Such drought-tolerance has significant physiological and agronomic consequences. During crop production, and in plant-nursery practice, it may result either from inavoidable or from intentionally imposed water stress During crop production in the tropics this situation may arise as a result of prolong dry season The present study shows little change of the general RWC- leaf water potential of each species as a result of inadequate water supply Also in both species, physiological process was affected indirectly by sudden closing of stomata at RWC greater than 97% in the inadequate plants

Also in this study, it was observed that the osmotic potential of *C argentea* young leaves at all times was generally about 2 bars lower than in the old leaves for both luxury and inadequate plants; and the corresponding leaf water potential was similar for the young and old leaves of the luxury plants but higher for young leaves of the inadequate plants (Figures 1c and 1d). Shepherd (8) noted that the difference in this relationship for osmotic potential and leaf water potential is due to the ability of the more elastic cells of the young leaves to sustain wall pressure as RWC decreases. With the luxury *C. argentea* plants in this experiment, it appears that the contraction or stiffening of cell wall in the old leaves was only enough to nullify but not to reverse, the effect of osmotic potential difference in the two leaf regions

It is observed in this study, as was noted by Shepherd (9), Cutler and Rains (3), Wenkert *et al* (13), Wenkert (12), that the relationships between RWC and both leaf water potential and LDR suggest that plants raised with insufficient or limited water supply developed in ways that tend to restrict transpiration during subsequent dry or drought periods.

Summary

The relationships between four indices of water status of plants-relative water content (RWC), sap osmotic potential, leaf tissue water potential and leaf water vapour diffusion resistance (LDR), were considered between and within *A. dubius* and *C argentea* at field capacity (luxury) and at limited water supply (inadequate).

The relationships were different for young (upper) and old (lower) leaves of plants, and for different leaf vegetables grown under various water treatments.

The leaf water potential is lower for young than old leaves of luxury *A. dubius* plants, whereas the reverse is true for inadequate plants. That of *C argentea* was similar for young and old leaves of the luxury plants and significantly increased for young leaves of the inadequate plants Per unit decrease of RWC in the two species, *A dubius* recorded greater decrease of leaf water potential than *C argentea*.

For a given RWC, the LDR of luxury plants, showed small increases in *A. dubius* and no difference in *C argentea* from old to young leaves The LDR of inadequate plants was greater for the young leaves in both species

The possible relevance of these relationships to drought resistance is briefly considered.

December 9, 1983

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Changes in the hormonal balance during seedling growth under salt stress in pigeon pea (*Cajanus cajan*, L.).

Resumen. Se estudió la variación del nivel de reguladores del crecimiento en los primeros estadíos de crecimiento de plántulas de *C. cajan*. bajo concentraciones isotónicas de Na Cl y Na_2 SO_4. Ambas sales redujeron inicialmente el nivel de los promotores del crecimiento, con un aumento simultáneo en inhibidores del tipo ABA. Posteriormente se observó un incremento gradual en sustancias del tipo de la giberalina y la citoquinina y una reducción en sustancias del tipo ABA con el crecimiento de las plántulas. las cuales mostraron una recuperación en los períodos posteriores. Sin embargo, la inhibición se perpetuó durante todo el estudio, con un efecto más marcado del Na_2 SO_4 que del Na Cl.

Salinity affect plant growth and influence several facets of plant metabolism. Several reports indicate changes in the levels of endogenous growth regulators under stress conditions. Ramana (11) observed measurable reduction in gibberellin activity under saline conditions in groundnut, and a reduced cytokinin activity in root exudate was observed when plants were subjected to water deficits (4) or to salt stress (5,9). Increased levels of ABA were reported to accumulate under water stress (8). Most of the earlier studies indicate that changes in hormonal balance during saline conditions depend more on the total concentration of soluble salts than on specific ions (7). Nevertheless this by no means rules out the possibility of a direct effect of salt on hormone levels (6).

The effect of salinity on plants varies depending on the phase of development. There is a lack of general relationship between the relative salt effect on germination and later phases of seedling growth. Studies on the influence of specific ions on the hormonal balance during a period of growth are scanty. Hence the present investigation is designed to study the effect of isotonic concentrations of NaCl and Na_2SO_4 salts on initial and subsequent changes in the endogenous levels of growth regulators during early seedling growth in pigeon pea (*Cajanus cajan* L.).

Material and methods

Plan Material: Healthy seeds of pigeon pea (*Cajanus cajan* L.) were surface sterilized with 0.1% $HgCl_2$ for 2-3 min and thoroughly washed with distilled water. Petridishes containing the seeds were lined with filterpaper and were divided into three sets. The first two sets were separately treated with iso-tonic solutions of NaCl and Na_2SO_4 (2.9 atmospheric pressure) and the third set which served as control, received distilled water. Five replicate samples were maintained for each treatment. Fifty germinated seeds were allowed to grow at $29 + 2°C$ in each petridish. The salt solutions were renewed daily to prevent evaporation losses and contamination. The endogenous levels of gibberellin and cytokinin-like substances and ABA-like inhibitors and growth patterns relating to fresh and dry weights and root and shoot lengths were determined in zero-, 3-, 6-, and 9- day old seedlings.

Extraction and purification

Growth regulators were extracted and chromatographed according to the method of Rudnicki and Nowak (14). Fifty grams of plant material (whole of seedling) were homogenized in 200 ml of 80% (v/v) methanol. The water residue was acidified to pH 2.5 and extracted with ethyl acetate. The combined ethyl acetate extracts were washed with 4% (w/v) sodium bicarbonate. The bicarbonate phase was readjusted to pH 2.5 and again extracted with ethyl acetate. The