Selection of Plant Type for Higher Biomass in *Prosopis* Species Using Correlation and Path Analysis

J.C. Tewari, L.N. Harsh, D. Tripathi, M.D. Bohra and N.K. Sharma
Central Arid Zone Research Institute, Jodhpur – 342003

ABSTRACT

Correlations and path analysis were worked out in three-year-old progeny trial of five different *Prosopis* species *viz. P. nigra, P. chilensis, P. flexuosa, P. alba* and *Prosopis* species - *preuvian*. All the correlations between plant height, collar diameter, crown diameter and biomass were found to be positive. Correlation coefficients were the maximum between plant height and collar diameter and ranged from 0.79 (*P.chilensis*) to 0.87 (*Prosopis* species - *peruvian*). Path analysis revealed that maximum direct effect towards biomass was contributed by collar diameter in *P. nigra* (0.48), *P. alba* (0.36) and *Prosopis* species - *peruvain* (0.38). However, in case of *P.chilensis* plant height had maximum direct effect towards biomass (0.36). In *P. flexuosa,* crown diameter contributed maximum in this respect (0.51). Residual effects were high in all the cases and ranged from 0.56, in *P. chilensis* to 0.73 in *P. flexuosa*.

Key words : *Correlations, crown diameter, path analysis, Prosopis spp.*

1. INTRODUCTION

Tree biomass is a complex character and is the multiplicative end product of many factors referred as biomass factors. Improvement of biomass generally depends upon the improvement of these factors. Component characters are inter-linked complexly, because of mutual positive or negative association with each other. Therefore, in order to improve biomass components breeding approach was found to be much gainful (Graffius, 1959).

Falconer (1960) suggested the possibility to achieve a more rapid progress in improvement through selection using secondary characters correlated with the one for which progressive selection is desired. In such a situation path analysis is a suitable tool for understanding the direct and indirect causes of associations between independent and dependent variables. The information obtained from this technique helps in the indirect selection for genetic improvement of biomass. The concept of path analysis was originally developed by Wright (1921), but the technique was first used in late 1950's for plant selection by Dewey and Lu (1959). Afterwards, using path analysis, wide genetic improvement for grain and fodder yield has been achieved in various crop plants however, no research on biomass improvement using this approach in tree species was cited.

The species of genus *Prosopis* are potentially productive and considered to be multipurpose tree for desert dwellers (Felker, 1984; Felker et al, 1989; Kackar, 1988; Sharma et al, 1993, 94). The present investigation aims to : (i) Study the association of biomass contributing characters and their interactions and (ii) Estimate the direct and indirect effects of component characters on biomass through path coefficient analysis in various *Prosopis* species.

2. MATERIALS AND METHODS

Present investigation was carried out with 106 groups of various exotic *Prosopis* spp. viz, *P. nigra* (12 groups), *P. chilensis* (19 groups), *P. flexuosa* (23 groups), *P. alba* (30 groups) and *Prosopis* species - *peruvian* (22 groups). Seedlings of all the species were first raised in nursery in the month of February in polythene tubes containing uniform rooting medium composed of FYM, sand and clay in 1:2:1 ratio and after five months, transplanted on the field (during the month of July). Planting was done at the spacing of 2.5 m x 4.0 m in randomized complete block design with four replications each having five plants. Plants were irrigated (15 litres water/plant) once in a month during winter season (November to March) and fortnightly in summer (April to June) during first year for better establishment. Afterwards, plants were irrigated only two times in a year during May and June (extreme hot period of summer season when average maximum temperature ranged between (42 – 44^{0}C). Timely hoeing was also carried out for weed control.

