Life Science Informatics Publications

Research Journal of Life Sciences, Bioinformatics, Pharmaceutical and Chemical Sciences

Journal Home page http://www.rjlbpcs.com/

RJLBPCS

ISSN 2454-6348

Original Research Article **DOI - 10.26479/2017.0205.09**

ANALYSIS OF EARLY GROWTH CRITERION TO SCREEN FOUR FABACEAE PLANTS FOR THEIR TOLERANCE TO DROUGHT STRESS

E. Tsoata[1]*, C. Nono Temegne[2], E. Youmbi [3]

Department of Plant Biology, Faculty of Science, University of Yaoundé 1, PO Box 812 Yaoundé, Cameroon

ABSTRACT: Early growth criterion of four Fabaceae leguminous plants, were analyzed, in a glasshouse, under water stress condition, in pots on a substrate made of ¾ of ground and ¼ of sand, with two threeleaflets leaves seedlings. Experimental design is a randomized factorial with: four species (*Cajanus cajan, Phaseolus lunatus, Tephrosia vogelii and Vigna subterranea*), four levels of water stress: 90 (blank), 60, 30 and 15 % of field capacity, five replications per treatment. Various parameters analyzed since stage threeleaflets leaves or at the end of water stress for each species are: leaves number, leaves area and specific weight, dry biomass of roots, stems and leaves. Results obtained show that, water stress has affected negatively almost all seedlings parameters of growth studied with notable inter specific variations. Broadly *Vigna subterranea*, less touched by water stress effects seems to be most tolerant specie, whereas *Tephrosia vogelii*, most touched, seems to be most sensitive of four studied species. The studied parameters can be used as marker to identify Fabaceae tolerant to water stress.

KEYWORDS: Water stress, early criterion, Growth, Fabaceae

***Corresponding Author: Dr. E. Tsoata** Ph.D.

Department of Plant Biology, Faculty of Science,

University of Yaoundé 1, PO Box 812 Yaoundé, Cameroon*

*Email Address: itchouata@gmail.com

1. INTRODUCTION

In world in general and Africa in particular, leguminous plants are integral part of industrial and rural systems of farming [1, 2]. They are able to fix molecular nitrogen [3, 4] and are thus of great interest: for restoration of soils having low mineral nitrogen content [3, 5-7] for human and animal consumption as source of energy and proteins [8-10] and as huge income source in economic [11]. The world production of leguminous plants cultivated for their seeds and sometimes for their leaves (*Vigna unguiculata*) exceeds 300 million tons yearly [12, 13, 10]. Insufficiency and irregularity of rains in rainagriculture, differences in temperature, edaphic conditions, global climatic warming, constitute essential factors limiting agricultural production [14-16]. These factors limit yield in arid and semi-arid regions, likewise in areas victims of current climatic changes [17, 18]. Water stress settles when plant water requirements are higher than the quantities available for roots and when water content of plant lessens sufficiently to interfere with normal processes of plant [19, 20]. He affects growth, physiology and metabolism of plant [21, 19]. Use of water stress tolerant plants on low moisture soils, would constitute a means to maximize production per area unit [22, 23]. It is thus significant to determine, incidence of water stress on growth parameters of plants at stage where they are most prone to water deficit in order to evaluate their level of tolerance to this constraint. It is in this context that we studied the effect of water stress on some growth parameters of four Fabaceae leguminous plants at an early stage.

2. MATERIALS AND METHODS

Healthy seeds of each species, are disinfected, germinate, then are sown in plastic bacs filled with river sand and watering regularly with tap water until stage two threeleaflets leaves per seedling [24]. Substrate used consists of: crush dried ground taken at 20 cm depth, mixed with river sand in proportions ¾ ground and ¼ sand. This mixture having good drainage, good permeability and better water retention capacity, is used to grow seedlings. Its field capacity and water stress levels are determined by [24]. Seedlings with two threeleaflets leaves are transplanted in plastic pots of 3 l containing substrate, and various water stress levels are applied. Experiment is laid out in randomized factorial design with: 4 leguminous plants (*C. cajan, P. lunatus, T. vogelii and V. subterranea);* 4 watering levels: 90(blank), 60, 30 and 15 % of field capacity; that means 900, 600, 300 and 150 ml of water for 2.4 kg of dry substrate respectively. Each of 16 treatments is replicated 5 times; the experimental unit comprises 25 seedlings per treatment and 5 seedlings per pot. Eight pots without seedlings are used in the design to determine substrate water lost by evaporation at the level each pot. Various parameters are evaluated since stage threeleaflets leaves per plantlet, regularly tile the end of experimentation [25, 26]. At the end of water stress period growth parameters: leaves number, leaf area, leaf specific weight, dry weight of plant, stems, leaves and ratios DBR/DBS and DBL/DBS are assessed [27].

Data analysis

Collected data are subjected to analysis of variance (ANOVA) to detect significant differences between averages. Averages are compared by using Student Newman-Keuls and Duncan test at 5 % level of significance. Software SAS (Statistical Analysis System) or SPSS 18.0 is used. The results, presented in form of histogram, of graph or table are carried out using the software Microsoft Excel 2007.

3. RESULTS AND DISCUSSION

Leaves number of (LN)

Number of emitted leaves varies according to specie and decreases when water stress level increases (Fig. 1). For *C. cajan*, *V. subterranea* and *T. vogelii*, reduction of LN at 15^{th} water stress day is significant from one treatment to another. In *P. lunatus*, this parameter decreases significantly ($p < 0.05$): 24.05, 48.42 and 49.05 % for T1, T2 and T3 respectively.

Leaf area (LA)

Leaf area (Fig. 2 and 3) of 3^{rd} and 4^{th}threeleaflets leaves decreases when water stress level increases for four studied species compared to unstressed plants. For *P. lunatus* and *C. cajan* this reduction is not significant for 3^{rd} leave on the 15^{th} day of stress. The LA of 4^{th} threeleaflets leave is significantly lower than that of 3^{rd} for T1, T2, T3 for *P. lunatus* and *C. cajan*; at T2 and T3 for *V. subterranea* and at T3 for *T. vogelii* (Fig. 3). The effect of water stress on LA is more marked on 4^{th} leave of four studied leguminous plants than on 3^{rd} one (Fig. 2 and 3). During experimentation, withering and/or death of plants was observed starting from T2 (30 % FC) for four studied leguminous plants (Fig. 2 and 3).

