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Degrees of moisture stress on rate of photosynthesis, rate of transpiration & Stomatal conductance in four cowpea (*Vigna unguiculata L.walp.*) genotypes

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Abstract
Present research was conducted to assess the performance of four cowpea genotypes (Fodder cowpea-1, konkan sadabahar, ACP-109, PCP-9702-1) under moisture stress conditions, at research farm Department of Agricutural Botany, COA, Dapoli, DBSKKV, Dapoli (M.S.). The photosynthesis rate showed variability amongst the genotypes studied under different water stressed conditions, itincreased with advancing age of crop. At 45 DAS, genotype ACP-109 showed less reduction in rate of photosynthesis under strong (8.72 %) stress but under severe (9.15 %) stress konkan sadabahar showed less reduction as compared to all other genotypes studied.This clearly indicates that it was because of this the genotypes were able to maintain low leaf temperature which is a desirable character.. Transpiration rate showed variability amongst the genotypes studied, at 45 and 75 DAS. At 45 DAS genotypes ACP-109 and Konkan sadabahar showed less reduction in transpiration rate under strong (16.03 %), (20.05 %) and severe (34.14 %), (44.67 %) stresses than all other genotypes studied indicating the ability of the genotype to retain more moisture in plants under water stress condition. The stomatal conductance increased with advancing age of crop. At 45 DAS genotypes Konkan sadabahar and ACP-109 showed less reduction in rate of stomatal conductance under strong (2.09 %), (2.33 %) and severe (13.34 %) and (19.74 %) stress condition than all other genotypes studied. Genotypes Konkan sadabahar and ACP-109 showed less reduction in rate of stomatal conductance indicating the sustainability of genotypes more robustly under water stress condition, with better physiological performence.

Keywords: *Photosynthesis, Transpiration, Stomatal Conductance, moisture stress*

Introduction
Pulses have been recognized as a major source of vegetable protein with needed minerals and vitamins. They play a vital role in maintaining soil fertility by fixing atmospheric nitrogen. Among pulses, Cowpea (*Vignaunguiculata* (L.) Walp.) is most important legume crop in Asia, Africa, Australia and U.S.A. Water stress is the most common adverse situation which affects the production of agricultural crops all over the world. Konkan region of Maharashtra represents a typical contrasting situation of ample availability of water through assured and heavy monsoon rainfall (average 3,500 mm) occurring rigidly only during June to October on one hand and ever-increasing terminal water stress caused by a high infiltration rate (4.4 cm/hr), poor water holding capacity (27.15 to 30.30 per cent at field capacity and 16.60 to 18.10 per cent at P.W.P. (Dongale *et al*., 1987) on the other hand. Practically no rainfall from October to May accentuates the strength of water stress which limits the yield of field crops, commonly the grain legumes viz., cowpea, horsegram, lablab bean etc. which are grown on stored soil moisture in rice fallows during post monsoon season. It is well known fact that cowpea has greater developmental plasticity than some of the cultivated legumes which imparts it drought tolerance.The present study was studied to reveal the component traits responsible for developmental plasticity and mechanism of sustaining yield levels in water deficit conditions with support of growth analysis and biochemical investigation. To investigate the impact of moisture stress on morpho-physiological traits of cowpea genotypes. To study the impact of moisture stress on various growth parameters and biochemical parameters of cowpea genotypes.To find out moisture stress tolerant, high yielding and high biomass producing genotypes of cowpea

Material and methods
The experimental material for the study consisted of 4 genotypes of cowpea. The seeds of four cowpea genotypes were collected from Research farm, Department of Agril. Botany, College of Agriculture, Dapoli. The experiment comprised of 4 genotypes of cowpea laid out in split plot Design with three replications provided with three different moisture stress levels.

The experiment was conducted in Split Plot Design with three replications. The stress treatments were imposed at three different levels. In first moisture stress treatment, crop was grown on control with zero stress from sowing to maturity. In second moisture stress treatment, cowpea crop was subjected to moisture stress from pre flowering to maturity, i.e. withhelding irrigations from 40 DAS; and third stress treatment was taken as cowpea crop was grown on available residual soil moisture from sowing to the maturity.

