



The study of sodium and potassium distribution in five host species of *Phragmanthera capitata* (Sprengel) S. Balle in the littoral region of Cameroon

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ABSTRACT

Objective: Studies were conducted to assess the response of five host species (*Citrus maxima*, *Manilkara zapota*, *Persia americana*, *Psidium guajava* and *Theobroma cacao*) of *Phragmanthera capitata* to sodium and potassium distribution in the plant organs.

Methods and results: After mineralization of plant organs of the parasite and the hosts, sodium (Na⁺) and Potassium (K⁺) concentrations were determined by Flame photometer on 30 samples belonging to five *P. capitata*/Host couples. The Na⁺ concentrations were higher in the leaves of the non parasitized host branches than the roots of the host, the suckers of the parasite, the leaves of the parasite and leaves of the distal sick boughs of the all host species. The results also showed a significant difference between the Na⁺ concentrations in the plant organs of parasite and the host. The K⁺ concentrations varied significantly in the plant organs of all the host species except for *P.americana* which had the lowest amount. The high concentration of K⁺ was observed in the leaves of the non parasitized host branches of *C.maxima*, *M. zapota* and *P. guajava*. *P. capitata* reduced Na⁺ concentrations in the aerial parts of host parasitized trees and maintained a low level of salt in the photosynthetic organs.

Conclusion and potential finding: Loranthaceae could contribute to decrease the content of salt on parasitized host boughs and then on branches carrying fruits.

Key words: host trees, salinity, Loranthaceae, ions partitioning.

INTRODUCTION

In the tropical region of Africa and especially in Cameroon, Loranthaceae are very common on woody forests. They are hemi parasite

epiphytoides phanerogams forming tufts that are spherical on the aerial parts of the host (Kuijt, 1969). They are able to carry out photosynthesis



and to make requisite substances for their carbohydrate nutrition, by setting on the host's tissues with a specific absorption system called sucker or haustorium. The sucker is a real structural and physiological way of controlling the debit of raw sap through direct xylemic connections (Boussim, 2002). Externally, the insert point of the parasite on the host shows the Puffiness at the level of the establishment of the parasite. On an axial longitudinal section, the sucker in "V" form is deeply pushed in the host wood.

The sucker ensures the continuity of the lead elements (Na^+ , K^+ , Ca^{2+} and Mg^{2+}) of the two plants and enables the diversion of water and nutritive substances from the plant to the parasite (Bannister et al., 2002). This trophic spoliation in the parasite's benefit brings about the malnutrition of the part of the branch located below the parasite's fixation point and this causes its smaller branch diameter. This part of the bough can afterwards shrivel up and finally fall down, thus secondarily bringing the Loranthaceae in terminal position. The Loranthaceae family is widespread in

MATERIALS AND METHODS

The study site: Douala (latitude, $03^{\circ}40'-04^{\circ}11'N$; longitude, $09^{\circ}16'-09^{\circ}52'E$; altitude, 13m) has a climate which belongs to the equatorial domain of a particular type called "Cameroonian". It is characterised by two seasons, a lengthy rainy season (at least 9 months), abundant rainfalls (about 4000 mm per year), high and stable temperatures ($26.7^{\circ}C$). The minimal average of temperature in Douala for 30 years (1961-1990) is $22.6^{\circ}C$ in July and the maximal average of temperature $32.3^{\circ}C$ in February. The relative humidity remains high the whole year and near to 100% (Din et al., 2008).

Materials: Samples were collected in the orchard of the Ndogbong chieftaincy's camp, a neighbourhood located at the North-East of Douala town. The orchard is about 8 ha and is essentially made up of fruit trees whose fruits are intended for consumption. Samples were made up of five Loranthaceae/host couples in which five are *Phragmanthera capitata* in Douala region. For the *P. capitata* parasitism, couples considerate were: *P. capitata/C. maxima* (Citrus tree), *P. capitata/M. zapota*, *P. capitata/P. Americana*, *P. capitata/P. guajava* and *P. capitata/T. cacao* (cocoa tree).

