GORBATENKO, E.M. and GORBATENKO Yu. I. (1985). Path analysis of economically useful characters in tomato. **Tsitologiya Genetika 19**: 206 - 210.

GRIFFING, [illegible] (1954). An analysis of tomato yield components in terms of genotypic and environmental effects. **Res. Bull. Ia. Agric. Exp. Sta., 397**: 324 - 380.

JOHNSON, C.E. and HERNANDEZ, T.P. (1980). Heritability studies of early and total yield in tomato. **Hort. Sci., 15**: 280.

KHALIL, R.M., El-GAZAR, T.M. and El-SAYED, M.M., (1986). Genetics and heritability of number of fruits per plant and fruit weight in tomato (*Lycopersicon esculentum* Mill).**Minufiya J. Agric. Res., 7**: 301 - 317.

MURTAZOR, T. and IVANOVA, L. (1979). Biological characterstics and correlation in determinate tomato cultivars. **Kerteszeti Egyetem Kozlemenyl 42**: 67 - 74.

NANDPURI, K.S., KUNWAR, J.S. and LAL, R. (1977). Variability, path analysis and discriminant function selection in tomato (*Lycoperison esculentum* Mill). **Haryana J. Hort Sci., 6**: 73 - 78.

NANDPURI, K.S., SINGH, S. and LAL., T. (1973). Studies on the genetic variability and correlation of some economic characters in tomato (*Lycopersicon esculentum* Mill). **Punjab Agric Uni. J. Res., 10**: 316 - 322.

PATIL., A.A. (1985). Studies on correlation, path analysis, genetic divergence, heterosis and combining ability in ten parent diallel crosses of tomato (*Lycopersion esculentum* Mill). **Mysore J. Agric Sci., 19**: 48 - 49.

PRASAD, A. and PRASAD, R. (1977). Variability and correlation studies in tomato. **Indian J. Agric. Sci., 47**: 77 - 80.

RAIJADHAV, S.B., KALE, P.N. and DESHMUKH, V.Z. (1986). Correlation and regression studies in tomato. **J.Maharashtra Agric Univ., 11**: 39 - 40.

RATTAN, R.S., KANWAR, H.S. and SAINI, S.S. (1983). Variability, path coefficient and discriminant function analysis in tomato. **Veg. Sci., 10**: 22 - 29.

SINGH, H.N., SINGH, R.R. and MITTAL, R.K. (1974). Genotypic and phenotypic variability in tomato. **Indian J.Agric. Sci., 44**: 807 - 811.

SINGH, R.R. and SINGH, H.N. (1980). Correlation studies in tomato. **Indian J. Agric. Sci., 50**: 595 - 598.

SRIVASTAVA, L.S. and SACHAN, S.C.P. (1973). Genetic parameters, correlation coefficient and path coefficient analysis in tomato (*Lycopersicon esculentum* Mill). **Indian J. Agric Sci., 43**: 604 - 607.

STEPANOVA, K.E. and STEVA, L. (1979). Relationship between some vegetable characters and yield in determinate tomato varieties. **Gardinar Ksai Lozarska Nanka 16**: 70 - 76.

(Received: October 1988 Revised: May 1995)

Madras Agric. J., 82(9, 10): 539-544 September, October 1995
https://doi.org/10.29321/MAJ.10.A01259

TRANSPIRATION REGULATION IN SOME LEGUME CROPS UNDER DIFFERENT FERTILITY LEVELS IN SEMIARID FARMING

S.SUNDARAMOORTHY and D.N.SEN

Ecology Laboratory
Department of Botany
University of Jodhpur
Jodhpur

ABSTRACT

To develop a mathematical model which can be used for prediction, one needs to have an assess of all variable pertaining to that system function. For water relation studies and to develop models, parameters like flow, leaf temperature, relative humidity, light intensity, diffusive resistance so also water/osmotic potential of leaf and soil, total transpiring area, their dynamics are prerequisites. However, during the present study, due to the lack of compatible apparatus to suit other measurements, no record could be made on a few parameters. And thus, a complete prediction equations could not be developed. Despite this fact, this investigation identified that flow and resistance have commendable relationship with transpiration than quantum and leaf temperature, changes in fertility levels bring non significant changes (*sensu lato*) intranspiration regulation, mothbean by exhibiting random variability indicates a complex mechanism involved in its transpiration regulation, warranting a detailed investigation.