Leave specific weight (LSW)

Leave specific weight (Fig. 4) decreases with increase in water stress level for two studied leguminous plant species compared to unstressed. For *V. subterranea* it decreases significantly ($p < 0.05$): 3.75 mg/cm^2 (14.24 %), 3.85 mg/cm^2 (14.62 %) and 7.20 mg/cm^2 (27.34 %) for T1, T2 and T3 respectively. There are no significant difference between LSW at T1 and T2. The highest reduction is observed at T3. For *C. cajan*, water stress doesn't have significant effect on LSW at T1 and T2; however, with T3, one observes a significant reduction in LSW of 5.45 mg/cm^2 (34.34 %).

Dry biomass

Dry biomass of leaves, stems and roots varies according to water stress level and according to leguminous plant species (Table 1). Significant differences ($p < 0.05$) of dry biomasses of leaves compared to blank are noted for four leguminous plants. For *P. lunatus* and *V. subterranea*, losses of leaves dry biomass due to moderate water deficit are higher than those due to marked restriction. Treatments T1, T2 and T3 reduce leaves dry biomass respectively: 0.37 g, 0.53 g, 0.01 g for *P. lunatus* and 0.32 g, 0.23g, 0.08 g for *V. subterranea*. For *C. cajan* and *T. vogelii*, it is the contrary: 0.02 g, 0.03 g, 0.06 g of loss, and 0.02 g, 0.26 g, 0.10 g respectively. Dry biomass of leaves at T3 decreases more in condition of water stress for *P. lunatus* (0.91 g) and *V. subterranea* (0.89 g), these two species would be thus more sensitive to water stress than *C. cajan* (0.11 g) and *T. vogelii* (0.38 g). Senescence and leaves abscission are faster for stressed plants and increase with level of water stress. Water stress significantly decreases dry biomass of stem of four leguminous plants compared to T0; *P. lunatus* produces more and *V. subterranea* less (Table 1). In *V. subterranea* it doesn't have significant difference between T2 and T3 in term of accumulated biomass. Dry biomass of roots decreases for four leguminous plants subjected to water stress compared to T0 (Table 1). For *P. lunatus*, water stress causes a significant reduction ($p < 0.05$) in roots dry biomass 0.74, 1.10 and 1.26 g respectively for T1, T2 and T3. In *T. vogelii*, at T1, no significant variation observes for RDB; for T2 and T3, significant reduction ($p < 0.05$) 0.17 g and 0.25 g respectively is recorded. *Vigna subterranea*, at T1, T2 and T3 exhibits significant reduction in DBR 0.13, 0.20 and 0.23 g respectively; between T2 and T3, DBR registers no significant variation. For the three treatments, there is no significant variation of DBR for *C. cajan*. For four studied species, for DBL and DBR, *P. lunatus* accumulates always more biomass and *V. subterranea* accumulates less. Broadly studied leguminous plants produce and accumulate more dry biomass at level of above ground parts compared to underground parts. Plant dry biomass decreases significantly ($p < 0.05$) when water stress level increases for four leguminous plants compared to T0 (Table 1). For *C. cajan*, water stress significantly decreases ($p < 0.05$) DBP 0.12 and 0.22 g only for T2 and T3 respectively. For the four leguminous plants *P. lunatus* produces more DBP and *C. cajan* less. At the end of experimentation, various levels of water stress didn't significantly modify distribution of dry biomass between roots and stems (Table 1). The studied species accumulate more dry biomass on the level of roots, because ratio DBR/DBS is always higher than one. Ratio DBL /DBS is higher than one for all studied species, which means that they accumulate more biomass in leaves compared to stems. According to values of ratios DBR /DBS and DBL /DBS for T3 following classification can be made:

V. subterranea > *P. lunatus* > *C. cajan* > *T. vogeli*

DISCUSSION

Leaves intervene in processes controlling growth and development of plants, such as photosynthesis, respiration, transport of nutritive substances among others [28, 29]. They constitute thus main propeller of plants growth because of photosynthesis which is crucial process that supports crop growth and development [29]. Growth parameters: leaves number, leaf area, leaves specific weight; dry biomass of: leaves stems, roots, whole plant and ratio DBR/DBS, DBL/DBS; of four studied leguminous plants decrease as water stress rises. This decrement was previously observed: on lentil [30], on leguminous plants [31-33], on *Stevia rebaudiana* [34], on *Ocimum basilicum* [35]. These reductions could be an avoidance strategy to water stress. The effect of water stress can be expressed, according to adaptive strategy of each species by morphological modifications. These modifications affect underground or above ground parts: reduction of LA and rolling up of leaves [36]. Vegetative development is very disturbed under conditions of water starvation [37]. Many authors [38-40] report a significant depressive effect of water stress on number of leaves per plant and leaf area. Similar effect was observed on voandzou [41, 42]. Reduction of leaves number would be consequence of stop and/or reduction of production of new leaves [26, 43] or due to reduction of cellular enlargement or more leaves senescence caused by lessen of turgid pressure [44]. Plant would prioritize maintenance of its existing structures to its increase. Reduction of LA of third and fourth three leaflets leaves can be allotted to combination of growth reductions of young leaves and formation of new ones [45]. The reduction of leaves area could be explained by reduction of leaf size due to an early senescence of these leaves in water limiting condition. It can also be due to slowdown of mitotic activity of epidermis cells which leads to reduction of total number of leaves cells. This reduction is one plants answer to dehydration; it contributes to conservation of water resources, which allows survival of plant [46]. Plants leaves subjected to water stress usually reach apparent final sizes smaller compared to controls [47]. This result is similar to those of [45] on *Sophora davidii* and [48] on *Eucalyptus globulus*. Leaves specific weight is one of significant plants markers in response to water starvation and can be regarded as a simple criterion of selection of species presenting great water use efficiency in water stress conditions. Under water stress, LSW decreases; this result is similar to that observed for durum wheat Vit genotype [26] and suggests a significant reduction in leaves weight. Dry biomass of plant, constitutes one of realistic criteria to determine the response of plant to various types of stress including water stress [49, 33]. Water stress induced in plants specific responses like: reduction of vegetative growth, closing of stomata, reduction in photosynthesis [50-52], cells divisions and expansion [53, 54]. These various answers permit plant to reduce water loss or to optimize its absorption [50-52]. In this work reduction of dry biomass is observed for leaves, stems, roots and entire plant under water stress compared to blank. This result corroborates those of: [30] on lentil; [55] on bambara groundnut; [56, 57] on bambara groundnut and [54] on *Cicer arietinum*. Reduction in growth would be explained by reduction of photosynthesis caused by water stress; but also by deficit of mineral nutrition (N, P especially) due to reduction of elements flow towards roots [58, 59]. By reducing cells division and their expansion, water stress slows down plant growth [54, 60]. This reduction of growth would constitute an adaptive mechanism allowing plant to survive in water stress condition. It would allow plant photosynthetic products and energy towards production of molecules enabling him to fight against stress [61] and/or to maintain roots growth to improve absorption of water [62]. A prolonged water stress can limit growth and production of biomass and even cause plant death [63]. Reduction of ratio DBR/DBS recorded for *P. lunatus* would be consequence of reduction of biomass allocated to roots. This result is not consistent with those of [64] on *Chamaecytisus palmensis*, [65] on coffee-tree. Differences observed for leguminous plants studied in water stress condition, were already reported for chickpea [54] and would be due to genotypic differences [54].

