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SHORT COMMUNICATION

MORPHOLOGICAL AND PHYSIOLOGICAL CHANGES IN COWPEA (*VIGNA UNGUICULATA* L.) SUBJECTED TO WATER DEFICIT

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The present study deals with the changes in morphological characteristics and physiological parameters in two varieties (*Vigna unguiculata* L. cv Pusakomal and *Vigna unguiculata* L. cv Kanakamony) of mature cowpea plants subjected to water stress. The colour and total number of leaves, specific leaf area, shoot length, chlorophyll content and relative water content in both varieties of plants subjected to water stress showed a significant decrease than its corresponding controls, while the root spread and the proline content in the water stressed plants showed a significant increase. The changes in above mentioned parameters showed that kanakamony variety is much tolerant to water stress compared to Pusakomal variety.

Key words: **Chlorophyll, proline, relative water content, specific leaf area, water stress.**

Cowpea is an annual legume chiefly used as a grain crop, for animal fodder or as a vegetable world wide. Scarcity of irrigation during flowering season is a major limiting factor in case of cowpea cultivation (Garg 2003). Depletion of soil water from the root zone affects many plant physiological and biochemical processes (Taiz and Zeiger 2003). The present investigation was undertaken to determine the effect of drought stress on the morphophysiological aspects of two different varieties of cowpea plants.

The seeds of cowpea varieties (*Vigna unguiculata* L. cv Pusakomal and *Vigna unguiculata* L. cv Kanakamony), were collected from National Seeds Corporation, Trivandrum and College of Agriculture, Vellayani, Trivandrum respectively. Earthen pots (20×30×40 cm) were filled with soil mixture containing garden soil, sand and cow dung in the ratio 1:1:1. Fourteen days after sowing, plants with same height and number of leaves were divided into three groups, planted in different pots maintained under controlled conditions. Sixty days after sowing, plants with flowers were divided into test and control groups. The test groups were subjected to mild, moderate and severe water stress by withholding irrigation for 3 days, 6 days and 9 days respectievely. Percent soil moisture content (SMC %) during moisture stress of different magnitudes was determined gravimetrically (Gupta 2000). The SMC for control (without water stress) was 30.02% for mild stress, 20.13% for moderate stress 9.04 % and 5.34% for severe stress. Corresponding control plants in each group were maintained with proper irrigation.

Morphological characteristics like the colour and number of leaves, specific leaf area (SLA), shoot length and root spread were recorded for test and control in each group. Physiological parameters like chlorophyll a, chlorophyll b, total chlorophyll, relative water content and

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proline were determined following the procedures of Arnon (1949), Barr and Weatherly (1962) and Bates *et al.* (1973) respectively. Data were statistically analysed by ANOVA and the means were compared by Duncan's Multiple Range Test using SPSS software (Windows 2000).

The observations on the morphological characteristics in two varieties of cowpea (control and test plants) studied are given in Table 1. The colour intensity and the number of leaves in plants subjected to water stress were reduced compared to the respective control plants. The leaf colour was dark green in control plants of both varieties and in water deficit plants it changed to pale green, yellowish green and then to yellowish brown in both varieties and later the affected leaves shed off. This shows chlorosis in the leaves of test plants under water stress. The specific leaf area showed a significant decrease in plants subjected to water stress compared to that of the controls in both varieties. The SLA and the nutrient concentration in the leaf is linear (Schulze *et al.* 1994; Naidu *et al*. 2001). Analysis of the results of root spread in the test plants showed that root spread increases during water stress conditions compared to controls (Jiang and Huang 2001). In Kanakamony variety of cowpea, the root spread was more than in Pusakomal. This shows that Kanakamony is more drought resistant than the Pusakomal variety. In Pusakomal, the effect of mild and moderate water stress on shoot length is insignificant, while in Kanakamony the water stress significantly reduces the shoot length. Therefore the observed morphological changes in water stressed cowpea plants in our present study was probably due to the reduction of metabolic activity of the cells, and hence resulted in stunted growth.