Experimental results and discussion

1. Total photosynthesis rate

Data in respect of the influence of different degrees of water stress on course of photosynthesis rate, at two critical growth stages i.e., 45 DAS and 75 DAS of the crop are presented in Table 1.

a) Main effect of moisture stress

It is evident from the data that, the photosynthesis rate progressively increased with the advancing age of the crop at 45 to 90 days. There was considerable variability amongst the genotypes studied for photosynthesis rate, at different growth stages under different intensities of water stress. The mean photosynthesis rate was and 17.009 and 15.3411 µmol CO_2 $m^{-2}sec^{-1}$ during the 45 and 75 DAS respectively. From 45 DAS, onwards zero stressed plants exhibited maximum rate of photosynthesis than those under various intensities of stress. In general, rate of photosynthesis decreased in proportion of intensity of stress.

b) Varietal Differences

At 45 DAS, the highest photosynthesis rate was found in genotype Konkan sadabahar (18.486 µmol CO_2 $m^{-2}sec^{-1}$), while the lowest in PCP-9702-1 (15.674 µmol CO_2 $m^{-2}sec^{-1}$). At 75 DAS, the highest photosynthesis rate was recorded by genotype Konkan sadabahar (17.110 µmol CO_2 $m^{-2}sec^{-1}$), followed by genotypes fodder cowpea (16.1180 µmol CO_2 $m^{-2}sec^{-1}$) and ACP -109 (15.0092 µmol CO_2 $m^{-2}sec^{-1}$). The lowest by genotype PCP-9702-1 (13.126 µmol CO_2 $m^{-2}sec^{-1}$). At 45 DAS, genotype ACP-109 showed less reduction in rate of photosynthesis under strong (8.72 %) stress but under severe (9.15 %) stressed condition konkan sadabahar showed less reduction as compared to all other genotypes studied. This clearly indicates that it was because of this the genotypes were able to maintain low leaf temperature which is a desirable character. The maintenance of plant water balance in these genotypes is due to its higher RWC values and more extraction of soil moisture which could have helped to keep low leaf temperature under water stressed environment (Chavan and Janagoudar, 2007). Varietal difference for photosynthesis rate in cowpea crop was also reported by Mekhri (1979).

2. Total stomatal conductance

The data on the course of stomatal conductance at two critical growth stages i.e., 45 and 75 DAS of the crop are illustrated in Fig. 1.

a) Main effect of moisture stress

There was considerable variability amongst the genotypes studied for stomatal conductance, at different growth stages. The mean stomatal conductance was 0.4246 and 0.4346 µg $m^{-2}sec^{-1}$ during the 45 and 75 DAS respectively. It is evident from the data that, the stomatal conductance progressively increased with the advancing age of the crop at 45 to 75 DAS.

b) Varietal Differences

At 45 DAS, the maximum stomatal conductance was found in genotype PCP-9702-1 (0.4680 µmol H_2O m^{-2} sec^{-1}), followed by Konkan sadabahar (0.4232 µg $m^{-2}sec^{-1}$). While the lowest stomatal conductance was found in genotypes fodder cowpea-1 (0.4081 µmol H_2O m^{-2} sec^{-1}) and ACP-109 (0.3991 µmol H_2O m^{-2} sec^{-1}