4. CONCLUSION

At early growth stage, water stress has affected negatively almost all studied growth parameters, with notable inter specific variations. Statistical analysis reveals a positive and significant correlation between growth parameters of four leguminous plants. Broadly *Vigna subterranea*, less touched by water stress seems to be most tolerant specie, whereas *Tephrosia vogelii*, specie most touched, seems to be most sensitive of four studied species. These parameters can be used as marker to identify Fabaceae tolerant to water stress.

CONFLICT OF INTEREST

The authors have no conflict of interest.

ACKNOWLEDGEMENT

The authors would like to extend their sincere appreciation to their institution.

REFERENCES

1. Okon JE. Effect of water stress on some growth aspects of two varieties of cowpea, *Vigna unguiculata* (L.)Walp.Fabaceae. Bull Env Pharmacol Life Sci. 2013; 2(5): 69-74.
2. Laamouri A, Elaloui M, Ennajal A, Bouabdelly N. Study of mineral and nutritional components of some leguminous herbaceous and shrubs species in Tunisia. IJAAR. 2015; 6 (4): 1-7.
3. Giller KE. Nitrogen fixation in tropical cropping systems.Cabi Publishing Series Wallinford UK, 2001.
4. Nwaga D. Agriculture biologiqueet alternative de la biofertilisationdansl'utilisation des biofertilisantsmicrobiens pour une agriculture biologique. Actes du 1er atelier de formation surl'utilisation des biofertilisants, Yaoundé, 2000.
5. Azzouz, F. Les réponsesmorphologiquesetbiochimiques chez le haricot (*Phaseolus vulgaris* L.) soumis à un stress hydrique. MémoireDiplôme de Magister Univer.D'Oran ESSENIA FacSc, 2009.
6. Thiébeau P, Badenhausser I, Meiss H, Bretagnolle V, Carrère P, Chagué J, Decourtye A, Maleplate T, Médiène S, Lecompte P, PlantureuxS etVertès F. Contribution des légumineuses à la biodiversité des paysagesruraux. InnovAgron. 2010;11: 187-204.
7. Gao X, Lu X, Wu M, Zhang H, Pan R. Co-Inoculation with *Rhizobia* and AMF inhibited soybean red crown rot: from field study to plant defense-related gene expression analysis. PLOSONE. 2012; 7(3): 33-97.
8. Bertrand, G. Caractéristiques des réponsesadaptatives à la contraintehydriquedans le Sud-Est de l'Amazonie chez troisespècesfourragèrescultivées en monoculture et en association: *Brachiarrabrizantha*, *Leuceanaleucocephala* et *Arachis pintoï*. Thèse de Doctorat Sciences de l'Universet de l'environnement. Univer Paris Est, 2009.
9. Vance CP, Graham PH, Allan DL. Biological nitrogen fixation. Phosphorous: a critical future need. In FO Pedrosa, Hungria M, Yates MG, Newton WE, eds, nitrogen fixation: from molecules to crop productivity. Kluwer Academic Publixhers, Dordrecht, The Netherlands, 2000, pp. 506-514.
10. Anonyme. Année international des légumineuses.Organisation des Nations Unies pour l'Alimentationetl'Agriculture, 2013.
11. Shao HB, Chu L-Y, Abdul Jaleel Manivannan CP, Panneerselvam R, Shao MN. Understanding water deficit stress-induced changes in the basic metabolism of higher plant-Biotechnologically and sustainably improving agriculture and ecoenvironment in arid regions of the globe.Critical Review in Biotechnology.2009; 29(2): 131-151.