Observations on plant height, collar diameter, crown diameter and biomass of all the surviving trees were recorded after three years of growth. Total above ground biomass of individual tree was estimated using collar diameter (15cm above the ground level) of single and multistemmed individuals. In multistemmed individuals, collar diameter of different 'stems' (upto the maximum of 5 stems/plant) were measured and biomass of each 'stem' was estimated, and then estimates were pooled to obtain total above ground biomass of the plant. Replication means were used for statistical analysis. The

Selection of Plant Type for Higher Biomass in *Prosopis* Species Using Correlation and Path Analysis

J.C. Tewari, L.N. Harsh, D. Tripathi, M.D. Bohra and N.K. Sharma
Central Arid Zone Research Institute, Jodhpur – 342003

ABSTRACT

Correlations and path analysis were worked out in three-year-old progeny trial of five different *Prosopis* species *viz. P. nigra, P. chilensis, P. flexuosa, P. alba* and *Prosopis* species - *preuvian*. All the correlations between plant height, collar diameter, crown diameter and biomass were found to be positive. Correlation coefficients were the maximum between plant height and collar diameter and ranged from 0.79 (*P.chilensis*) to 0.87 (*Prosopis* species - *peruvian*). Path analysis revealed that maximum direct effect towards biomass was contributed by collar diameter in *P. nigra* (0.48), *P. alba* (0.36) and *Prosopis* species - *peruvain* (0.38). However, in case of *P.chilensis* plant height had maximum direct effect towards biomass (0.36). In *P. flexuosa,* crown diameter contributed maximum in this respect (0.51). Residual effects were high in all the cases and ranged from 0.56, in *P. chilensis* to 0.73 in *P. flexuosa*.

Key words : *Correlations, crown diameter, path analysis, Prosopis spp.*

1. INTRODUCTION

Tree biomass is a complex character and is the multiplicative end product of many factors referred as biomass factors. Improvement of biomass generally depends upon the improvement of these factors. Component characters are inter-linked complexly, because of mutual positive or negative association with each other. Therefore, in order to improve biomass components breeding approach was found to be much gainful (Graffius, 1959).

Falconer (1960) suggested the possibility to achieve a more rapid progress in improvement through selection using secondary characters correlated with the one for which progressive selection is desired. In such a situation path analysis is a suitable tool for understanding the direct and indirect causes of associations between independent and dependent variables. The information obtained from this technique helps in the indirect selection for genetic improvement of biomass. The concept of path analysis was originally developed by Wright (1921), but the technique was first used in late 1950's for plant selection by Dewey and Lu (1959). Afterwards, using path analysis, wide genetic improvement for grain and fodder yield has been achieved in various crop plants however, no research on biomass improvement using this approach in tree species was cited.

The species of genus *Prosopis* are potentially productive and considered to be multipurpose tree for desert dwellers (Felker, 1984; Felker et al, 1989; Kackar, 1988; Sharma et al, 1993, 94). The present investigation aims to : (i) Study the association of biomass contributing characters and their interactions and (ii) Estimate the direct and indirect effects of component characters on biomass through path coefficient analysis in various *Prosopis* species.

2. MATERIALS AND METHODS

Present investigation was carried out with 106 groups of various exotic *Prosopis* spp. viz, *P. nigra* (12 groups), *P. chilensis* (19 groups), *P. flexuosa* (23 groups), *P. alba* (30 groups) and *Prosopis* species - *peruvian* (22 groups). Seedlings of all the species were first raised in nursery in the month of February in polythene tubes containing uniform rooting medium composed of FYM, sand and clay in 1:2:1 ratio and after five months, transplanted on the field (during the month of July). Planting was done at the spacing of 2.5 m x 4.0 m in randomized complete block design with four replications each having five plants. Plants were irrigated (15 litres water/plant) once in a month during winter season (November to March) and fortnightly in summer (April to June) during first year for better establishment. Afterwards, plants were irrigated only two times in a year during May and June (extreme hot period of summer season when average maximum temperature ranged between (42 – 44^{0}C). Timely hoeing was also carried out for weed control.