KEY WORDS : Transpiration, Fertility Levels, Moongbean, Clusterbean, Mothbean

Leaves are most directly exposed to variation in light, temperature and moisture deficit in atmosphere and hence indicative of the evolution of adaptation to environment (Larcher, 1983; Sen and Lekhak, 1984). The crops cultivated in arid and semiarid regions are confronted to maintain a favourable balance between absorption and transpiration under the adverse conditions of environment. The hot-and dry atmosphere demands excessive transpiration , while deficient soil moisture impedes absorption (Sen, 1982). Water relation studies were carried out on many desert plants by various workers (Mathur and Sen,1972; Sen and Chawan, 1972; Sen and Bhandari, 1978) following the traditional methods which led to the pattern of changes in the parameters studied over season. However, little efforts were made to interrelate the parameters (Sen *et al.,* 1990). This paper deals with the inter relationships of some parameters which affect transpiration in three legume crops of semiarid farming.

MATERIALS AND METHODS

Three legume crops, *viz.,* moongbean *(Phaseolus aureus* Roxb cv. Pusa Vaishaki), clusterbean *(Cyamopsis tetragonoloba* (Linn.) Taub. cv. Maru), mothbean *(Phaseolus aconitifolius* Jacq cv. Jadia) were selected for the present study. And these crops were cultivated in the experimental fields during the monsoon season of 1988-89, under five fertility levels: M1-0 Kg N + 0 Kg P_2O_5 + Kg K_2O; M2-15 Kg N + 10 Kg P_2O_5 + 30 Kg K_2O; M3 -30 Kg N + 20 Kg P_2O_5 + 30 KgK_2O; M4-45 Kg N+ 30 Kg P_2O_5 + 30 Kg K_2O; M5-60 Kg N + 45 KgP_2O_5 + 30 Kg K_2O, ha^{-1} with 45 cm apart rows and 15 cm within rows. With the help of Steady State Porometer (Li- Cor) various parameters like flow (cm3 S^{-1}), leaf temperature ^{o}C), relative humidity (%), quantum of light (µ E m^{2}Sec^{-1}), diffusive resistance (S cm^{-1}) and transpiration (µg cm^{-2} Sec^{-1}) were measured, by clamping the leaf sample in the cuvette and the data of that time were recorded. The observations were made during different hours of the day for each crop and fertility levels from 20 days after emergence (DAE) to 65 DAE. An average of 75 for moongbean, 55 for clusterbean and 50 for mothbean, times with pentaplicate observataions each time were made. The mean value of each time and parameter is used for analysis.

The transpiration measured was considered as a dependent factor (Y) of various independent factors. And simple correlation coefficients (r) and best fitting linear or curvilinear equations were computed individually to understand the relationships. Step-wise regression analysis for each fertility level and considering all fertility

Table 1. Relationships between flow and transpiration of legume crops at different fertility levels

Crop(s)/Fertility levels	Number of mean observations	Range of Flow	Equations
Moongbean			
M1	75	0.013 - 7.756	Y = 6.788 ^ 0.870 X (r = 0.986)
M2	75	0.008 - 8.310	Y = 6.925 ^ 0.883 X (r = 0.991)
M3	75	0.008 - 8.386	Y = 6.755 ^ 0.879 X (r = 0.987)
M4	75	0.012 - 8.223	Y = 6.986 ^ 0.874 X (r = 0.989)
M5	75	0.008 - 8.534	Y = 6.869 ^ 0.898 X (r = 0.991)
Clusterbean			
M1	55	0.004 - 5.028	Y = 7.361 ^ 0.894 X (r = 0.990)
M2	55	0.133 - 8.990	Y = 8.529 ^ 0.807 X (r = 0.979)
M3	55	0.138 - 7.533	Y = 8.481 ^ 0.802 X (r = 0.937)
M4	55	0.140 - 8.045	Y = 8.348 ^ 0.810 X (r = 0.981)
M5	55	0.110 - 8.936	$Y = 3.174 + 6.772 X - 0.196 X^2$ ($R^2 = 0.764$)
Mothbean			
M1	50	0.934 - 6.082	Y = 11.124 ^ 0.439 X (r = 0.773)
M2	50	1.599 - 8.540	Y = 19.968 + 0.477 X (r = 0.812)
M3	50	1.700 - 7.940	Y = 10.742 ^ 0.564 X (r = 0.910)
M4	50	0.957 - 8.700	Y = 10.984 ^ 0.475 X (r = 0.840)
M5	50	1.799 - 7.805	Y = 7.542 + 3.819 X (r = 0.947)