12. Duranthi M, Gius C. Legume seeds: protein content and nutritional value. Field Crops Res. 1997; 53: 31-45.
13. Anonyme. Normes Codex pour les céréales, légumessecs, légumineuses et matièresprotéiquesvégétales. FAO/OMS 1ereédition, 2007.
14. Abdalla MM and El-Khoshiban NH. The influence of water stress on growth, relative water content, photosynthetic pigments, some metabolic and hormonal contents of two *Triticumaestivum* cultivars.Journal of Applied Sciences Research. 2007; 3(12): 2062-2074.
15. Pennisi E. The blue revolution drop by drop, gene by gene.Science.2008; 32: 171-173.
16. Ceccarelli S, Plant breeding and climate change: in Ceccarelli S and Grando S (eds) 2010. Proceedings of the 10th International *Barley* Genetic Symposium 5-10April 2008, Alexandria, Egypt, 2010, pp. 16-29.
17. Fischer EM and Schär C. Consistent geographical patterns of changes in high impact European heatwaves. Nat Geosci. 2010; 3: 398-403.
18. Smith MD. The ecological role of climate extremes: current understanding and future prospects. J Ecol. 2011; 99: 651-655.
19. Gaye JP, Bloc D. La tolérance au stress chez le maïs. Perspective agricole.1992; 175: 100-106.
20. Pierce S, Vianelli A and Cerabolini B. From ancient genes to modern communities: the cellular stress response and the evolution of plant strategies. Funct Ecol. 2005; 19: 763-776.
21. AbdelmoneimA, Cocks PS. Adaptation of *Medicago rigidula* to cereal rotation in north-West Syria. J Agri Sci. 1986; 27: 227-234.
22. Hassanzadeh M, Ebadi A, Panahyan-e-KivilM, Jarnaati-e-Somarin SH, Saeidi M, GholipouriHassanzadehA. Investigation of Water Stress on Yield and Yield Components of Sesame (*Sesamumindicum* L.) in Moghan Region. Research Journal of Environrnental Sciences. 2009; 3(2): 239-244.
23. Ennajeh M, Vadel AM, Cochard H and Khemira H. Comparative impacts of water stress on the leaf anatomy of a drought-resistant and drought-sensitive Olive cultivar. Journal of Horticultural Science and Biotechnology. 2010; 85(4): 289-294.
24. Tsoata E, Njock SR, Youmbi E, Nwaga D. Early effects of water stress on some biochemical and mineral parameters of mycorrhizal *Vigna subterranea* (L.) Verdc.(Fabaceae) cultivated in Cameroon. Int J Agri&Agri R. 2015a; 7(2): 21-35.
25. Mefti M, Abdelguerfi A &Chebouti A. Etude de la tolérance à la sécheressechezquelquespopulations de *Medicago truncatula* (L.). Gaerth. INA/INRA, El Harrach (Alger), 2000.

26. Mouellef, A.Caractèresphysiologiquesetbiochimiques de tolérance du blédur (*Triticum durum* Desf.) au stress hydrique. Mémoire de magistère en Biotechnologies Végétales, Université de Mentouri, Constantine, 2010.
27. Tsoata E, Njock SR, Youmbi E, Nwaga D. Alleviation of drought effect on two mycorrhizal leguminous plants (*Tephrosiavogelii* and *Vigna subterranea*) at an early growth phase. Int J of Current Research. 2015b; 7(9): 20424-20438.
28. Ren S, Weeda S, Akande1 O, Guo Y, Rutto L & Mebrahtu T. Drought tolerance and AFLP-based genetic diversity in purslane (*Portulaca oleracea* L.). Biological Research. 2011; 3: 51-61.
29. NuuguluMegameno, L. Growth and physiological response of *Amaranth*seedlingstotemperature and drought stress, thesis magister ScientiaeAgricuturaedegree, University of Free State Bloemfontein, South Africa, 2013.
30. Talukdar D. Comparativemorpho-physiological and biochemical responses of lentil and grass pea genotypesunderwater stress. J Nat Sci Biol Med. 2013; 4(2): 396-402.
31. Garg G. Response in germinationanseedlinggrowth in *Phaseolus mungo*undersalt and drought stress. J Environ Biol. 2010; 31: 261-264.
32. Kostopoulou P, Vrahnakis MS, Merou T, Lazaridou M. Perennial-likeadaptationmechanisms of anual legumestolimitedirrigation. J Environ Biol. 2010; 31: 311-314.
33. Slama I, Tayachi S, Jdey A, Rouached A, Abdelly C. Differential response to water deficit stress in alfalfa (*Medicago sativa*) cultivars: Growth, water relations, osmolyte accumulation and lipid peroxidation. Afr J Biotech. 2011; 10: 16250-9.
34. Srivastava S and Srivastava M. Influence of Water Stress on Morpho-Physiological and Biochemical Aspects of Medicinal Plant *Stevia rebaudiana*. Life Sciences Leaflets.2014; 49: 35-43.
35. Khalil SE, El-Aziz, Abd NG and AbouLeil BH. Effect of water stress and ascorbic acid on some morphological and biochemical composition of *Ocimumbasilicum* plant. J Am Sci. 2010; 6(12): 33-44.
36. Slama A, Ben Salem M, Ben Naceur M & Zid E. Les céréales en Tunisie: production, effet de la sécheresseetmécanismes de résistance. Sécheresse.2005; 16(3): 225-229.
37. Ferryra R, Sellés G, Ruiz RS &Sellés IM. Effect of water stress induced at different growth stages on grapevine cv. Chardonnay on production and wine quality. Acta Hort. 2004; 664: 233-236.
38. Molaaldoila YAA, Al-Kumali B and Al-Hakimi KAA. Comparison of phenotypical and physiological responses of cowpea [*Vigna unguiculata* (L.) Walp.] genotypes as affectedbydrought and normal conditions. Inter J Agri and Environ Res. 2016; 2(4): 631-663.

39. Samson H, Helmut H. Drought effect on yield, leaf parameters and evapotranspiration efficiency of cowpea. Conference of International Agricultural Research for Development, University of Kassel-Witzenhausse and University of Gotteingen, October 9/11/2007.

40. AbdouRazakou IBY, Mensah B, AddamKiari S and Akromah R. Using morpho-physiological parameters to evaluate cowpea varieties for drought tolerance. Inter J Agri Sci Res. 2013; 2(5): 153-162.

41. Mwale SS, Azam-Ali SS &Massawe FJ. Growth and development of bambara groundnut (*Vigna subterranea*) in response to soil moisture: 1. Dry matter and yield. Eur J Agron. 2007; 26: 345-353.

