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Introduction

Casuarina equisetifolia Forst., a fast growing tree of multiple end uses is raised extensively by farmers and Forest Departments. Phenotypic variants are reported on this species throughout the distribution range in India on crown shape, branch angle, cladode length, size and shape of fruiting cones and seed morphology. (Anon., 1994). This tree flowers twice a year, once from February to April and again September to October, the fruits ripening in June and December. Male, female and monoecious trees are found in this species. Male flowers are produced in catkins and each flower consists of a single stamen enclosed in a pair of deciduous petals and two small bracteoles in the bud stage. The female flowers have no perianth and are produced in small cones. Each female flower consists of a single unilocular gynaecium formed from two carpels subtended by two lateral bracteoles and a bract (Troup, 1921). Generally, in a population 48 per cent of trees are male and 49 per cent female with 2 to 3 per cent being monoecious. Change of sex expression in this species is unreported though there are reports of change in sex expression in *Salix* species (Malyutina, 1973), *Morus nigra* (Jaiswal and Kumar, 1980) and *Acer* species (Matsui, 1995). The present study provides conclusive evidence for the first time that change in sex expression occurs in *C. equisetifolia*.

Material and Methods

Three to four year old plantations in Chengalpet and Chidambaram in Tamil Nadu were surveyed and extremely superior trees were selected and cloned using the cladodes (Gurumurthi and Bhandari, 1988). Ramets of these clones were established in the clone bank of Institute of Forest Genetics and Tree Breeding (IFGTB), Coimbatore for selection and breeding work in the year 1992 (Kumar and Gurumurthi, 1996). Observation on various biometric and physiological parameters are being recorded at intervals of three months. The observations recorded during the month of September, 1997 and March, 1998 on flowering behaviour in the clones assembled from the Chengalpet and Chidambaram areas provided proof of change in sex expression in this species. Data on flowering were collected regularly

and the plant samples analysed to study the variation in protein profiles during flowering and non-flowering seasons.

Results and Discussion

The population assembled from Chengalpet and Chidambaram consisted of clearly identified males, females and monoecious individuals at the time of introduction in the clone bank of IFGTB in 1992. Observations taken on flowering pattern from September, 1997 onwards proved that sex change had occurred in few clones. Constant males accounted for 59 per cent, constant females 26 per cent and constant monoecious individuals 4 per cent of the population. Six clones (11 per cent of the population) changed their sex in various ways (Table 1). Four clones viz., CHCE 1003, CHCE 2903, CPCE 0109 and CPCE 3702 were females originally and changed their sex to bisexuals. Clones CHCE 0401 and CPCE 3501 were originally males and transformed into monoecious plants by producing female cones approximately five years after introduction.

Studies were initiated to understand this rare phenomenon at the molecular level. Protein profiles of the inconstant individuals were compared with those of the constant males, constant females and monoecious individuals during the flowering season. Further studies were taken up during the non-flowering season also to test for variations in protein levels. Total crude protein levels were analyzed during the flowering (January to March) and non-flowering (July to August) seasons during the year 2000. It was observed that the two types of plants namely the constants and the inconstants differed remarkably with respect to their protein levels (Fig. 1).

Protein levels were as low as 9.62 and 8.68 mg/g fresh tissue in males and females respectively during the non-flowering seasons which increased drastically to 39.4 and 32.0 mg/g fresh tissue during flowering (almost 4 fold increase over the initial values). In monoecious individuals, the protein levels were comparatively higher during the flowering season, but the variation in protein levels between the flowering and non-flowering seasons were marginal.

In case of the inconstants, there was a remarkable change in protein levels. During flowering, the male plants, which changed their sex to inconstant individuals showed a 15 fold increase in protein levels when compared to the non-flowering season, while the female plants, which changed to inconstants showed a 10 fold increase. A reduction in protein content was noticed in the transformed plants when compared to the constant individuals at the time of flowering. But the rate of increase in protein levels in the transformants during flowering was almost thrice that of the normal plants. This may be effected as a result of the change in the sex expression in the transformants from either male or female to monoecious where it is required to produce female or male inflorescence additionally.

