Variability in Epicuticular Wax in 35 Woody Plants in Linares, Northeast Mexico

Maiti R1, Rodriguez HG1, Gonzalez EA2, Kumari A3 and Sarkar NC4

1Visiting Scientist, Universidad Autónoma de Nuevo León, Facultad de Ciencias Forestales, Carr. Nac. No. 85 Km. 45, Linares, Nuevo León 67700, México
2Student Universidad Autónoma de Nuevo León, Facultad de Ciencias Forestales, Carr. Nac. No. 85 Km. 45, Linares, Nuevo León 67700, México
3Plant Physiology, Professor Jaya Shankar Telangana State Agricultural University, Agricultural College, Polasa, Jagtial, Karimnagar 505 529, India
4Department of ASEPN, Institute of Agriculture, Visva-Bharati, PO- Sriniketan, Birbhum (Dist), West Bengal (731 236), India

Abstract

A study has been undertaken on epicuticular wax on the leaves of 35 woody species in Linares, Northeast Mexico at the experimental station of Facultad de Ciencias Forestales, Universidad Autónoma de Nuevo León, located in the municipality of Linares. Considerable variation in wax accumulation was found among species showing prominent interspecific variation. Wax load varied from 11.18 to 702.04 µg/cm² among species studied during summer. Few species selected with high epicuticular wax viz, Forestiera angustifolia (702.04 µg/cm²), Diospyros texana (607.65 µg/cm²), Bernardia myricifolia (437.53 µg/cm²), Leucophyllum leucocephala (388.50 µg/cm²), during summer which could well be adapted under semi-arid environments for their efficiency in the reflection of radiation load, reduced transpiration, gas exchange and probably impart drought resistance. The large variations in epicuticular wax could be related to their physiological functions such as transpiration, gas exchange, water relations etc.

Keywords: Epicuticular wax; Variability; Woody trees; Physiological function; Adaptation

Introduction

Leaves contain waxy coating. Environmental conditions may strongly influence the quantity, composition, and morphology of the waxy coverings of leaf surfaces. Wax and cutin function as primary components of the leaf cuticle covering the leaf epidermal cells [1]. Waxes are composed of long-chain paraffins, alcohols, ketones, esters and free fatty acids in proportions determined by both genetic capability and environmental factors [2-4]. Epicuticular wax enhances the reflectance of visible and near infrared radiation from leaf surface thereby reducing net radiation and cuticular transpiration and seems to contribute drought resistance of plants [5-7]. These waxes also impart resistance to plants to absorption and penetration of foliar-applied herbicides [4,8,9]. It has been reported that leaves of mesquite (Prosopis spp.) develop a thick waxy cuticle [10,11]. An increase in wax accumulation was observed with leaf maturity in velvet mesquite (P. velutina), while [12] observed most rapid wax accumulation on honey mesquite (P. glandulosa) with early leaf development and expansion.

Researches undertaken on epicuticular wax under controlled condition have documented various factors such as, light level [13,14] photoperiod [15] temperature [16,17] and water stress [18-19] influencing the wax contents in leaves. Variations in wax properties can affect the cuticular functions such as, regulation of gas exchange and transpiration, protection against pathogens, and absorption of foliar-applied chemicals as herbicides in agriculture. Few studies are available on variation in epicuticular wax characterstics among plants growing in the field. It has been reported by [20] that the composition and quantity of epicuticular waxes of shrubs in a semiarid environment showed seasonal variations in temperature and rainfall, and both cuticular and total transpiration appeared to be affected with changes in wax composition. Ecotypic variation in the quantity and composition of waxes on leaves of salt cedar (Tamarix pentandra Pall.) was considered as the basis of differences among populations in sensitivity to herbicide sprays [4]. Leaves of a cabbage cultivar (Brassica oleracea L. var. capitata), tolerant of foliar applications of the herbicide nitrofen (2,4-dichlorophenyl-p-nitrophenyl ether) were more heavily waxed than an intolerant cultivar [21]. The heavier wax deposit on leaves of the tolerant cultivar substantially decreased the rate and extent of herbicide penetration of the cuticle. The development of leaf cuticle of velvet mesquite was investigated [22] and detected well defined crystalline wax structures on even the youngest leaves. The amount of wax appeared to increase with leaf maturity, and a dendritic-shaped wax plate was formed in July in addition to the small, linear structure already present. The epicuticular wax structure of five Prosopis species, consisted of an aggregate coating of rods and dendritic platelets [23].

