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Full Length Research Paper

Stomatal studies of some selected medicinal plants of family solanaceae

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The study reports variation in the structure and distribution of stomata in some members of Solanaceae viz., *Datura innoxia* Miller*, Solanum nigrum* L.*, Solanum surattens* Burm. f.*, Withania somnifera* (L.) Dunal and *Withania coagulans* (Stocks) Dunal. The type of stomata, density, frequency, stomatal index, size of stomatal pore (average length and width), size of guard cells (average length and width) and percentage of the open and close stomata were determined. The upper epidermises of the five plants contain anomotetracytic, anisocytic and amphianisocytic and the lower epidermises of these plants contain anomotetracytic, anisocytic, paracytic and amphianisocytic. The statistical evaluation of the stomata and epidermis included mean, standard deviation, variance, coefficient of variance, standard error and 95% confidence interval for mean were carried out. The study indicates the taxonomic utility of the stomatal type.

Key words: Stomatal study, statistical analysis, Solanaceae.

INTRODUCTION

Leaves can have a wide range of anatomical and morphological structures that partially isolate stomata from the turbulent atmosphere. Traditionally, such stomatal protection has been considered as an adaptation to dry climates (Raven et al., 2005), with the suggestion that they increase the effective boundary layer, decreasing stomatal conductance and thereby reducing stomatal transpiration (Roth-Nebelsick, 2007). Scotland et al. (2003) opinioned that careful and decisive anatomical studied of fewer morphological characters, in the framework of molecular phylogenies is productive to integrating the powers of morphological data with those of sequence information. Since the leaf epidermal studies are considered important in phylogeny and taxonomy (Taia, 2005), attention of plant taxonomists has been attracted toward the leaf epidermal anatomical studies to resolve the taxonomic problems (Hardin, 1979; Fang and Fan, 1993). It has been shown that normal and vitreous leaves of *Datura insignis* differ in the frequency of normal and abnormal stomata (Miguens, 2008). According to Perveen et al. (2007), *Melilotus indicus*, *Datura alba* and *Tribulus terrestris* have anomocytic while *Calotropis procera* and *C. brachycarpa* have paracytic type of stomata. The structure and ontogeny of the stomata has been studied in 26 species of Rubiaceae by Bahadur et al. (2008) in relation to their organographic distribution. The stomata are mostly paracytic on the leaves. Ferris et al. (2002) reported co-efficient of variance, stomatal density, stomatal index, epidermal cells area and number of epidermal cells per leaf of poplar. Patel and Kumar (2008) reported stomatal number of the upper epidermis is 41 to 47 and that of the lower epidermis is 42 to 45 in *Neolamarckia cadamba* (Roxb.). Kong (2001) reported various types of stomata in the genus *Ficus*. Hameed et al. (2008) reported variation in the structure and distribution of stomata in some members of Polygonaceae viz., *Rumex hastatus*, *Rumex dentatus*, *Rumex nepalensis*, *Rheum australe*, *Persicaria maculosa* and *Polygonum plebejum*. The type of stomata, density, frequency, stomatal index, size of stomatal pore, size of guard cells and percentage of the close and open stomata and the statistical evaluation of the stomata and epidermis included mean, standard deviation, variance, coefficient of variance, standard error and difference of

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standard error were carried out. Little information is available on stomata of plants from Pakistan (Abid et al., 2007). Stomata studies of the some medicinal plants, of the family Solanaceae.

MATERIALS AND METHODS

Datura innoxia, Solanum nigrum, Solanum surattens, Withania somnifera and *Withania coagulans* were collected from Shahi Bala, Peshawar during March to July, 2009. These plants were identified with the help of Flora of Pakistan (Ali and Qaiser, 2007). The fresh leaves were immersed in water to prevent desiccation to procure epidermal cells. Peels from both abaxial and adaxial surfaces were obtained with the help of the razor and mounted in Canada balsam for microscopic examination (Chaudhary and Imran, 1997). The parameters studied were the presence and absence of stomata on each epidermis, type of stomata, density, frequency, stomatal index, size of the stomatal pore (average length and width having 10 readings), size of the guard cells (average length and width having 10 readings) and percentage of the open and close stomata (Wallis, 1985). The micrometry of the cells was carried out after following a standard method of Singh, 2009. The statisticial evaluation of the stomata and epidermis included mean, standard deviation, variance, coefficient of variance, standard error and 95% confidence interval for mean (Choudhary and Kamal, 2004).