At 75 DAS, the highest stomatal conductance was recorded by genotype PCP-9702-1 (0.4564 µmol H_2O m^{-2} sec^{-1}) which was significantly more than rest of the genotypes. The minimum stomatal conductance was found in genotype ACP-109 (0.4131 µmol H_2O m^{-2} sec^{-1}). It was observed that stomatal conductance increased with advancing age of the crop at two active growth stages i.e. 45 to 75 DAS. Under drought stress, stomata are partially closed resulting in limited water loss and reduced photosynthetic rate with restricted diffusion of CO_2 into the leaf, which leads to lower internal CO_2 level and CO_2 deficiency at the reaction site of RuBisCo and however it might not be the only reason for decline in the photosynthesis. Direct inhibition of biochemical processes by altered ionic or osmotic conditions, which affect ATP synthesis and RuBisCo activity, might be another reason for decrease in rate of stomatal conductance (Chowdhary and Varma, 1998). At 45 DAS genotypes Konkan sadabahar and ACP-109 showed less reduction in rate of stomatal conductance under strong (2.09 %), (2.33 %) and severe (13.34 %) and (19.74 %) stress condition than all other genotypes studied, indicating the sustainability of genotypes more robustly under water stress condition, with better physiological performence. Varietal difference for stomatal conductance in cowpea crop was also reported by Hsiao (1973), Sinclair *et.al* (1988), Nwalozie and Annerose (1996).

3. Total transpiration rate

Data in respect of the influence of different degrees of water stress on course of transpiration rate at two critical growth stages i.e., 45 DAS and 75 DAS of the crop are illustrated in Fig.2.

a) Main effect of moisture stress

It is evident from the data that, the transpiration rate progressively increased with the advancing age of the crop at 45 to 75 DAS.

There was considerable variability amongst the genotypes studied for transpiration rate, at different growth stages under different moisture stress levels. The mean transpiration rate was 1.1025 and 1.7888 µg $m^{-2}sec^{-1}$ during the 50 and 75 DAS respectively.

b) Varietal Differences

At 45 DAS, the mean transpiration rate ranged from 0.2321 to 2.0807 µg $m^{-2}sec^{-1}$, the highest transpiration rate was found in genotype fodder cowpea-1 (4.282 µg $m^{-2}sec^{-1}$) followed by, PCP-9702-1 (3.888 µg $m^{-2}sec^{-1}$) and ACP-109 (3.693 µg $m^{-2}sec^{-1}$) while the lowest in konkan sadabahar (3.208 µg $m^{-2}sec^{-1}$). Transpiration occurs through the stomatal action, through which the gaseous exchange takes place. Hence it is indirectly related to photosynthesis and thus, influences the production. In the present investigation, transpiration rate was measured with the help of infrared gas analyzer (LICOR-6400) at two active growth stages i.e. 45 and 75 DAS. It was observed that the transpiration rate increased with advancing age of the crop from 45 to 75 DAS. At 45 DAS genotypes ACP-109, followed by Konkan sadabahar showed less reduction in transpiration rate under strong (16.03 %), (20.05 %) and

severe (34.14 %), (44.67 %) stresses than two other genotypes studied, indicating that it may be due to cooling of the leaf surface on account of excessive loss of water through transpiration leading to lesser leaf temperature which helps the plants to tolerate the excessive heat load. Varietal difference for transpiration rate was also reported by Hamidou *et al*., (2007) and Maharaj singh (2009).

Conclusion

In conclusion, it is to be stated that, a wide range of variability existed for the different growth and yield parameters among 4 cowpea genotypes. Among four genotypes of cowpea studied, under three different water stress conditions genotypes, fodder cowpea-1 followed by konkan sadabahar recorded high yield under severe stressed condition, owing to their higher efficiency to accumulate more dry matter, less reduction in plant height, maintainance of photosynthetically active apparatus, less transpirational water loss and relative water content. This showed attributed to better yield. This information may be helpful for better understanding of concepts of critical stages of vegetative.