42. Vurayai R, Emongor V &Moseki B. Effect of water stress imposed at different growth and development stages on morphological traits and yield of bambara groundnuts (*Vigna subterranea* L. Verdc). Am J Physiol. 2011; 6(1): 17-27.

43. Kariuki LW, Masinde P, Githiri S and Onyango AN. Effect of water stress ongrowth of threelinseed (*Lilnumusitatissimum* L.) varieties. SpringerPlus. 2016; 5: 759-774.

44. Shao HB, Chu LY, Shao MA, AbulJaleel C, Hong-Mei M. Higherplantantioxydant and redoxsignalingunderenvironmentalstresses. CompRend Biol. 2008; 331: 433-441.

45. Li FL, Bao WK & Wu N. Effects of water stress on growth, dry matter allocation and water-use efficiency of a leguminous species, *Sophoradavidii*. Agrofor Syst. 2009; 77: 193-201.

46. Lebon E, Pellegrino A, Tardieu F &Lecoeur J. Shoot development in grapevine is affected by the modular branching pattern of the stem and intra and inter-shoot trophic competition. Ann. Bot.2004; 93: 263-274.

47. Granier C, Inzé D & Tardieu F. Spatial distribution cell division rate can be deduced from that of P34cdc2 kinase activity in maize leaves grown in contrasting conditions of temperature and water status. Plant Physiol.2000; 124: 1393-1402.

48. Coopman RE, Jara JC & Bravo LA. Changes in morpho-physiological attributes of *Eucalyptus globulus* plants in response to different drought hardening treatments.Electron J Biotechnol.2008; 11(2): 1-10.

49. Talukdar D. Morpho-physiological responses of grass pea (*Lathyrus sativus* L.) genotypes to salt stress at germination and seedling stages. Legume Res. 2011; 34: 232-41.

50. Ohashi Y, Saneoka H, Fujita K. Effect of water stress ongrowth, photosynthesis and photoassimilatestranslocation in soybean and tropical pasture legumessiratro. Soil Sci Plant Nutr. 2000; 46: 417-425.

51. Farooq M, Wahid A, Kobayashi N, Fujita D, Basra SMA. Plantdrought stress: effects,

mechanisms and management. AgrSustDev. 2009; 29: 185-212.
52. Krouma A. Plantwaterrelations and photosyntheticactivity in threetunisianchickpea (*Cicer arietinum* L.) genotypessubjectedtodrought. Turk J Agric For. 2010; 34: 257-264.
53. Nonami H, Wu Y, Boyer JS. Deceasedgrowthinducedwaterpotential: aprimary cause of growthinhibition at lowwaterpotentials. Plant Physiol. 1997; 114: 501-509.
54. Krouma A, Fujimura T and Abdelly C. Growth, photosyntheticactivity and waterrelation in threetunisianchickpeagenotypes (*Cicer arietinum* L.) subjectedto a progressivewaterdeficit stress. Agri Sci Res J. 2015; 5(12): 206-214.
55. Mabhaudhi T and Modi AT. Growth, phenological and yield response of bambaragroundnut (*Vigna subterranea* L. Verdc) landracestoimposedwater stress: I. Field conditions. S Afr J PlantSoil. 2013; 30(2): 69-79.
56. Berchie JN, Sarkodie-Addo J, Adu-Dapaah H, Agyemang A, Addy S, Asare E and Donkor J. Yieldevaluation of threeearlymaturingbambaragroundnut (*Vigna subterranea* L. Verdc) landraces at the CSIR-Cropresearchinstitute, Fumesua- Kumasi, Ghana. J Agron. 2010; 9: 175-179.
57. Berchie JN, Opoku M, Adu-Dapaah H, Agyemang A, Sarkodie-Addo J, Asare E, Addo J and Akuffo H. Evaluation of fivebambaragroundnut (*Vigna subterranea* L. Verdc) landracestoheat and drought stress at Tono-Navrongo, uppereast región Ghana. Afr J Agric Res. 2012; 7: 250-256.
58. Gahoonia TS, Raza S, Nielsen NE. Phosphorus depletion in the rhizosphere as influenced by soil moisture. Plant and Soil.1994; 159: 213-218.
59. Dugo, MVG. Effet du déficithydriquesurl'état de nutrition azotée chez les graminéesfourragères.ThèseUniversité de Poitiers, France, 2002.
60. Schuppler H, He PH, John PCL, Munns R. Effect of water stress oncelldivision and cell-division-cycle 2-like cell-cyclekinaseactivity in wheatleaves. Plant Physiol. 1998; 117: 667-678.
61. Zhu JK. Salt and drought stress signaltransduction in plants. AnnualReviewPlantbiology. 2002; 53: 247-273.
62. Chaves MM, Maroco JP, Pereira JS. Understandingplant response todrought: from genes tothewholeplant. FunctionalPlantBiology. 2003; 30: 239-264.
63. Gindaba J, Rozanov A &Negash L. Response of seedlings of two *Eucalyptus* and three deciduous tree species from Ethiopia to severe water stress. ForEcolManage. 2004; 201: 119-129.
64. González-Rodríguez AM, Martín-Olivera A & Morales D. Physiological responses of tagasaste to a progressive drought in its native environment on the Canary Islands. Environ Exp Bot. 2005; 53: 195-204.

65. Dias PC, Araujo WL, Moraes GABK & Barros RS. Morphological and physiological responses of two coffee progenies to soil water availability. J Plant Physiol. 2007; 164: 1639-1647.