^ = To the power

Table 2. Relationships between leaf temperature and transpiration of legume crops at different fertility levels

Crop(s)/Fertility levels	Range of leaf temperature	Equation
Moongbean		
M1	26.7 - 33.4	$Y = -338.704 + 105.751 \log X \ (r = 0.701)$
M2	26.5 - 34.4	$Y = -393.668 + 122.870 \log X \ (r = 0.767)$
M3	26.5 - 34.3	$Y = -440.756 + 136.239 \log X \ (r = 0.817)$
M4	26.5 - 33.9	$Y = -396.375 + 122.938 \log X \ (r = 0.771)$
M5	26.7 - 34.1	$Y = -401.275 + 124.681 \log X \ (r = 0.761)$
Clusterbean		
M1	26.9 - 33.9	$Y = -487.857 + 149.575 \log X \ (r = 0.897)$
M2	27.1 - 34.2	$Y = -511.644 + 156.137 \log X \ (r = 0.905)$
M3	27 - 34.3	$Y = -486.166 + 148.577 \log X \ (r = 0.815)$
M4	27.1 - 34.8	$Y = -483.836 + 147.942 \log X \ (r = 0.905)$
M5	23.6 - 33.4	$Y = -82.956 + 3.345 \quad \log X \ (r = 0.722)$
Mothbean		
M1	27.4 - 34.5	–
M2	26.4 - 34.5	–
M3	27.4 - 34.7	$Y = 2.207 \text{ e } 7.917\text{E-}02 \text{ X} \quad (r = 0.523)$
M4	21.1 - 35.2	–
M5	27.4 - 35.8	–

Number of mean observatiions are same as Table

e = To the exponential

E = To the power of 10

- = Variables are scattered

Table 3. Relationships between relative humidity and transpiration of legume crops at different fertility levels

Crop(s)/Fertility levels	Range of relative humidity	Equation
Moongbean		
M1	15.6 - 82	$Y = 295.395 \text{ e } -0.069 \quad X \ (r = -0.771)$
M2	20.8 - 82.4	$Y = 440.193 \text{ e } -7.485\text{E-}02 \ X \ (r = -0.802)$
M3	12.8 - 82.4	$Y = 429.782 \text{ e } -7.761\text{E-}02 \ X \ (r = -0.799)$
M4	20.8 - 81.6	$Y = 348.001 \text{ e } -7.37\text{E-}02 \ X \ (r = -0.798)$
M5	17.6 - 82.8	$Y = 720.226 \text{ e } -8.815\text{E-}02 \ X \ (r = -0.805)$
Clusterbean		
M1	18 - 82	$Y = 462.503 \text{ e } -7.36\text{E-}02 \ X \ (r = -0.757)$
M2	22.4 - 80	$Y = 154.271 \text{ e-}4.342\text{E-}02 \ X \ (r = -0841)$
M3	23.2 - 80.4	$Y = 129.512 \text{ e-}3.936\text{E-}02 \ X \ (r = -0.747)$
M4	22 - 80.4	$Y = 164.961 \text{ e } --4.586\text{E-}02 \ X \ (r = -0.862)$
M5	18.8 - 79.6	$Y = 105.457 \text{ e-}0.038 \quad X \ (r = -0.662)$
Mothbean		
M1	12.8 - 68.4	$= 2.804 + 1.271 X - 1.729\text{E-}02 X^2 \ (R^2 = 0.82)$
M2	16 - 60.4	$Y = 1.259 + 1.493 X - 206 X^2 \ (R^2 = 0.52)$
M3	20.6 - 59.5	$Y = 202{,}926 \text{ e } -0.585 \ X \ (r = -0.603)$
M4	13.6 - 68.4	$= 6.729 + 1.107 X - 5.104\text{E-}02 X^2 \ (R^2 = 0.69)$
M5	20.6 - 57.2	$= 45.094 + 3.933 X - 5.104\text{E-}02 X^2 \ (R^2 = 0.60)$

Number of mean observatiions are same as Table 1

e = To the exponential

E = To the power of 10

Table 4. Relationship between quantum and transpiration of legume crops at different fertility levels