Table 1: Influence of various degrees of water stress on rate of photosynthesis (µmol CO_2 $m^{-2}sec^{-1)}$ in cowpea genotypes at various phases of plant growth

Genotypes	Degrees of water stress				SE ±	CD at 5%
	Zero	Strong	Severe	Mean		
45 DAS						
Fodder Cowpea -1	19.475	17.363	15.655	17.497	V.0.0372	0.10883
PCP 9702-1	17.815	15.704	13.503	15.674	S.0.0336	0.12894
Konkan sadabahar	20.347	18.483	16.629	18.486	S × V 0.11173	0.35977
ACP -109	18.128	16.543	14.469	16.380		
Mean	18.941	17.023	15.064	17.009		
75 DAS						
Fodder Cowpea -1	27.570	12.037	8.7467	16.118	V.0.0404	0.11818
PCP 9702-1	23.715	9.2987	6.3650	13.126	S.0.0268	0.10295
Konkan sadabahar	29.449	12.336	9.5470	17.110	S × V 0.12134	0.37753
ACP -109	25.431	11.161	8.4353	15.009		
Mean	26.54	11.208	8.2735	15.341		

V. – Variety S. – Stress S ×V. - Stress× Variety

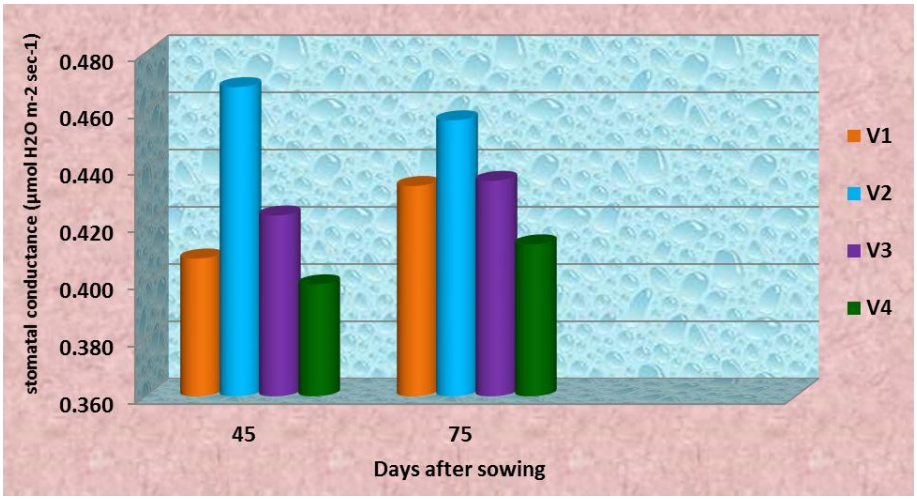

Fig 1: Mean net stomatal conductance per plant in four cowpea genotypes at various phases of plant growth under different degrees of water stress.

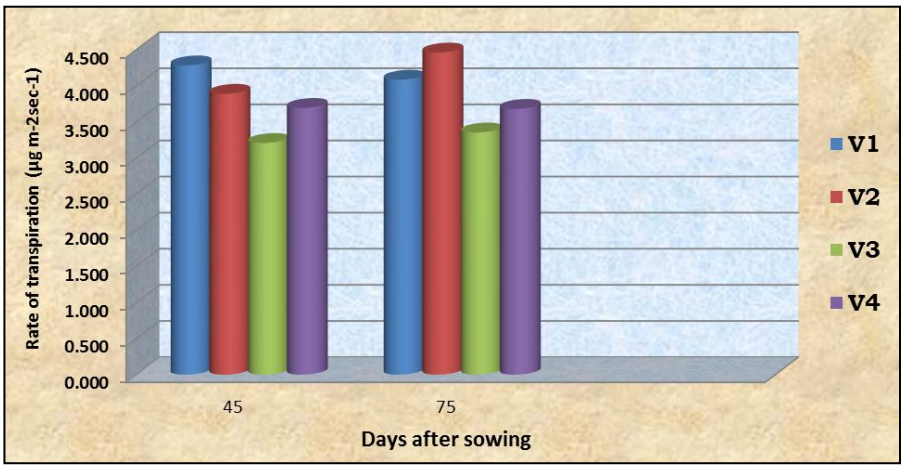

Fig 2: Mean net transpiration rate per plant in four cowpea genotypes at various phases of plant growth under different degrees of water stress.

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