SUPPLEMENTARY FILES

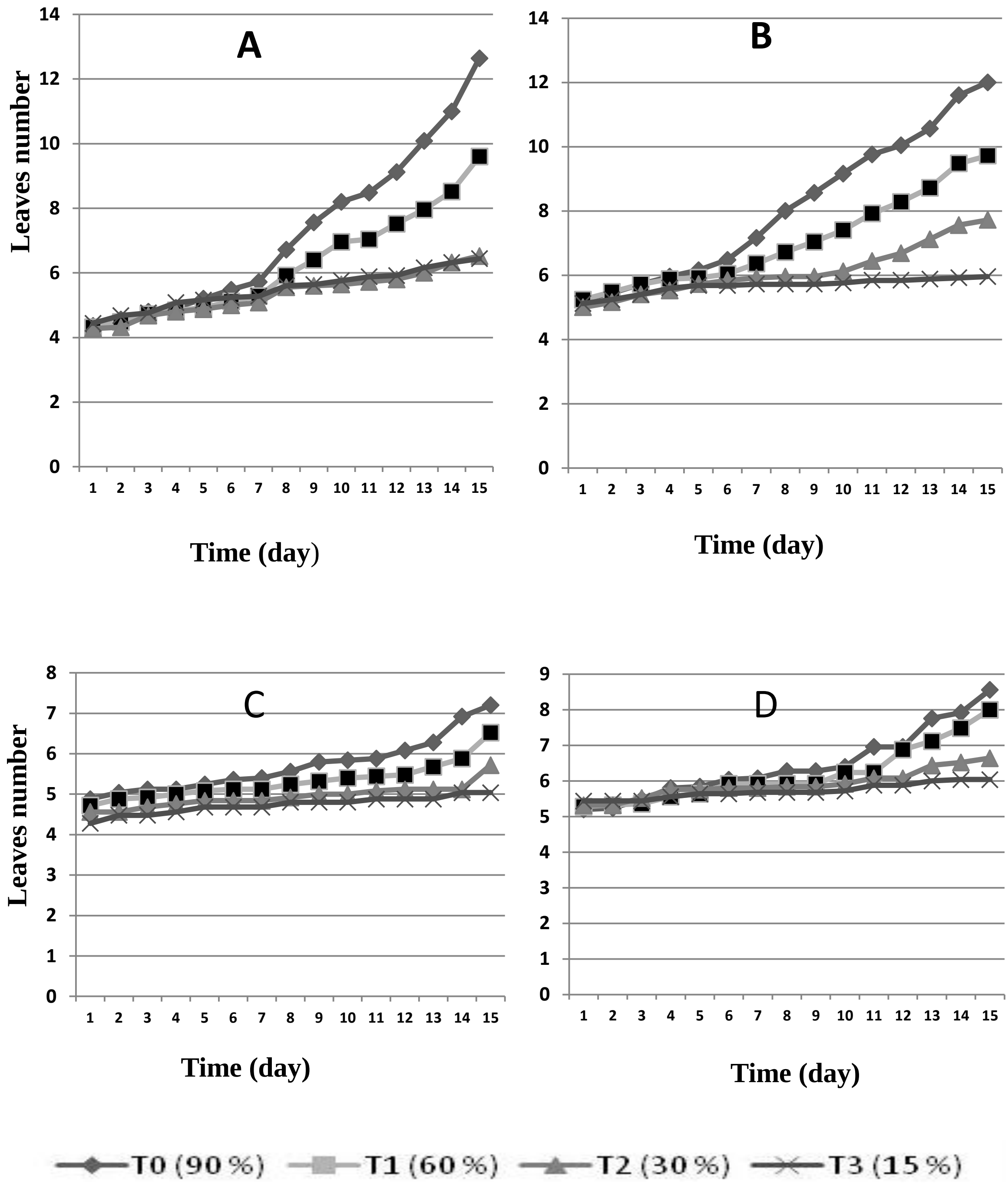

Fig. 1 Average leaves number per plant (A: *P. lunatus*, B: *V. subterranea*, C: *C. cajan*, D: *T. vogelii)*