RESULTS

The type of the stomata in the upper epidermis of the *D. innoxia* is anomocytic and anisocytic. The density and frequency of anomocytic and anisocytic stomata are 30.5, 28.5 and 3050, 2850, respectively. The type of the stomata in the lower epidermis of the *D. innoxia* is anisocytic and anomocytic. The density and frequency of these stomata are 9.5, 16.1 and 950, 1610, respectively. The type of the stomata in the upper epidermis of the *S. nigrum* is anomotetracytic. The density and frequency of anomotetracytic stomata are 70.30 and 7030. The type of the stomata in the lower epidermis of the *S. nigrum* is anisocytic. The density and frequency of these stomata is 77.8 and 7780. The types of stomata on both upper and lower epidermis of *S. surattense* are amphianisocytic and anomotetracytic. The densities of these stomata on the upper epidermis are 19.5 and 21.6 and the frequencies of these stomata are 1950 and 2160. Densities of these stomata on the lower epidermis are 13.5 and 11.1 and the frequencies of these stomata are 1350 and 1110. Stomata on the upper epidermis of *W. somnifera* are anomotetracytic. Density and frequency of the stomata are 27.1 and 2710. Stomata on the lower epidermis of *W. somnifera* are anomotetracytic and anisocytic. Density and frequency of these stomata are 35.6, 21.3 and 3560, 2130, respectively. Stomata on the upper epidermis of *W. coagulans* are anomotetracytic. Density and frequency of the stomata are 12 and 1200. Stomata on the lower epidermis of *W. coagulans* are paracytic and anisocytic. Density and frequency of these stomata are 7, 11.5 and 700, 1150, respectively.

Average length and width of the stomatal pore of the upper epidermis of *D. innoxia* is 6 and 3.7 µ, respectively. Average length and width of the stomatal pore of the lower epidermis of *D. innoxia* is 6.3 and 2.8 µ, respectively. Average length and width of the stomatal pore of the upper epidermis of *S. nigrum* is 8.1 and 3.2 µ, respectively. Average length and width of the stomatal pore of the lower epidermis of *S. nigrum* is 28.8 and 14.6 µ, respectively. Average length and width of the stomatal pore of the upper epidermis of *S. surattense* is 15.8 and 7.4 µ, respectively. Average length and width of the stomatal pore of the lower epidermis of *S. surattense* is 36.1 and 16.6 µ, respectively. Average length and width of the stomatal pore of the upper epidermis of *W. somnifera* is 13.7 and 7.1 µ, respectively. Average length and width of the stomatal pore of the lower epidermis of *W. somnifera* is 14 and 8.2 µ, respectively. Average length and width of the stomatal pore of the upper epidermis of *W. coagulans* is 53.2 and 33.6 µ, respectively. Average length and width of the stomatal pore of the lower epidermis of *W. coagulans* is 19 and 8.5 µ, respectively.

Average length and width of the guard cells of the upper epidermis of *D. innoxia* is 15.2 and 4.1 µ, respectively. Average length and width of the guard cells of the lower epidermis of *D. innoxia* is 13.8 and 2.4 µ, respectively. Average length and width of the guard cells of the upper epidermis of *S. nigrum* is 17.3 and 6.5 µ, respectively. Average length and width of the guard cells of the lower epidermis of *S. nigrum* is 35 and 10.3 µ, respectively. Average length and width of the guard cells of the upper epidermis of *S. surattense* is 24.7 and 15 µ, respectively. Average length and width of the guard cells of the lower epidermis of *S. surattense* is 50.4 and 35.3 µ, respectively. Average length and width of the guard cells of the upper epidermis of *W. somnifera* is 12.5 and 5.6 µ, respectively. Average length and width of the guard cells of the lower epidermis of *W. somnifera* is 24.8 and 13.5 µ, respectively. Average length and width of the guard cells of the upper epidermis of *W. coagulans* is 56.1 and 38.3 µ, respectively. Average length and width of the guard cells of the lower epidermis of *W. coagulans* is 38.5 and 17.3 µ, respectively.