the world and is consisted of 77 genus and 950 species (Polhil & Wiens, 1998). Seven kinds and about thirty species are pointed out in Cameroon (Balle, 1982). Among these species, *Phragmanthera capitata* (Sprengel) S. Balle is in majority (Dibong et al., 2009) and attack most of the cultivated or spontaneous trees (citrus fruits, avocado trees, cocoa trees, coffee trees and *guajava* trees) whose fruits are marketed and exported. The result is a trophic diversion of water and mineral elements responsible by losing of parasitized branches fruits (Sonké et al., 2000). In Douala region, the high rate of salinity in the coastal soils causes a drop in yield and damages the quality of fruits, notably citrus fruits. Fruits with a very salty taste become unfit for consumption. Sodium (Na^+) is the mineral element implicated in this salinity. The formulated hypothesis is that Loranthaceae would contribute to decrease the content in salt on parasitized host boughs notably those carrying fruits.

This work consists on verifying this hypothesis from the repartition of K^+ and Na^+ on five Loranthaceae/host couples.

On the field: The samples were collected in July 2009 on five host individuals per couple that is 36 samples in total. For every couple, the roots of the host (HR), the suckers of the parasite (PS), the parasite's leaves (PL), the leaves of the non parasitized hosts (NPHL) and parasitized host's leaves (PHL) were sampled. The stocking and transport to the laboratory was done in black plastic bags.

In the laboratory: The samples were washed with distilled water and then they were dried in an oven for 96 hours at $60^{\circ}C$. For the analysis of Na^+ and K^+ , five samples each of 0.5 g of the roots of the host, the suckers of the parasite, the parasite's leaves, the leaves of the non parasitized hosts and parasitized host's leaves were thoroughly grinded and homogenized into 20 mL of HCL 1/10 for 24 h. Sodium and potassium were determined through Flame photometer (Jenway) as described by Taffouo et al. (2008). The results were analysed by using the software Stat soft, Inc. (2001) STATISTICA (data analysis software system) 6.0 version.



RESULTS

The Na⁺ concentrations were higher in the leaves of the non parasitized host branches than the roots of the host, the parasite suckers, and the parasite's leaves of the distal sick boughs of the all host species (Fig.1). In contrast, the Na⁺ concentrations were low in the roots

of the host and the suckers of the parasite. The results also showed a significant difference between the Na⁺ concentrations in the plant organs of parasite and the host (Fig.1).

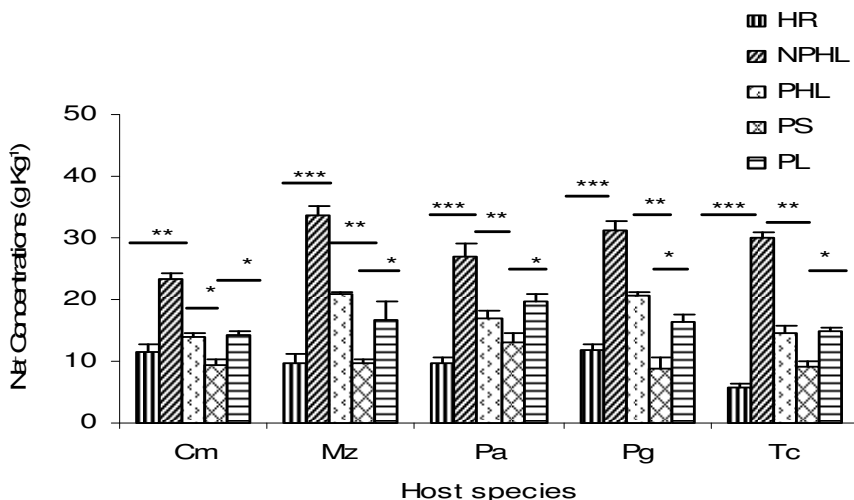


Figure 1: Na⁺ partitioning (g Kg⁻¹) in five host species of *Phragmanthera capitata* in Ndogbong chieftaincy's orchard. HR: Host Roots; NPHL: Non Parasitized Host Leaf; PHL: Parasitized Host Leaf; PS: Parasite Sucker; PL: Parasite Leaf; Cm: *Citrus maxima*; Mz: *Manilkara zapota*; Pa: *Persia Americana*; Pg: *Psidium guajava*; Tc: *Theobroma cacao*, ns = P > 0.05; * = P < 0.05; ** = P < 0.01, *** = P < 0.001.