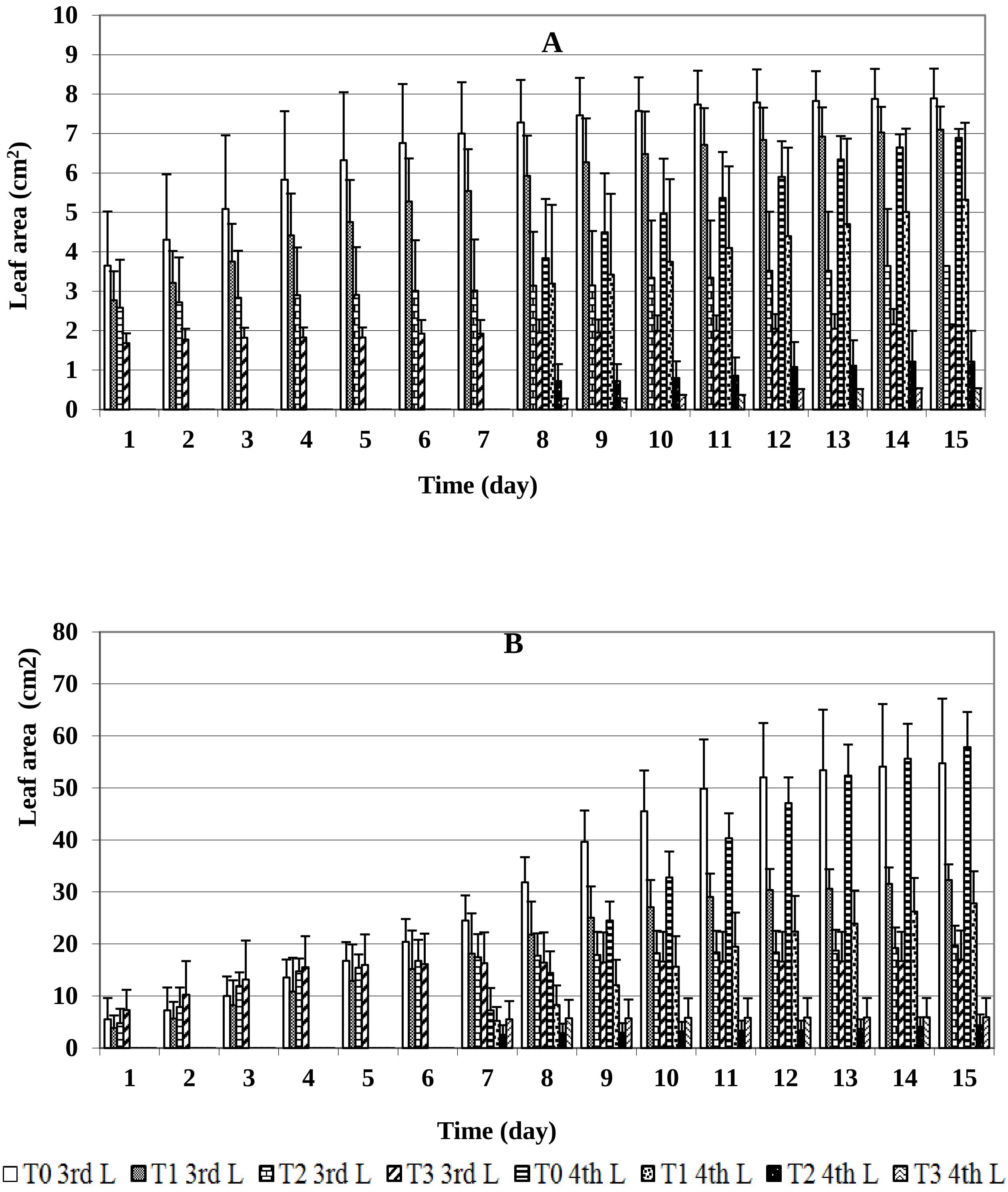

Fig. 2 Average leaf area for *Cajanus cajan* (A) and *Phaseolus lunatus*(B)

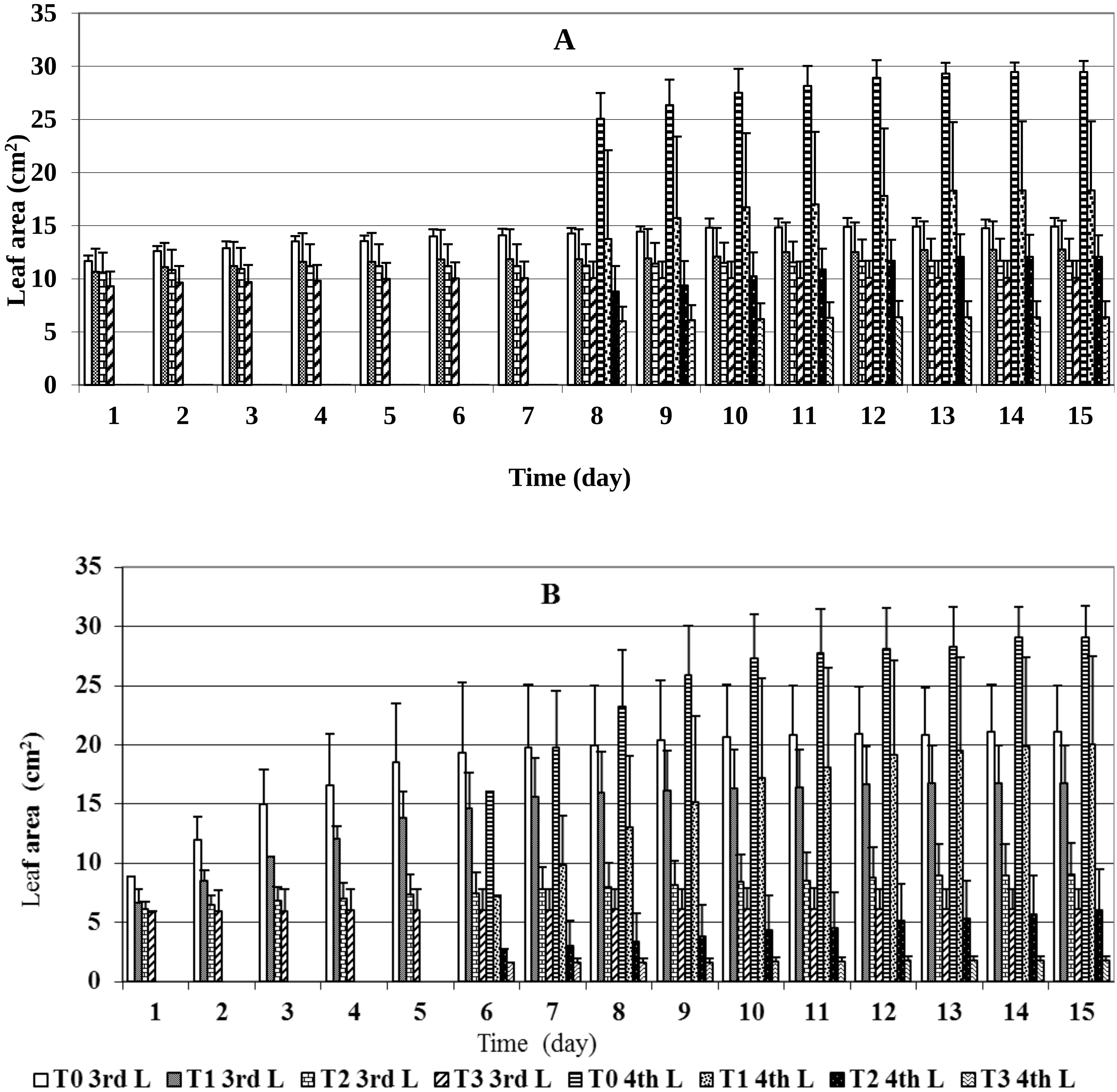

Fig . 3 Average leaf area of *Tephrosia vogelii*(A) and *Vigna subterranea* (B) under water stress