Materials and Methods

The study was under taken in thirty five woody trees species in the summer season (June 2015) at the experimental station of Facultad de Ciencias Forestales, Universidad Autónoma de Nuevo Leon, located in the municipality of Linares. Fresh leaves from different woody plant species were collected from the forest. Then leaflets were separated individually to complete a sub sample having an approximate surface area of 100 cm² which is determined by a leaf area meter. Sub-samples were then reweighed to quantify the amount of residual wax. Amount of wax for a field sample was the mean of 5 laboratory replications. Wax
was calculated reported on a weight per area basis (g m⁻²) derived by dividing wax weight by the actual area of the sub-sample unit.

Results and Discussion

The present study indicated the presence of large variations in the wax contents among the different woody tree species studied. The results obtained are presented below. Table 1 gives the summary of Kwalis analysis. Table 2 presents the epicuticular wax content in 35 woody species. The species showed significant variation in epicuticular wax contents among these 35 species. These variations are seen in Figure 1. Most of the tree species has shown a large variation in the wax contents. The wax contents in these thirty five woody species ranged from 11.18 to 702.04 µg/cm². On the basis of total epicuticular wax contents species are selected and categorized into high, medium and low wax content species.

The species showing high epicuticular wax load are *Forestiera angustifolia* (702.04 µg/cm²), *Diospyros texana* (607.65 µg/cm²), *Bernarda myricifolia* (437.53 µg/cm²), *Leucophyllum leucocephala* (388.50 µg/cm²), *Acacia farnesiana* (373.49 µg/cm²), *Cercidium macrum* (308.63 µg/cm²). Similarly the species showing medium epicuticular wax load are *Lantana macropoda* (294.86 µg/cm²) *Quercus polymorpha* (199.40 µg/cm²), *Parkinsonia aculeata* (196.20 µg/cm²), *Acacia shaffneri* (170.04 µg/cm²), *Diospyros palmeri* (163.25 µg/cm²), *Helietta parvifolia* (151.19 µg/cm²), *Eysenhardtia polystachya* (138.49 µg/cm²), *Bumelia celastriña* (112.50 µg/cm²) while the species showing minimum epicuticular wax are *Ehretia anacua* (17.58 µg/cm²), *Karwinska humboldtiana* (15.47 µg/cm²), *Amyris texana* (11.18 µg/cm²). The rest of the species had near medium to very low wax content are shown in the Table 1.

The results reveal that there exists large variability in epicuticular wax accumulation among 35 species. This large variability in interspecific

| Scientific name   | Family     | Type     | Wax µg/cm² |
|-------------------|------------|----------|------------|
| Helietta parvifolia | Rutaceae   | Shrub    | 151.19 ± 82.29 |
| Amyris texana     | Rutaceae   | Tree     | 11.18 ± 12.67 |
| Leucophyllum leucocephala | Scrophulariaceae | Tree | 388.50 ± 78.74 |
| Zanthoxylum fagara | Rutaceae   | Tree     | 63.98 ± 16.47 |
| Karwinska humboldtiana | Rhamnaceae | Shrub    | 15.47 ± 8.54 |
| Celtis pallida    | Ulmaceae   | Tree     | 75.64 ± 16.47 |
| Gualacum angustifolium | Zygophyllaceae | Tree | 122.50 ± 123.36 |
| Bernarda myricifolia | Euphorbiaceae | Tree | 437.53 ± 221.86 |
| Forestiera angustifolia | Oleaceae | Shrub | 702.04 ± 392.57 |
| Croton suaveolens | Euphorbiaceae | Tree | 62.97 ± 11.03 |
| Eysenhardtia polystachya | Fabaceae   | Shrub    | 138.49 ± 32.32 |
| Cordia boissieri  | Borajcinaceae | Tree | 59.62 ± 5.50 |
| Ehretia anacua    | Borajcinaceae | Tree | 17.58 ± 5.50 |
| Caesalpinia mexicana | Fabaceae | Tree | 38.49 ± 10.86 |
| Condalia hoockeri | Rhamnaceae | Tree | 59.46 ± 49.54 |
| Sargentia gregii | Rutaceae   | Tree     | 55.44 ± 19.31 |
| Diospyros palmeri | Ebenaceae  | Tree     | 163.25 ± 41.34 |
| Bumelia celastriña | Sapotaceae | Tree | 132.38 ± 45.90 |
| Ebenopsis ebano | Fabaceae   | Tree     | 62.71 ± 30.12 |
| Leucaena leucocephala | Fabaceae   | Tree | 59.18 ± 16.01 |
| Celtis laevigata  | Ulmaceae   | Tree     | 34.25 ± 15.93 |
| Cercidium macrum  | Fabaceae   | Tree     | 308.63 ± 176.60 |
| Acacia rigidula   | Fabaceae   | Tree     | 31.24 ± 10.14 |
| Gymnosperma glutinosum | Asteraceae | Shrub | 65.12 ± 21.62 |
| Acacia farnesiana | Fabaceae   | Shrub    | 373.49 ± 217.84 |
| Lantana lipocephala | Verbenaecae | Tree | 294.86 ± 84.36 |
| Berberis chocooco | Berberidaceae | Shrub | 98.65 ± 58.50 |
| Diospyros texana  | Ebenaceae  | Tree     | 607.65 ± 226.73 |
| Acacia berlandieri | Fabaceae   | Tree     | 58.15 ± 17.84 |
| Quercus polymorpha | Fabaceae   | Tree     | 199.40 ± 140.81 |
| Salix lasiolepis | Salicaceae | Tree     | 42.96 ± 20.81 |
| Acacia shaffneri  | Fabaceae   | Tree     | 170.04 ± 86.08 |
| Prosopis laevigata | Fabaceae   | Tree     | 103.73 ± 23.65 |
| Parkinsonia aculeata | Fabaceae | Tree | 196.20 ± 63.25 |
| Acacia wrightt | Mimosaecae | Tree | 114.48 ± 38.05 |