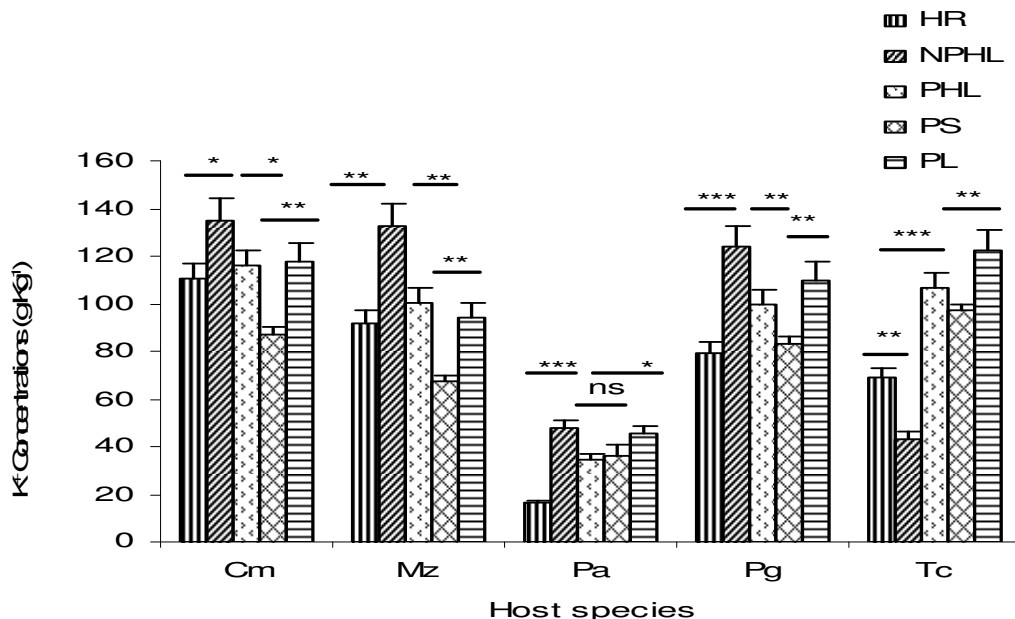


Figure 2: K⁺ partitioning (g Kg⁻¹) in five host species of *Phragmanthera capitata* in Ndogbong chieftaincy's orchard. HR: Host Roots; NPHL: Non Parasitized Host Leaf; PHL: Parasitized Host Leaf; PS: Parasite Sucker; PL: Parasite Leaf; Cm: *Citrus maxima*; Mz: *Manilkara zapota*; Pa: *Persia Americana*; Pg: *Psidium guajava*; Tc: *Theobroma cacao*, ns = P > 0.05; * = P < 0.05; ** = P < 0.01, *** = P < 0.001.



In this study, the concentrations of K^+ were markedly higher in plants organs of all the host species than the Na^+ concentrations (Fig.1 and 2). The K^+ concentrations varied significantly in the parts of all the host species except for *Persea Americana* which had the lowest amount (Fig.2).

The high concentrations of K^+ were observed in the leaves of the non infected host branches of *Citrus*