Crop(s)/Fertility levels	Range of quantum	Equation
Moongbean		
M1	77 - 2430	$Y = 9.589 + 1.31E\text{-}02\,X\ (r = 0.733)$
M2	73 - 1920	$Y = -35.00 + 9.606 \log X\ (r = 0.797)$
M3	66 - 2140	$Y = -24.518 + 7.613 \log X\ (r = 0.803)$
M4	78 - 1940	$Y = -21.792 + 7.276 \log X\ (r = 0.778)$
M5	79 - 1920	$Y = -23.115 + 7.613 \log X\ (r = 0.784)$
Clusterbean		
M1	139 - 2170	$Y = -71.788 + 14.787 \log X\ (r = 0.890)$
M2	154 - 2210	$Y = -79.80 + 15.502 \log X\ (r = 0.909)$
M3	160 - 2050	$Y = -75.757 + 15.452 \log X\ (r = 0.838)$
M4	174 - 1870	$Y = -74.180 + 15.056 \log X\ (r = 0.876)$
M5	191 - 1880	$Y = -74.792 + 14.366 \log X\ (r = 0.904)$
Mothbean		
M1	70 - 1850	
M2	99 - 1680	$Y = 6.402 + 2.769 \log X\ (r = 0.484)$
M3	73 - 1890	$Y = 6.178 \,\hat{}\, 0.212\,X\ (r = 0.629)$
M4	88 - 1880	
M5	84 - 1850	

Number of mean observatiions are same as Table 1
e = To the exponential
E = To the power of 10
- = Variables are scattered

Table 5. Relationships between diffusive resistance and transpiration of legume crops at different fertility levels

Crop(s)/Fertility levels	Range of diffusion resistance	Equation
Moongbean		
M1	0.22 - 34.1	$Y = 11.304 \,\hat{}\, -1.221\,X\ (r = -0.967)$
M2	0.26 - 42.7	$Y = 10.533 \,\hat{}\, -1.229\,X\ (r = -0.967)$
M3	0.26 - 54.2	$Y = 12.086 \,\hat{}\, -1.112\,X\ (r = -0.971)$
M4	0.29 - 47.2	$Y = 21.468 \,\hat{}\, -1.255\,X\ (r = -0.967)$
M5	0.28 - 53.1	$Y = 12.114 \,\hat{}\, -1.059\,X\ (r = -0.905)$
Clusterbean		
M1	0.30 - 6.20	$Y = 11.396 \,\hat{}\, -1.215\,X\ (r = -0.970)$
M2	0.31 - 3.59	$Y = 9.729 \,\hat{}\, -1.421\,X\ (r = -0.858)$
M3	0.28 - 3.45	$Y = 9.846 \,\hat{}\, -1.354\,X\ (r = -0.841)$
M4	0.30 - 3.30	$Y = 9.661 \,\hat{}\, -1.530\,X\ (r = -891)$
M5	0.32 - 4.62	$Y = 10.181 \,\hat{}\, -1.458\,X\ (r = -0.911)$
Mothbean		
M1	0.31 - 2.31	$Y = 17.422 - 1.520 \log X\ (r = -0.526)$
M2	0.29 - 2.97	-
M3	0.11 - 2.85	$Y = 17.342 - 9.627 \log X\ (r = -0.519)$
M4	0.32 - 2.04	-
M5	0.36 - 3.61	$Y = 15.606 \,\hat{}\, -0.555\,X\ (r = -0.741)$

Number of mean observatiions are same as Table 1
e = To the exponential
E = To the power of 10
- = Variables are scattered

Tab[illegible]mulative relationships of independent variables to transpiration of legume crops at different fertility levels