Percentages of the open and close stomata in the upper epidermis of *D. innoxia* are 37.83 and 62.16 and that of the lower epidermis are 39.84 and 60.15. Percentages of the open and close stomata in the upper epidermis of *S. nigrum* are 51.06 and 48.93 and that of the lower epidermis are 24.42 and 75.57. Percentages of the open and close stomata in the upper epidermis of *S. surattense* are 35.03 and 64.96 and that of the lower epidermis are 37.39 and 62.60. Percentages of the open and close stomata in the upper epidermis of *W. somnifera* are 52.76 and 47.23 and that of the lower epidermis are 52.54 and 47.45. Percentages of the open and close stomata in the upper epidermis of *W. coagulans* are 48.33 and 51.66 and that of the lower

epidermis are 48.64 and 51.35.

The statistical evaluation of the stomata of the upper epidermis of *D. innoxia* shows 59.2 mean, 4.70 standard deviation, 22.16 variance, 7.95 coefficient of variance, 1.48 standard error and 55.83 to 62.56 confidence interval for mean; and the lower epidermis have 25.6 mean, 2.33 standard deviation, 5.44 variance, 9.11 coefficient of variance, 0.73 standard error and 23.93 to 27.26 confidence interval for mean. The stomata of the upper epidermis of *S. nigrum* shows 70.3 mean, 8.52 standard deviation, 72.61 variance, 12.12 coefficient of variance, 2.69 standard error and 63.63 to 76.96 confidence interval for mean; and the lower epidermis have 77.8 mean, 7.20 standard deviation, 51.96 variance, 9.26 coefficient of variance, 2.27 standard error and 72.64 to 82.95 confidence interval for mean. The stomata of the upper epidermis of *S. surattense* shows 41.1 mean, 7.04 standard deviation, 49.69 variance, 17.15 coefficient of variance, 2.22 standard error and 36.05 to 46.14 confidence interval for mean; and the lower epidermis have 24.6 mean, 2.24 standard deviation, 5.04 variance, 9.12 coefficient of variance, 0.70 standard error and 22.99 to 26.20 confidence interval for mean. The stomata of the upper epidermis of *W. somnifera* shows 27.1 mean, 3.58 standard deviation, 12.87 variance, 13.23 coefficient of variance, 1.13 standard error and 24.53 to 29.66 confidence interval for mean; and the lower epidermis have 56.9 mean, 5.99 standard deviation, 35.89 variance, 10.52 coefficient of variance, 1.89 standard error and 52.61 to 61.18 confidence interval for mean. The stomata of the upper epidermis of *W. coagulans* shows 12.0 mean, 2.68 standard deviation, 7.2 variance, 22.36 coefficient of variance, 0.84 standard error and 10.08 to 13.91 confidence interval for mean; and the lower epidermis have 18.5 mean, 4.43 standard deviation, 19.65 variance, 23.96 coefficient of variance, 1.40 standard error and 15.32 to 21.67 confidence interval for mean.