DISCUSSION

One prominent physiological characteristic of non parasite plants is the high degree of perspiration which sometimes exceeds that of the host (Glatzel, 1983). It engenders a gradient of water potential on the parasite's leaves which enables the flow of nutrient resources. This mechanism is common to epiphyte parasites of tropical regions. The perspiration degree of parasite plants is highest among angiosperma (Whittongton & Sinclair, 1988). The loss of water by perspiration, high in Loranthaceae is under stomata control. The result is a hydrostatic gradient which enables the transfer of liquids from the host to the parasite. The hosts' species thus accumulate Na^+ in their aerial parts (Fig.1). According to Levitt (1980) and Taffouo et al. (2008) they could describe as tolerant glycophytes. The observed Na^+ and K^+ low concentrations concerning the host's roots and Loranthaceae suckers is because they are transit organs. The Loranthaceae suckers could play the same role as the host's roots. These two organs absorb mineral elements and transfer them to the rest of the plant, especially in leaves. The Na^+ and K^+ high concentrations concerning the hosts' leaves are because they are accumulation organs. Nevertheless, for the same kind of leaves, the Na^+ concentrations are always lower than those of K^+ (Fig.1 and 2). This implies a competition between Na^+ and K^+ absorption in the host species, resulting in a Na/K antagonism (Mezni et al., 2002; Al-Khateeb, 2006). The K^+ is the most studied nutrient in Loranthaceae and its concentrations vary from 13 to 40 mg/g in the host's infected boughs' leaves (Lamont, 1983). The variations observed depend on the hosts and on seasons too. Lamont (1983) holds that most of the Loranthaceae have more Na^+ per unit of weight than their hosts and some accumulate Na^+ on infected boughs. Results obtained with the different studied parasite/host couples confirm that. Similar results have been obtained previously (Schulze et al., 1984). Na^+ and K^+ move *via* the xylem and the apoplasmic way in general. This movement is passive

maxima; *Manilkara zapota* and *Psidium guajava*. In the other hand the parasite leaves of *Theobroma cacao* had the higher concentrations of K^+ than those of roots host, leaves of non parasite host branches, the parasitized host's leaves and the parasite suckers (Fig.2).

at the level of host-parasite where xylemic continuities are very important (Neumann, 1999). In the xylem, the K^+ and Na^+ can also benefit from the water floodtide resulting from the high perspiration characterising epiphyte plants (Stewart, 1990).

The littoral region is located on the Atlantic coastal zone and consequently is made up of saline soils (Taffouo, 2005). The aridity emphasised by the climate's changes, increases the salinity of soils and induces high osmotic pressure that limits water absorption by the crops (Munns, 2002). Thus, the salt concentration of the soil is the main factor responsible of soils' degradation but also of the drop in yield of agricultural products and of their quality. In this study, Loranthaceae reduce the Na^+ concentrations in the aerial parts of parasitized host trees and maintain the salt level low in the photosynthetic organs. Concentrations in Na^+ are very high (2.7 mg/g of DW) in all *Amyema preisii* individual in a site where the soil has been salinized (Lamont and Southall, 1982). Consequently, the parasitized host trees leaves' invasion by toxic elements interfering in the opening of stomata and other metabolic processes is avoided and the photosynthetic activity is increased (Turan et al., 2007). These results are in agreement with those obtained for other tolerant glycophytes (Taffouo et al., 2008). Fruits' taste and the yield are improved. Similar results have been obtained on cereals (Munns & Rowson, 1999). In these environmental conditions; parasitism becomes an asset and Loranthaceae's eradication erroneous. The sahelian zones of the continent where irrigation is commonly practised also increase the salinity rate of the soil. The Loranthaceae have a deficient carbohydrates production (Tuquet & Sallé, 1996). In these conditions, the host's photosynthesis is touched, not only by trophic spoliation, but also by the competition that can settle down between both partners' foliages for light. Other researches carried out in African countries (Cameroon, Gabon and Ghana) have shown the negative effect of



parasite plants on fruit trees (Engone & Sallé, 2006). However, according to Hull and Leonard (1964), the impact of epiphyte parasites on their hosts depends on the species. In the littoral region, *Phragmanthera capitata* has a 76.14% rate of parasitism in comparison with other Loranthaceae in heterogeneous vegetal groupments (Dibong et al., 2008). This ubiquitous and very abundant Loranthaceae is however less dependent to the host's carbohydrates. If this was not the case, the consequences of parasitism on fruits trees could be more severe, and comparable to those observed on trees infected by *Arceuthobium americanum* (Mathiasen, 2002) stirring considerable losses in wood. Thus, *P. capitata* has no significant effect on the clones GT1, PB235 and RRIM600 rubber production, for trees with comparable girth (Engone & Sallé, 2006). These clones sustain the parasite and maintain a good level in latex production. It is not the case of fruit trees whose growth is reduced by trophic diversion of K⁺ ions. Otherwise, the curative fight by