Crop(s)/Fertility levels	% of variation explained/a	Final equation computed \b
Moongbean		
M1	88.97 (4.60)	$Y = -44.173 + 6.471\ X1 + 0.17\ X2 + 0.672\ X3 + 5.815E\text{-}03\ X4 -0.546\ X5$
M2	92.05 (4.43)	$Y = -55.254 + 9.309\ X1 + 1.457\ X2 + 0.516\ X3 + 1.202E\text{-}02\ X4 = -0.163\ X5$
M3	88.44 (5.40)	$Y = -48.660 + 8.554\ X1 + -0.80\ X3 + 7.815E\text{-}04\ X4 - 0.422\ X5$
M4	87.81 (5.46)	$Y = -67.814 + 6.626\ X1 + 1.177\ X2 + 0.597\ X3 + 1.198E\text{-}04\ X5 - 0.463\ X5$
M5	86.87 (5.62)	$Y = -48.353 + 7.639\ X1 + 1.636E\text{-}02\ X2 + 0.729\ X3 + 8.865E\text{-}03\ X4 - 0.238\ X5$
Clusterbean		
M1	93.46 (4.07)	$Y = -157.152 + 5.385\ X1 + 4.129\ X2 + 0.709\ X3 -5.406E\text{-}04\ X4 - 0.151\ X5$
M2	96.83 (2.75)	$Y = -215.009 + 5.513\ X1 + 6.159\ X2 + 0.760\ X3 - 5.545E\text{-}03\ X4 - 3.828\ X5$
M3	96.12 (3.15)	$Y = -217.235 + 4.734\ X1 + 5.912\ X2 + 0.865\ X3 + 7.238E\text{-}05\ X4 - 4.951\ X5$
M4	96.79 (2.72)	$Y = -136.518 + 4.282\ X1 + 3.689\ X2 + 0.653\ X3 + 3.256E\text{-}03\ X4 - 6.441\ X5$
M5	91.40 (4.25)	$Y = -2.511 + 5.619\ X1 + 0.180\ X3 + 4.026E\text{-}04\ X4 - 3.473\ X5$
Mothbean		
M1	90.84 (2.06)	$Y = -38.430 + 2.101\ X1 + 2.155\ X2 - 5.856E\text{-}03\ X3 - 16.939\ X5$
M2	91.12 (1.54)	$Y = 16.423 + 3.125\ X1 + 4.293E\text{-}02\ X2 - 2.204E\text{-}03\ X4 - 11.00\ X5$
M3	92.84 (1.84)	$Y = -28.973 + 6.297\ X1 + 0.604\ X3 - 1.379\ X5$
M4	92.84 (1.88)	$Y = 31.467 + 1.652\ X1 - 0.183\ X3 - 3.434E\text{-}04\ X4 - 13.246\ X5$
M5	95.69 (1.84)	$Y = -9.413 + 4.74\ X1 + 9.053E\text{-}02\ X2 + 0.240\ X3$

\a = Values in paranthesis are standard deviation of residuals

\b = Independent variables X1 = Flow; X2 = Leaf temperature; X3 = Relative humidity; X4 = Quantum; X5 = Diffusive resistance
Dependent variable Y = Transpiration

E = To the power of 10

levels together were also made (Snedecor and Cochran, 1967).

RESULTS AND DISCUSSION

Flow and transpiration were related curvilinearly with a straight line on log vs log scale. This relationship remained same in all five fertility levels in moongbean and clusterbean, except for clusterbean at M5 where the variables follow a parabolic relation. However, in mothbean, flow and transpiration were related linearly at M2 and M5, and curvilinearly at M1, M3 and M4. In all the three crops flow showed significant positive relationship (Table 1). Similar to flow, leaf temperature also showed significant positive relationship with transpiration. In moongbean and clusterbean, these variables followed a sigmold pathway, whereas, they showed random variability in mothbean (Table 2). Compared to flow, leaf temperature exhibited lesser correlation coefficient. Contrary to flow and leaf temperature, relative humidity exhibited negative correlation with transpiration. Relative humidity and transpiration follow an exponential pathway at all five fertility levels in moongbean and clusterbean. Interestingly, these variables follow mostly parabolic pathway in mothbean, except at M3, where it was exponential (Table 3). Quantum of light at leaf surface and transpiration follow a sigmold pathway and exhibited direct relationship in moongbean and clusterbean, whereas, the variabilities were random in mothbean (Table 4). Like flow diffusive resistance also follows a curve linear pathway of a straight line in log vs log scale with transpiration. However these two variables show significant negative correlation in moongbean and clusterbean and random pattern in mothbean (Table 5). It is clear from the equations obtained considering the variables separately against transpiration that increase in fertility levels did not bring any significant change in the pattern of relationships.

As all the independent variables mostly play a significant role in regulating transpiration, these variables were related together and their contributions to transpiration were tested against factorial ratio at 5 per cent. Interestingly, the contributions of all the independent variables were significant in transpiration regulation at all fertility levels in moongbean and clusterbean except leaf temperature at M3 of moongbean and M5 of clusterbean. In mothbean, the contributions of independent variables were random. However, flow the significant at all five levels and diffusive resistance at four levels. The percentage of variability explained was low in moongbean (87-92%) as compared to mothbean (91-96%) and clusterbean (91-97%). Despite random variability in mothbean, the standard deviations of residuals were least ranging from 1.54 to 2.06 as compared of clusterbean (2.72-4.25) and moongbean (4.49-5.62 ; Table 6).