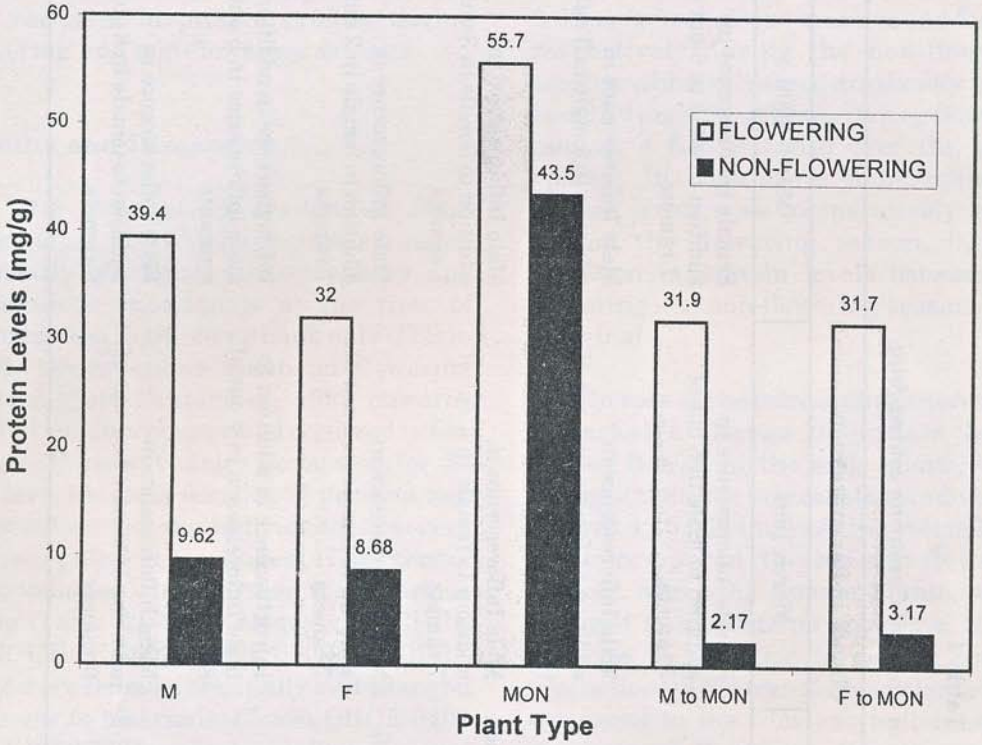
Continuous hedging done on the trees may be one of the reasons for this phenomenon of change in sex expression. Clones are maintained as hedges for production of several thousands planting stock using cladodes (Gurumurthi and Rawat, 1992). Malyutina (1973) studying the reasons for change of sex in *Salix* reported that the sex change is attributed not only to the very mutable nature of the

Table 1

Change in sex expression in clones of Casuarina equisetifolia

Clone Number	Sex when planted (1992)	Change in Sex expression		
		March 1998	March 1999	March 2000
CHCE 0401	Male	Female inflorescence in addition to male in 3 out of 7 ramets	Female inflorescence in addition to male in 6 out of 7 ramets	Female inflorescence in addition to male in 6 out of 7 ramets
CHCE 1003	Female	Male Inflorescence in addition to female in 3 out of 9 ramets	Male Inflorescence in addition to female in 3 out of of 9 ramets	Male Inflorescence in addition to female in 3 out of 9 ramets
CHCE 2903	Female	Iinitiation of Male Inflorescence addition to female in all the 7 ramets	Male Inflorescence in addition to female in 3 out of 7 ramets	Male Inflorescence in addition to female in 3 out of 7 ramets
CPCE 0109	Female	Initiation of Male Inflorescence addition to female in 3 out of 7 ramets	Male Inflorescence in addition to female in 2 out of 7 ramets	Male Inflorescence in addition to female in 2 out of 7 ramets
CPCE 3501	Male	Infructuscence in addition to male inflorescence in 2 out of 9 ramets	Infructuscence in addition to male inflorescence in 4 out of 8 ramets	Infructuscence in addition to male inflorescnce in 5 out of 8 ramets
CPCE 3702	Female	Male Inflorescence in addition to female in 5 out of 9 ramets	Male Inflorescence in addition to female in 7 out of 9 ramets	Male Inflorescence in addition to female in 8 out of 8 ramets

Fig. 1



Variations in protein levels in *Casuarina equisetifolia* during flowering and non-flowering seasons