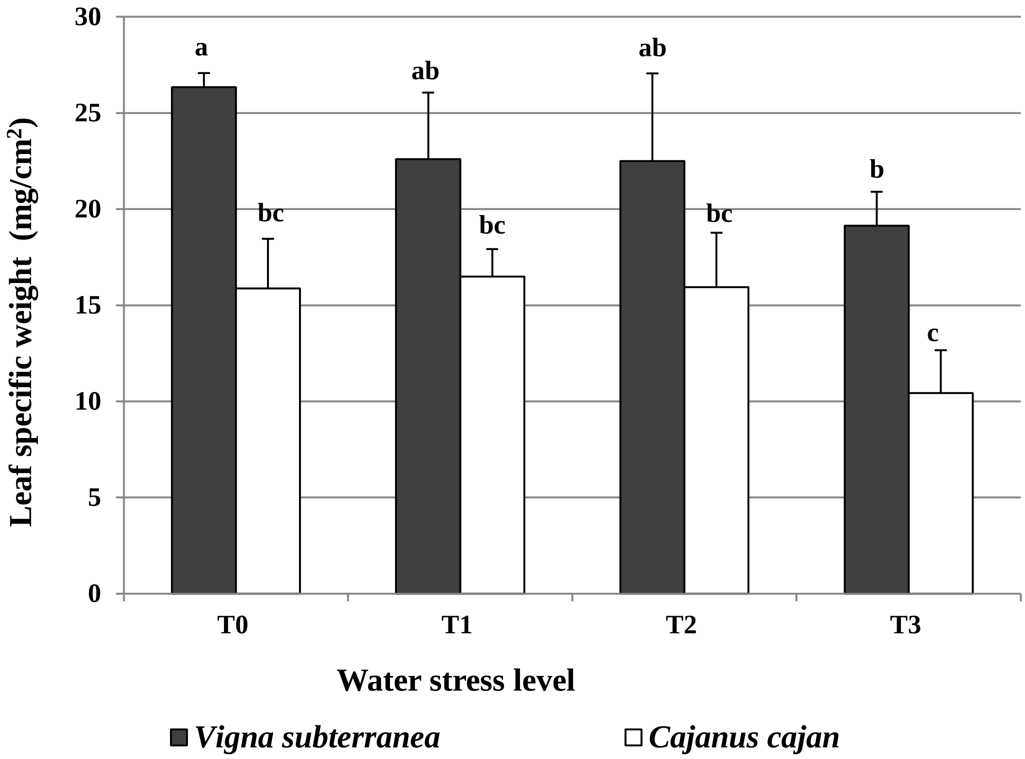

Fig. 4 Leaf specific weight

Table 1. DRY BIOMASS: STEM; LEAVE; ROOT; PLANT; DBR/DBS and DBL/DBS

Parameters \ Traitments		T0 (90 % FC)	T1 (60 % FC)	T2 (30 % FC)	T3 (15 % FC)
DBL (g)	*C. cajan*	0.16 ± 0.02 c	0.14 ± 0.06 c	0.11 ± 0.02 c	0.05 ± 0.02 c
	P. lunatus	1.27 ± 0.21 a	0.90 ± 0.15 ab	0.37 ± 0.14 bc	0.36 ± 0.09 bc
	T. vogelii	0.45 ± 0.07 bc	0.43 ± 0.05 bc	0.17 ± 0.05 c	0.07 ± 0.02 c
	V. subterranea	1.05 ± 0.91 a	0.47 ± 0.21 bc	0.24 ± .04 c	0.16 ± 0.02 c
DBS (g)	*C. cajan*	0.12 ± 0.01 e	0.11 ± 0.02 ef	0.07 ± 0.01 ef	0.07 ± 0.01 ef
	P. lunatus	0.58 ± 0.07 a	0.41 ± 0.07 b	0.23 ± 0.03 cd	0.25 ± 0.03 c
	T. vogelii	0.26 ± 0.02 c	0.19 ± 0.02 d	0.12 ± 0.03 e	0.10 ± 0.01 ef
	V. subterranea	0.09 ± 0.01 ef	0.06 ± 0.01 ef	0.03 ±0.01 f	0.03 ± 0.01 f
DBR (g)	*C. cajan*	0.13 ± 0.02 e	0.15 ± 0.04 e	0.11 ± 0.01 e	0.09 ± 0.02 e
	P. lunatus	1.66 ± 0.06 a	0.92 ± 0.07 b	0.55 ± 0.08 c	0.40 ± 0.08 d
	T. vogelii	0.37 ± 0.11 d	0.32 ± 0.05 d	0.20 ± 0.04 e	0.11 ± 0.02 e
	V. subterranea	0.33 ± 0.10 d	0.20 ± 0.02 e	0.13 ± 0.03 e	0.10 ± 0.03 e
DBP (g)	*C. cajan*	0.42 ± 0.04 def	0.39 ± 0.08def	0.30 ± 0.03 ef	0.20 ± 0.03 f
	P. lunatus	3.50 ± 0.29 a	2.22 ± 0.14 b	1.15 ± 0.21 cd	1.00±0.13 cdef
	T. vogelii	1.07 ± 0.20 cde	0.94±0.02cdef	0.49 ± 0.01 def	0.28 ± 0.03 ef
	V. subterranea	1.47 ± 1.02 c	0.73 ± 0.18def	0.39 ± 0.04 def	0.29 ± 0.04 ef
DBR/DBS	*C. cajan*	1.11 ± 0.12 c	1.39 ± 0.30 c	1.48 ±0.11 c	1.30 ± 0.21 c
	P. lunatus	2.98 ± 0.14 ab	2.39 ± 0.31 bc	2.39 ± 0.36 bc	1.67 ± 0.14 c
	T. vogelii	1.41 ± 0.42 c	1.87 ± 0.28 c	1.71 ± 0.35 c	1.17 ± 0.20 c
	V. subterranea	3.85 ± 1.19 a	3.69 ± 0.42 a	4.11 ± 0.85 a	3.69 ± 0.89 a
DBL/DBS	*C. cajan*	1.64 ± 0.12 d	1.33 ± 0.17 d	1.48 ± 0.10 d	0.68 ± 0.05 d
	P. lunatus	2.23 ± 0.26 d	2.24 ± 0.40 d	1.66 ± 0.18 d	1.49 ± 0.18 d
	T. vogelii	1.75 ± 0.14 d	2.35 ± 0.26 d	1.44 ± 0.40 d	0.68 ± 0.07 d
	V. subterranea	11.80 ± 1.32 a	8.45 ± 1.10 b	7.76 ± 1.78 b	5.79 ± 1.06 c

Values follow by same letter on one line are not significant at $p < 0.05$ %.