In moongbean and clusterbean, the pattern followed by the independent variables against transpiration were mostly similar so also their contributions. This fact led to further analysis of the data considering all fertility levels together. And the final equations obtained for these crops were as follows:

$$Y = -53.193 + 6.351\,X1 + 0.681\,X2 + 0.583\,X3 + 3.803E\text{-}03\,X4 - 0.335\,X5 \text{ .... moongbean}$$

$$Y = -128.941 + 4.556\,X1 + 3.638\,X2 +)0.469\,X3 - 2.091E\text{-}05\,X5 - 0.115\,X5 \text{ .... clusterbean.}$$

Where X1, X2, X3,X4 and X5 are flow, leaf temperature, relative humidity, quantum, and diffusive resistance, respectively, and Y represent transpiration. The variability explained was satisfactory for moongbean (85.58%) and clusterbean (89.37%) with standard deviation of the residuals of 5.43 and 4.61, respectively.

Transpiration cools leaves (Larcher, 1983) and fluctuations in its rate may indicate the degree of stomatal control and potential for the assimilation of carbon dioxide (Hall and Schulze, 1980). However, these are indirect applications and it is preferable to measure leaf temperature. stomatal aperture and assimilation rates directly (Bannister, 1973). There is no unique relationship between water content and water potential of plant tissues (Jarvis and Jarvis, 1963). Plants growting in arid conditions (physical drought) often show shallow curves with relatively small reductions in water content for large differences in water potential. Stomatal closure and desiccation damage are often more readily related to water content than to water potential (Jarvis and Jarvis, 1963). The considerations of the resistance of leaves to the diffusive of water vapour and carbon di oxide have led to the formulation of a number of mathematicals models which can predict both physiological and ecological response (Lewis, 1972).

ACKNOWLEDGEMENT

The authors are grateful to UGC, New Delhi for financial assistance in the form of a major research project.

REFERENCES

BANNISTER, P. (1973) A note on some observations on frost damage in the damage in the field with particular reference to various ferns **Trans. Bot. Soc. Edinb., 42:** 111-113

HALL, A.E. and SCHULZE, E.D. (1980) Stomatal response to environment and a possible interrelation between stomatal effect on transpiration and CO_2 assimilation **Plant Cell Environ., 3:** 467- 474

JARVIS, P.G. and JARVIS, M.S. (1963) The water relations of tree seedlings. I Growth and water use in relation to soil water potential. **Physiol. Plantarum 16:** 485-500

LARCHER, W. (1983)**Physiological Plant Ecology.** Springer Verlag, Berlin.

LEVIS, M.C. (1972) The physiological significance of variation in leaf structure. **Sci.Prog.,60:** 25-57

MATHUR, T. and SEN, D.N. (1972) Ecology of Indian desert. VIII. On the water relations and assimilate balance of some desert plants. **Ann.Arid Zone 11:** 18-30

SEN, A.P., SUNDARAMOORTHY, S. and CHAWAN, D.D. (1990). Transpiration and its dependence in some desert plants. **13th All India Bot. Conf., Abst.** p.71

SEN, D.N.(1982) **Environment and Plant Life in Indian desert.** Geobios Intern., Jodhpur.

SEN, D.N. and BHANDARI, M.C. (1978) Ecology and water relation of two *Citrullus* spp. in Indian arid zone. In: **Environmental Physiology and Ecology of Plants** (Sen, D.N. and Bansal, R.P.eds). BishenSingh Mahendra Pal Singh Publ., Dehradun, pp. 203- 228.

SEN, D.N. and CHAWAN, D.D.(1972) Leafless *Euphorbia* on Rajasthan (India) rocks IV.Water relations of seedlings and adult plants. **Vegetatio 14:** 193-214.

SEN, D.N and LEKHAK, H.D. (1984). Leaf response under drought. **Indian Rev. Life Sci., 4:** 279-311.

SBEDECOR, G.W. and COCHRAN,W.G. (1967) **Statistical Methods.** Oxford and IBH Publ. & Co., New Delhi.

(Received: October 1991 Revised: May 1995)