The results of chlorophyll a, chlorophyll b, total chlorophyll and relative water content (RWC) in the leaves, the proline content of leaves and roots of two varieties of cowpea plants are given in Table 2. Chlorophyll content showed a significant decrease due to water deficit as compared to control. Drought stress significantly reduced chlorophyll content in arid legumes (Garg *et al*. 2005). The reduction in chlorophyll content of Pusakomal variety was more compared to that of Kanakamony. The RWC decreased due to water stress and the genotype Pusakomal showed RWC less than that of Kanakamony. RWC has been shown to be negatively correlated with water stress (Krishnamurthy 2003; Sunita Gupta *et al*. 2005). The significant decrease in RWC in

Table 1. Effect of water stress on morphological parameters in cowpea varieties [Mean ± SD along with results of Duncan's test ($P<0.05$)]

Varieties	Drought stress (days)*	Colour intensity of leaves	Number of leaves	Specific leaf area (cm^2/gm)	Shoot length (cm)	Root spread (cm)
Pusakomal (PL)	0	Dark green	27 ± 0.816^{a}	112.45 ± 1.151^{e}	31 ± 0.326^{i}	22 ± 0.346^{m}
	3	Pale green	19 ± 0.408^{b}	100.39 ± 0.582^{f}	30 ± 0.244^{i}	28 ± 0.173^{n}
	6	Yellowish green	13 ± 0.163^{c}	90.09 ± 0.816^{g}	28 ± 0.489^{j}	32 ± 1.094^{o}
	9	Yellowish brown	9 ± 0.326^{d}	60.00 ± 0.612^{h}	25 ± 0.364^{k}	36 ± 0.572^{p}
Kanakamony (KY)	0	Dark green	$41\pm 0.751^{a*}$	$135.07\pm 0.823^{e*}$	$60\pm 0.682^{i*}$	$25\pm 0.173^{m*}$
	3	Pale green	$33\pm 1.632^{b*}$	$111.3\pm 1.370^{f*}$	$56\pm 1.151^{j*}$	$30\pm 0.516^{n*}$
	6	Yellowish green	$27\pm 0.816^{c*}$	$93.3\pm 0.892^{g*}$	$52\pm 0.143^{k*}$	$33\pm 0.446^{o*}$
	9	Yellowish brown	$23\pm 0.577^{d*}$	$68.96\pm 0.819^{h*}$	$49\pm 0.230^{l*}$	$38\pm 0.288^{p*}$

Values are mean of four replications

Means with different superscripts in each column differ significantly.

*0 days – no water stress, 3 days – mild water stress, 6 days – moderate water stress, 9 days – severe water stress

Table 2. Water stress induced changes in chlorophyll content, relative water content (RWC) and proline content in cowpea varieties (Mean ± SD along with results of Duncan's test. [P<0.05])

Varieties	Water stress (days)*	Chlorophyll in leaves (mg/g dw)				Proline (µmol/g dw)	
		Chlorophyll a	Chlorophyll b	Total chlorophyll	RWC (%)	Leaf	Root
Pusakomal (PL)	0	6.98± 0.011^{a}	4.26± 0.004^{e}	11.24± 0.503^{i}	92.08± 0.255^{m}	0.406± 0.013^{q}	0.772±0.003^{u}
	3	5.05± 0.021^{b}	3.05± 0.012^{f}	8.10± 0.551^{j}	80.44± 0.579^{n}	0.506± 0.030^{r}	0.821±0.012^{v}
	6	3.02± 0.015^{c}	2.66± 0.009^{g}	5.68± 0.522^{k}	62.92± 0.215^{o}	0.598± 0.002^{s}	0.894±0.015^{w}
	9	2.14± 0.013^{d}	1.52± 0.065^{h}	3.66± 0.530^{l}	36.99± 0.201^{p}	0.649± 0.003^{t}	1.152±0.040^{x}
Kanakamony (KY)	0	7.91± 0.018^{a*}	4.15± 0.020^{e*}	12.06± 0.588^{i*}	93.16± 0.326^{m*}	0.532± 0.012^{q*}	0.808±0.013^{u*}
	3	6.93± 0.005^{b*}	2.91± 0.018^{f*}	9.84± 0.602^{j*}	84.66± 0.230^{n*}	0.718± 0.030^{r*}	0.968±0.030^{v*}
	6	4.38± 0.014^{c*}	1.82± 0.012^{g*}	6.20± 0.604^{k*}	68.4± 0.446^{o*}	0.804± 0.050^{s*}	1.064±0.020^{w*}
	9	2.86± 0.017^{d*}	1.13± 0.008^{h*}	3.99± 0.566^{l*}	39.89± 0.115^{p*}	0.958± 0.005^{t*}	1.658±0.010^{x*}

Values are mean of four replications

Means with different superscripts in each column differ significantly.

*0 days – No water stress, 3 days – Mild water stress, 6 days – Moderate water stress, 9 days – Severe water stress

Pusakomal compared to that of the control plants shows that Pusakomal is less tolerant to water stress than Kanakamony.