M - Male F- Female Mon - Monoecious

M to Mon - Sex changed from male to monoecious

F to Mon - Sex changed from female to monoecious

reproductive organs in *Salix*, but also to the effect of unfavourable external influences including tree surgery. Jaiswal and Kumar (1980) reported that treatment of male plants of *Morus nigra* L. with 2 chloroethylphosphonic acid (ethophon) at concentrations in the range of 960-3840 mg/l induced the production of female flowers and intersexual flowers, which showed various degrees of transformation of male sex organs into female ones. Sex expression, sex change and fruiting habit in *Acer rufinerve* was studied by Matsui (1995) in Japan. Two types of flowers, functionally male and female were recognised. The adult population consisted of constant males, constant females and inconstants. Constant male plants that bore exclusively male flowers throughout the study period accounted for 87 per cent of the adult population. Plants accounting to eleven per cent of the population changed their sex in various ways and only 2 per cent of the population were comprised of constant females. When the dioecious species *Acer negundo, A. dasycarpum* and

A. monspessulanum were grown in an alien environment at the limits of their natural range, a sex change occurred in individual trees accompanied by parthenocarpy (Beskaravainaya, 1971). McArther *et al.* (1992) opined that the magnitude of sex change in trees is a product of the interaction of genetics and environment.

In the present study, the only external influence was continuous hedging of plants. It may however, be pointed out that though all the 103 clones are maintained as hedge orchards for planting stock production, only 11 per cent of the population showed change of sex termed as inconstants which may have evolutionary significance. Plant health and the successional stage of the stand need to be studied along with resource allocation to explain the proximate mechanisms of sex expression.

SUMMARY

Flowering pattern in sex identified clones of *Casuarina equisetifolia* Forst. grown as hedges in the clone bank of Institute of Forest Genetics and Tree Breeding, Coimbatore, India revealed that sex change occurs in this species. The population assembled and rooted ramets from three year old trees selected from Chengalpet and Chidambaram area of Tamil Nadu, India consisted of constant males, constant females and monoecious individuals at the time of introduction during 1992 and remained so till 1997. The data on flowering collected afterwards showed that constant males, constant females and monoeciouis individuals accounted for 59, 26 and 4 per cent of the population respectively. Six clones (11% of the population) changed their sex in various ways and became inconstant individuals. Studies on protein profiles undertaken during flowering and non-flowering seasons envisaged that the constants and inconstants differed remarkably with respect to their protein levels. Continuous hedging may bring out plasticity of sex expression in a small per cent of population.

कैजुआरिना इक्विसेटिफोलिया फौर्स्ट० के कृन्तकों में लैंगिक विभिन्नता का अध्ययन

कण्णन चन्द्रशेखर वारियर, के०जी० अजित कुमार, रेखा आर० वारियर व के० गुरूमूर्ति

साराशं

कैजुआरिना इक्विसेटिफोलिया फौर्स्ट० के लिंग पहचाने कृन्तकों की, जिन्हें वन आनुवांशिकी एंव वृक्ष प्रजनन संस्थान, कोयम्बटूर के कृन्तक-कोश में झाड़ियों की तरह उगाया गया, पुष्पन सज्जा से पता चला कि इस वृक्षजाति में लिंग परिवर्तन होता है । तमिलनाडु, भारत के चिंगलपेट और चिदम्बरम क्षेत्रों के तीन-वर्षीय वृक्षों से चुने गए जड़ें निकले रैमेट से बनाई गई वृक्ष संख्या में 1992 में आरम्भन करते समय स्थिर नर, स्थिर मादा और उभयलिंगी पौधे ही लिए गए थे जो 1997 तक यथावत् बने रहे । तदुपरान्त एकत्रित पुष्पों के आंकड़ों ने दिखाया कि स्थिर नर, स्थिर मादा और उभयलिंगी पादपों की संख्या कुल वृक्ष संख्या की क्रमशः 59, 26 और 4 प्रतिशत थी । छह कृन्तकों (कुल वृक्ष संख्या का 11%) का विभिन्न तरीकों से लिंग परिवर्तन हो गया था और वे अस्थिर वृक्ष बन गए थे । पुष्पन और अपुष्पन समय में किए गए प्रोटीन स्थिति अध्ययनों ने दिखाया कि स्थिर और अस्थिर पादपों ने इनके प्रोटीन स्तरों की दृष्टि से बहुत अन्तर पाया जाता है । निरन्तर बाड़ लगाए रखने से वृक्षों के छोटे से प्रतिशत की लिंग अभिव्यक्ति में अभिघटन हो सकता है ।

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