The statistical evaluation of the epidermal cells of the upper epidermis of *D. innoxia* shows 87.7 mean, 5.1 standard deviation, 26.01 variance, 5.81 coefficient of variance, 1.61 standard error and 84.05 to 91.34 confidence interval for mean and the lower epidermis have 32.6 mean, 3.23 standard deviation, 10.44 variance, 9.91 coefficient of variance, 1.02 standard error and 30.28 to 34.91 confidence interval for mean. The epidermal cells of the upper epidermis of *S. nigrum* shows 89.9 mean, 5.14 standard deviation, 26.49 variance, 5.72 coefficient of variance, 1.62 standard error and 86.21 to 93.58 confidence interval for mean; and the lower epidermis have 92.1 mean, 7.89 standard deviation, 62.29 variance, 8.56 coefficient of variance, 2.49 standard error and 86.45 to 97.74 confidence interval for mean. The epidermal cells of the upper epidermis of *S. surattense* shows 69.9 mean, 2.7 standard deviation, 7.29 variance, 3.86 coefficient of variance, 0.85 standard error and 67.96 to 71.83 confidence interval for mean; and the lower epidermis have 39.0 mean, 3.06 standard deviation, 9.4 variance, 7.86 coefficient of variance, 0.96 standard error and 36.80 to 41.19 confidence interval for mean. The epidermal cells of the upper epidermis of *W. somnifera* shows 43.1 mean, 6.44 standard deviation, 41.49 variance, 14.94 coefficient of variance, 2.03 standard error and 38.49 to 47.70 confidence interval for mean; and the lower epidermis have 83.0 mean, 6.44 standard deviation, 41.6 variance, 7.77 coefficient of variance, 2.03 standard error and 78.38 - 87.61 confidence interval for mean. The epidermal cells of the upper epidermis of *W. coagulans* shows 25.2 mean, 3.73 standard deviation, 13.96 variance, 14.82 coefficient of variance, 1.17 standard error and 22.52 - 27.87 confidence interval for mean; and the lower epidermis have 68.2 mean, 3.91 standard deviation, 15.36 variance, 5.74 coefficient of variance, 1.23 standard error and 65.39 to 71.00 confidence interval for mean.

DISCUSSION

Different parameters were observed in this study such as presence or absence of stomata on each epidermis, type of stomata, density, frequency, stomatal index, size of stomatal pore (average length and width), size of guard cells (average length and width) and percentage of the open and close stomata. The statistical evaluation of the stomata and epidermis included mean, standard deviation, variance, coefficient of variance, standard error and 95% confidence interval for mean, the stomata type can be singled out as being the most significant in relation to the taxonomic separation of the taxa.

The upper and lower epidermises of *D. innoxia* contain aminotetracytic and anisocytic stomata. The upper epidermis of *S. nigrum* contains anomotetracytic and the lower epidermis contains anisocytic stomata. Both upper and lower epidermises of *S. surattense* contain amphianisocytic and amonotetracytic stomata. Aliero et al. (2007) reported that the leaves are characterized by anisocytic stomata which are more abundant on the abaxial surfaces in *Solanum pseudocapsicum*. Upper epidermis of *W. somnifera* contains amonotetracytic and lower epidermis contains amonotetracytic and anisocytic stomata. Upper epidermis of the *W. coagulans* contains anomotetracytic and the lower epidermis contains paracytic and anisocytic stomata. Density of the amonotetracytic was high in both upper and lower epidermises in *S. nigrum* and it was low for amonotetracytic of upper epidermis in *W. coagulans* and paracytic stomata of lower epidermis in *W. coagulans.* Similarly frequency of the amonotetracytic was high in both upper and lower epidermises in *S. nigrum* and it was low for amonotetracytic of upper epidermis in *W. coagulans* and paracytic stomata of lower epidermis in *W. coagulans.*

The stomatal indices have a wide range of variation. Although stomatal indices have been given considerable importance for making comparison in different taxa, it does not seem to be of any significance in the present study. This is because their values vary inconsistently in different taxa. The stomatal index of the stomata of the upper epidermis was highest 43.88 in *S. nigrum* and was lowest 32.25 in *W. coagulans*. Mishra et al. (2008) reported stomatal index (upper epidermis) is 30.12 and stomatal index (lower epidermis) is 36.31 in the leaves of *Tridax procumbens* L. Stomatal index of the stomata of the lower epidermis was highest 45.8 in *S. nigrum* and was lowest 21.3 in *W. coagulans*. Krishnaveni and Thaakur (2009) reported stomatal index (upper epidermis) is 4.5/mm^2 and stomatal index (lower epidermis) is 16/mm^2 in the leaves of *Argyreia nervosa* Burm. Average length of the stomatal pore of the upper epidermis was highest 53.2 µ in *W. coagulans* and was lowest 6 µm in *D. innoxia*. Average length of the stomatal pore of the lower epidermis was highest 36.1 µ in *S. surattense* and was lowest 6.3 µ in *D. innoxia*. Average width of the stomatal pore of the upper epidermis was highest 33.6 µ in *W. coagulans* and was lowest 3.2 µ in *S. nigrum*. Average width of the stomatal pore of the lower epidermis was highest 16.6 µ in *S. surattense* and was lowest 2.8 µ in *D. innoxia*. Percentage of the open stomata of the upper epidermis is highest 52.76 in *W. somnifera* and lowest 35.03 in *S. surattense* and in the lower epidermis highest 52.54 in *W. somnifera* and lowest 24.42 in *S. nigrum*. Percentage of the close stomata of the upper epidermis is highest 64.96 in *S. surattense* and lowest 47.23 in *W. somnifera* and in the lower epidermis highest 75.57 in *S. nigrum* and lowest 47.45 in *W. somnifera*.