Table 1: Summary of Kwalis Analysis.

![Figure 1: Epicuticular wax content of 35 woody species.](image-url)
variation in epicuticular wax contents among among different species are rarely found, although [24] demonstrated variability in wax content among different species of *Prosopis* and in different seasons.

The large variation in epicuticular wax observed in the present study could be related to physiological function and adaptation of the species to varying environments. With respect to the physic-chemical and physiological functions it has been reported that epicuticular wax enhances the reflectance of visible and near infrared radiation from leaf surface, which in turn reduce net radiation and cuticular transpiration and seem to contribute drought resistance of plants [5-7]. The presence of wax impart resistance of plants to absorption and penetration of foliar-applied herbicides [4,8,9]. We selected few species with high epicuticular wax viz, *Forestiera angustifolia* (702.04 µg/cm²), *Diospyros texana* (607.65 µg/cm²), *Bernardia myricifolia* (437.53 µg/cm²), *Leucophyllum leucophyllum* (388.50 µg/cm²), during summer which could well adapt under semi-arid environments for their efficiency in the reflection of radiation load, reduced transpiration, gas exchange and probably impart drought resistance. They could impart resistance to insect attack and herbicide penetration as reported by few authors [4,8,9].

Few studies are available on variation in epicuticular wax characteristics among plants growing in the field. The large variations in epicuticular wax could be related to their physiological functions such as transpiration, gas exchange, water relations etc. The result of epicuticular wax of the species reported in the present study was undertaken in the summer. The wax content was reported to vary in different environments [13,14], photoperiod [15], temperature [14,16] and water stress [17-19]. It has been reported by [20] that the composition and quantity of epicuticular waxes of shrubs in a semi-arid environment showed seasonal variations in temperature and rainfall, and both cuticular and total transpiration appeared to be affected with changes in wax composition. We claim this is the first research ever dealt with the analysis of epicuticular wax in a large number of woody species.

**Conclusion**

It is well documented that epicuticular wax on leaf surface play an important role in the physiological function and adaptation of trees in an ecosystem with respect to loss of transpiration owing to the reflection of solar radiation, and other aspects such as gas exchange, water stress, herbicide resistance etc. The present study show a large variations in the contents of epicuticular wax thereby giving opportunity to select species for future research with respect to the adaptation of these species to semiarid environment. The species selected with high epicuticular wax contents viz., *Forestiera angustifolia* (702.04 µg/cm²), *Diospyros texana* (607.65 µg/cm²), *Bernardia myricifolia* (437.53 µg/cm²), *Leucophyllum leucophyllum* (388.50 µg/cm²) may be well adapted to the semi-arid conditions. Future research needs to be directed on these selected species with special reference to their physiological function and adaptation to water stress.