manual destruction of Loranthaceae tufts is the only way of recourse for the concerned farmers. It concurs to reduce parasitism's hotbeds and to diminish the stock of Loranthaceae seeds. However the gash of the host infected bough gives an open way to other parasites. In the case of avocado tree, *Cercospora purpurea* is generally the cause of pimples and clefts on fruits. Now, amongst fruit trees, avocado tree is predominant and abundant on the littoral zone (Dibong et al., 2008); it remains sensible to Loranthaceae attacks. The mechanical fight practised by farmers exposes most often avocado trees' fruits to fungous diseases (Schall, 1987). Fruit quality is damaged. Nowadays, there is distress among farmers of the littoral region for whom fruits compose the staple alimentation. Then it should be urgent to rather advocate the preventive fight of Loranthaceae and avoid the mechanical one in order to not compromise alimentary self-sufficiency in the area.

CONCLUSION

In this study, *Phragmanthera capitata* reduces the Na⁺ concentrations in the aerial parts of infected host trees and maintain the salt level low in photosynthetic organs. The high concentration of K⁺ was observed in the leaves of the non parasitized host branches of

Citrus maxima; *Manilkara zapota* and *Psidium guajava*. The coastal and sahelian regions show low yields due to the sensitiveness of plants cultivated to salt. The quality of fruits equally declines due to the parasitism of Loranthaceae.

REFERENCES

- Al-Khateeb SA, 2006. Effect of calcium/sodium ratio on growth and ion relations of Alfalfa (*Medicago sativa* L.) seedling grown under saline condition. *Journal of Agronomy*, 5(2): 175-181.
- Bannister P, Graham L, Strong, Inge A, 2002. Differential accumulation of nutrient elements in some new mistletoes and their hosts. *Functional Plant Biology* 29 (11): 1309-1318.
- Boussim IJ, Sallé G, Guinko S, 1993. *Tapinanthus* parasite du karité au Burkina Faso, 2. Phénologie, biologie et dégâts. *Bois et Forêts des Tropiques* 238 : 53-65.
- Boussim IJ, 2002. Les phanérogames parasites du Burkina Faso : inventaire, taxonomie, écologie et quelques aspects de leur biologie. Cas particulier des Loranthaceae parasites du karité. Thèse de Doctorat d'Etat, Université de Ouagadougou, 285 p.
- Dibong SD, Din N, Priso RJ, Taffouo VD, Fankem Henri, Amougou A, 2008. Parasitism of host trees by the Loranthaceae in the region of Douala (Cameroon). *African Journal of Environmental Science and Technology*. 2 (11): 371-378.
- Dibong SD, Engoné Obiang NL, Din N, Priso RJ, Taffouo VD, Fankem Henri, Amougou A, 2009. Niveau d'infestation des arbres fruitiers des groupements végétaux par *Phragmanthera capitata* (Sprengel) S. Balle (Loranthaceae) dans la région littorale du Cameroun. *International Journal of Biological and Chemical Sciences* 3 (2): 347-454.
- Din N, Priso JR, Dibong SD, Amougou A, 2008. Logging activities in mangrove forests: A case study of Douala Cameroon. *African Journal of Environmental Science and Technology* 2 (2): 22-30.
- Engone Obiang NL, Sallé G, 2006. Faut-il éradiquer *Phragmanthera capitata*, parasite des hévéas en Afrique ? *C. R. Biologies* 329: 185-195.
- Glatzel G, 1983. Mineral nutrition and water relations of hemi parasitic Mistletoes: a question of partitioning. Experiment with *Loranthus*