The mean number of the stomata of the upper epidermis was highest 70.3 in *D. innoxia* and was lowest 12 in *W. coagulans*. The mean number of the stomata of the lower epidermis was highest 77.8 in *S. nigrum* and was lowest 18.5 in *W. coagulans*. The standard deviation of the stomata of the upper epidermis was highest 8.52 in *S. nigrum* and was lowest 2.68 in *W. coagulans*. The standard deviation of the stomata of the lower epidermis was highest 7.2 in *S. nigrum* and was lowest 2.24 in *S. surattense*. The variance of the stomata of the upper epidermis was highest 72.61 in *S. nigrum* and was lowest 7.2 in *W. coagulans*. The variance of the stomata of the lower epidermis was highest 51.96 in *S. nigrum* and was lowest 5.44 in *D. innoxia*. The coefficient of variance of the stomata of the upper epidermis was highest 22.36 in *W. coagulans* and was lowest 7.95 in *D. innoxia*. The coefficient of variance of the stomata of the lower epidermis was highest 23.96 in *W. coagulans* and was lowest 9.11 in *D. innoxia*. The standard error of the stomata of the upper epidermis was highest 2.69 in *S. nigrum* and was lowest 0.84 in *W. coagulans*. The standard error of the stomata of the lower epidermis was highest 2.27 in *S. nigrum* and was lowest 0.7 in *S. surattense*. Hameed et al. (2008) reported variation in the structure and distribution of stomata in some members of Polygonaceae viz., *R. hastatus*, *R. dentatus*, *R. nepalensis*, *R. australe*, *P. maculosa* and *P. plebejum*. The type of stomata, density, frequency, stomatal index, size of stomatal pore, size of guard cells and percentage of the close and open stomata and the statistical evaluation of the stomata and epidermis included mean, standard deviation, variance, coefficient of variance, standard error and difference of standard error were carried out.

The mean number of the epidermal cells of the upper epidermis was highest 89.9 in *S. nigrum* and was lowest 25.2 in *W. coagulans*. The mean number of the epidermal cells of the lower epidermis was highest 92.1 in *S. nigrum* and was lowest 32.6 in *D. innoxia*. The standard deviation of the epidermal cells of the upper epidermis was highest 6.44 in *W. somnifera* and was lowest 2.7 in *S. surattense*. The standard deviation of the epidermal cells of the lower epidermis was highest 7.89 in *S. nigrum* and was lowest 3.23 in *D. innoxia*. The variance of the epidermal cells of the upper epidermis was highest 41.49 in *W. somnifera* and was lowest 7.29 in *S. surattense*. The variance of the epidermal cells of the lower epidermis was highest 62.29 in *S. nigrum* and was lowest 9.4 in *S. surattense*. The coefficient of variance of the epidermal cells of the upper epidermis was highest 14.94 in *W. somnifera* and was lowest 3.86 in *S. surattense*. The coefficient of variance of the epidermal cells of the lower epidermis was highest 9.91 in *D. innoxia* and was lowest 5.74 in *W. coagulans*. The standard error of the epidermal cells of the upper epidermis was highest 2.03 in *W. somnifera* and was lowest 0.85 in *S. surattense*. The standard error of the epidermal cells of the lower epidermis was highest 2.49 in *S. nigrum* and was lowest 0.96 in *S. surattense*.

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