**Acknowledgement**

The authors are highly thankful to Elsa Gonzalez for dedicated hard work in the chemical analysis.

**References**

1. Martin JT, Junier BE (1970) The cuticles of plants. St. Martin’s, New York.
2. Fernandez AMS, Baker EA, Martin JT (1964) Studies on plant cuticle-VI. The isolation and fractionation of cuticular waxes. Ann. Appl. Biol.53: 43-58.
3. Hull HM, Went FW, Bleckmanu CA (1979) Environmental modification of epicuticular wax structure of *Prosopis* leaves. J. Arizona- Nevada Acad. Sci. pp. 1439-1442.
4. Wilkinson RE (1980) Ecotypic variation of *Tamarix pentandra* epicuticular wax and possible relationship with herbicide sensitivity. Weed Sci. 28: 110-113.
5. Kurtz EB (1950) The relation of the characteristics and yield of wax to plant age. Plant Physiology, 25: 269-278.
6. Ebercon A, Blum A, Jordan WR (1977) A rapid calorimetric method for epicuticular wax content of sorghum leaves. Crop Sci., 17:179-180.
7. Hull HM, Bleckman CA (1977) An unusual epicuticular wax ultrastructure on leaves of *Prosopis farnamii* Amer. J. Bot. 64: 1083-1091.
8. Hammerston JL (1967) Environmental factors and susceptibility to herbicides. Weeds, 15: 330-336.
9. Sharma MP, Vanden Born WH (1970) Foliar penetration of picloram and 2, 4-D in aspen and balsam poplar. Weed Sci. 18: 57-63.
10. Hull HM (1970) Leaf structure as related to absorption of pesticides and other compounds. Residue Rev, 31: 1-155.
11. Meyer RE, Morton HL, Haas RH, Robison, ED, Riley TE (1971) Morphology and anatomy of honey mesquite. U.S. Dep. Agr. Tech. Bull. 1423: 186.
12. Mayeux HS, Jordan WR, Meyer RE, Meeu SM (1981) Epicuticular wax on goldenweed (*Isocoma* spp.) leaves: variation with species and season. Weed Sci, 29: 389-393.
13. Juniper BE (1960) Growth, development, and effect of the environment on the ultra-structure of plant surfaces. J. Linnean Soc. Bot. 56: 413-418.
14. Reid DW, Tukey JR (1982) Light intensity and temperature effects on epicuticular wax morphology and internal cuticle ultrastructure of carnations and Brussels sprouts leaf cuticles. J. Amer. Soc. Hort. Sci, 107: 417-420.
15. Wilkinson RE (1972) Sicklepod hydrocarbon response to photoperiod. Phytochemistry. 11: 1273-1280.
16. Hull HM (1958) The effect of day and night temperature on growth, foliar wax content, and cuticle development of velvet mesquite. Weeds, 6: 133-142.
17. Skoss JD (1955) Structure and composition of plant cuticle in relation to environmental factors and permeability. Bot. Gaz. 117: 55-72.
18. Bengtson C, Larson S, Liljenberg (1978) Effects of water stress on cuticular transpiration rate and amount and composition of epicuticular wax in seedlings of six oat varieties. Physiol. Plantarum. 44: 319-324.
19. Baker EA, Procopioli J (1980) Effect of soil moisture status on leaf surface wax yield of some drought-resistant species. J. Hort. Sci. 55: 85-87.
20. Rao JVS, Reddy KR (1980) Seasonal variation in leaf epicuticular wax of some shrub species. Indian J. Exp. Biol. 18: 495-499.
21. Preira JF, Splitsstoesser WE, Horen HU (1971) Mechanism of intraspecific selectivity of cabbage to nitrofen. Weed Sci. 19: 647-651.
22. Hull HM, Morrison, Orton HL, Whanrie JR (1975) Environmental influences on cuticle development and resultant foliar penetration. Bot. Rev. 41: 421-452
23. Bleckmann CA, Hull HM (1975) Leaf and cotyledon surface ultrastructure of five Prosopis species. J. Ari- zona Acad. Sci. 10: 98-105.
24. Jacoby PW, Coby, Ansley RJ, Medores CH, Huffman AX (1990) Epicuticular wax in honey mesquite: Seasonal accumulation and intraspecific variation. Journal of Range Management, 43: 347-350.