- europeans on *Quercus petraeae* and *Quercus robur*. *Oecologia* 56: 193-201.
- Hull R, Leonard O, 1964. Physiological aspect of parasitism in mistletoes (*Arceuthobium* and *Phoradendron*). The photosynthetic capacity of mistletoe. *Plant Physiology* 30: 1008-1017.
- Kuijt J, 1969. Mistletoes are members of the Loranthaceae and Viscaceae families (The biology of flowering parasitic plants). University of California Press, Berkeley.
- Lamont B, Southall, 1982. Distribution of mineral nutrients between the Mistletoe, *Amyema preissii* and its hosts, *Acacia acuminata*. *Annale Botanique* 49: 721-725.
- Lamont B, 1983. Mineral nutrition of Mistletoes in: Calder M. & Bernhardt P. (eds), *The Biology of Mistletoes*. Academic Press of Sydney, pp. 185-203.
- Levitt J. 1980. Responses of plants to environmental stresses. United Kingdom Edition. Edition Ademic Press, London, pp 395-434.
- Mathiasen R, 2002. Ecology of dwarf mistletoes (*Arceuthobium* spp., Viscaceae), Third International Canopy Conference, Cairns, Australia.
- Mezni M, Albouchi A, Bizid E, Hamza M, 2002. Effects of salt water irrigation on mineral uptake in three Alfalfa varieties (*Medicago sativa*). *Agronomie* 22: 283-291.
- Munns R, Rawson HM, 1999. Effect of salinity on salt accumulation and reproductive development in the apical meristem of wheat and barley. *Australian Journal Physiology* 26: 459-464.
- Munns R, 2002. Comparative physiology of salt and water stress. *Plant, Cell and Environment* 25: 239-250.
- Neumann U, 1999. Etude ontogénique, structurale et immunocytochimique des suçoirs de 3 Scrophulariacées parasites africaines. Thèse de Doctorat de l'Université Pierre et Marie Curie, Paris 6, Tome 1, 177 p.
- Polhill R, Wiens D, 1998. Mistletoes of Africa, the Royal Botanic, Kew, 370 p.
- Schall C, 1987. La multiplication de l'avocatier (*Persea americana* Mill. Cv. Fuerte) par microbouturage in vitro. *Fruits* 42 (3) : 171-174.
- Schulze ED, Turner NC, Glatzel G, 1984. Carbon, water and nutrient relations of two mistletoes and their hosts: A hypothesis. *Plant, Cell and Environment* 7: 293-299.
- Sonké B, Kenfack D, Tindo M, 2000. Parasitisme de l'avocatier (*Persea americana*, Lauraceae) par les Loranthacées dans la région de Yaoundé (Cameroun). *Fruits* 55 : 325-331.
- Stewart GR, Press MC, 1990. The physiology and biochemistry of Angiosperms. Review *Physiology Plant Molecular Biology* 41:127-151.
- Taffouo VD, Kenne M, Fokam TR, Fotso WO, Fonkou T, Vondo Z, Amougou A, 2004. Réponse au stress salin chez cinq espèces de Légumineuses. *Agronomie Africaine* 16 : 33-44.
- Taffouo VD, 2005. Variation de la réponse au stress salin chez cinq espèces de Légumineuses : étude des marqueurs physiologiques et biochimiques. Thèse d'Etat ès Sciences, Université de Yaoundé I, 150 p.
- Taffouo VD, Djotie NL, Kenne M, Din N, Priso RJ, Dibong SD, Amougou A, 2008. Effects of salt stress on physiological and agronomic characteristics of three tropical cucurbit species. *Journal of Applied Biosciences* 10: 434-441.
- Tuquet C, Sallé G, 1996. Characteristics of chloroplast isolated from two mistletoes originating from temperate (*Viscum album*) and tropical (*Tapinanthus dodoneifolius*) areas. *Plant Physiology Biochemistry* 34: 283-292.
- Turan MA, Katkat V, Taban S. 2007. Variation in proline, chlorophyll and mineral elements content of wheat plants grown under salinity stress. *Journal of Agronomy* 6 (1): 137-141.
- Whittington, Sinclair R, 1988. Water relations of the Mistletoes, *Amyema miquelli* and its hosts *Eucalyptus fasciculosa*. *Australian Journal Botany* 36: 239-255.