The free proline content in leaves of both the test varieties under water stress showed a considerable increase as compared with the corresponding controls. The leaves of Kanakamony accumulated more proline than Pusakomal indicating its adaptability to drought than Pusakomal. Proline accumulation in roots was found to be higher than that in the leaves of both varieties. It is widely accepted that water deficit enhances accumulation of proline in many plant species. (Chandrasekhar *et al.* 2000, Tholkappian *et al.* 2001). Proline may regulate the osmotic balance of the cell, thus relieving the negative effect of stress (Shen *et al.* 1990). Proline accumulation under stress has been correlated with stress tolerance of plants. In addition to the role of proline as an osmolite for osmotic adjustments, it also stabilizes cellular structures, scavenges free radicals and buffers cellular redox potential under stress.

Therefore the present study showed that Pusakomal variety under water stress had significant reduction in colour intensity and numbers of leaves, specific leaf area, shoot length, chlorophyll content and relative water content. The proline accumulation in the leaves and roots of Pusakomal under water stress was much less than that of Kanakamony. From the results obtained for the morpho-physiological aspects of two cowpea varieties subjected to water stress, it was found Pusakomal variety is more sensitive to water deficit than Kanakamony. This study points to the fact that mild water deficit for three days can cause a drastic change in the whole plant body function of cowpea. This study also showed that after nine days of water deficit the plant started permanent wilting. Therefore proper irrigation during flowering season is essential for healthy sustenance of cowpea varieties for getting good yield. Also a comparative assessment of the present results obtained for the two varieties of cowpea shows that the Kanakamony variety is more tolerant to water stress and can be recommended for cultivation in water deficit areas.

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REFERENCES

Arnon, D.I. (1949). Copper enzymes in isolated chloroplasts. *Plant Physiol.* **24**: 1-15.

Barr, H.D., Weatherly, P.E. (1962). A re-examination of the relative turgidity technique for estimating water deficit in leaves. *Aust. J. Biol. Sci.* **15**: 413-428.

Bates, L.S., Baldren, P.E. and Teare, I.D. (1973). Rapid determination of proline for water stress studies. *Plant & Soil.* **39:** 205-206.

Chandrasekhar, V., Sairam, R.K. and Srivastava G.C. (2000). Physiological and biochemical responses of hexaploid and tetraploid wheat to drought stress: *J .Agron Crop Sci* **185** (4): 217-227.

Garg, B.K. (2003). Physiological Aspects of Abiotic Stress Tolerance in Arid Legumes. In: A. Henry, D. Kumar and N.B. Singh (eds.), Advances in Arid Legume Research, pp. 347-354. Jodhpur Scientific Publishers, Jodhpur.

Garg, B.K., Burman, U. and Kathju, S. (2005). Comparative water relations, photosynthesis and nitrogen metabolism of arid legumes under water stress. *J. Plant Biol*. **32** (2): 83-93.

Gupta, P.K. (2000). Soil, Plant, Water and Fertilizer Analysis, pp 21. Agrobotanica Publishers, Bikaner.

Krishnamurthy, K.S. (2003). Physiological and biochemical changes during water stress in Ginger. *J.Plant Biol*. **30** (3): 313-317.

Taiz, L. and Zeiger, E. (2003). Stress Physiology. In: Plant Physiology, pp. 591-623, Panima Publishing Corporation, New Delhi.

Naidu, T.C., Raju, M.N. and Narayanan, A. (2001). Screening of drought tolerance in *Green gram* (*Vigna radiata* L.) genotypes under receeding soil moisture. *Indian J. Plant Physiol* .**6**(2): 197-201.

Schulze, E.D., Kelliher, F.M., Korner, C., Lloyd, J., and Lenning, P. (1994). Relationship among maximum stomatal conductance, ecosystems surface conductance, carbon assimilation and plant nitrogen nutrition: A global ecology scaling exercises. *Annu. Rev. Ecol. Syst.* **25**: 629-660.

Schen, C., Orgutt, D.M. and Foster, J.G. (1990). Influence of drought on concentration and distribution of 2,4-diaminobutyric acids in tissues of flat pea [*Lathyrus sylvestris*.L.]. *J. Environ. Expt. Bot*. **30**: 497-504.

Sunita Gupta., Gupta, N.K., Sharma, M.L. and Purohit, A.K. (2005). Water stress induced antioxidant defense mechanism in seedlings of contrasting wheat genotypes. *J. Plant Biol*. **32** (1):143-146.

Tholkappian, P., Prakash, M and Sundaram, M.D. (2001). Effect of VAM fungi on proline, nitrogen and pod number of soybean under moisture stress. *Indian J. Plant Physiol*. **6** (1): 98-99.

Jiang, Y. and Huang, B. (2001). Physiological responses to heat stress alone or in combination with drought: A comparison between tall fescue and perennial rye grass. *Hort Science*. **36** (4): 682-686.