Observations on plant height, collar diameter, crown diameter and biomass of all the surviving trees were recorded after three years of growth. Total above ground biomass of individual tree was estimated using collar diameter (15cm above the ground level) of single and multistemmed individuals. In multistemmed individuals, collar diameter of different 'stems' (upto the maximum of 5 stems/plant) were measured and biomass of each 'stem' was estimated, and then estimates were pooled to obtain total above ground biomass of the plant. Replication means were used for statistical analysis. The following empirical equation (originally developed by Felker et al., 1989 for *Prosopis* spp.) was used for estimation of biomass in both single stemmed and multistemmed trees.

log 10 dry wt. (kg) = 2.1905 {log 10 stem diameter (cm)} - 0.9811

Phenotypic and genotypic correlation coefficients were calculated from variances and covariances following Johnson et al. (1955) procedure. The direct and indirect contributions of plant height, collar diameter and crown diameter towards biomass were obtained following Dewey and Lu (1959).

3. RESULTS AND DISCUSSION

3.1. Correlations

All the correlation coefficients between plant height, collar diameter, crown diameter and estimated biomass were positive at both phenotypic and genotypic levels (Table 1.). In *P. chilensis*, *P. alba* and *Prosopis* species – *peruvian*, all the character combinations were significantly correlated. In *P. nigra*, correlation coefficients between plant height with that of collar diameter and crown diameter; and between collar diameter and crown diameter were significant. In *P. flexuosa*, all the correlation coefficients (except between collar diameter and biomass) were significant. The correlation coefficient of plant height with collar diameter and crown diameter; and between collar diameter and crown diameter were highly significant in all the five species. The magnitude of correlation coefficient was found to be maximum between plant height and collar diameter in all the cases; ranging from 0.79 (*P. chilensis*) to 0.87 (*Prosopis* species - *peruvian*).

In general, genotypic correlation coefficients were higher than phenotypic correlation coefficients, indicating the inherent associations. This may be attributed to some environmental influences because at genotypic levels correlations may be high but they get masked due to certain environmental factors, hence there would be a decrease in the phenotypic correlations. Tewari et. al, (1994) found that environmental factors like soil heterogeneity, cultural irregularities, chances of error in the experimentation, etc. may exert influence at genotypic level which in turn is expressed at the phenotypic level in one way or another. Saini and Kackar (1982) also found that in such cases either correlated characters are under the control of same set of genes or have same physiological basis for their expressions.

In some cases, the genotypic correlation coefficients were found higher than the unity. This could be due to the fact that genotypic correlations, being estimates, might have been subjected either to estimation error or negative environmental association between replications (Burton, 1951). Ledig and Whitmore (1981) suggested that genotypic correlations needed to be used with caution because standard error of genotypic correlation in general is notoriously large. Positive and high correlations at phenotypic and genotypic levels between different plant characters have also been reported earlier by Khosla et al. (1985) in *Pinus roxburghi*, Jindal et al. (1987) in *Acacia senegal*, Kackar (1988) in *P. cineraria*, Malan (1988) in *Eucalyptus grandis*, Tewari et al. (1994) in *Populus deltoides* and Prabhakar et al. (1994) in *Solanum khasianum*.

3.2. Path Analysis

The direct and indirect effects of plant height, collar diameter and crown diameter on above ground biomass, which were assessed through path analysis in five different *Prosopis* species are presented in table 2. In *P. nigra*, collar diameter had maximum direct effect (0.48 at the genotypic level and 2.10 at the phenotypic level); and indirect effect of plant height and crown diameter via collar diameter was also positive and high at both levels. The direct effect of plant height was 0.38 at phenotypic level and 1.36 at genotypic level; and indirect effects of crown diameter and collar diameter via plant height were also high. The direct effect of crown diameter; and indirect effects of plant height and collar diameter via crown diameter were negative at both levels. Because the indirect effect of crown diameter via plant height and collar diameter was highly positive, therefore, crown diameter may also be considered as a selection parameter for biomass improvement.

In *P. chilensis*, maximum direct effect at the phenotypic level was contributed by plant height (0.36); and indirect effect of collar diameter at both levels. The direct effect of collar diameter and crown diameter was moderate and almost similar at the phenotypic level; but at the genotypic level, the effect of crown diameter was very much high (0.95), while collar diameter had a negative effect. The effect of crown diameter via plant height and collar diameter was positive and moderate at the phenotypic level, while it was high at the genotypic level. The effects of plant height and crown diameter via collar diameter were moderate and positive at phenotypic level, while at genotypic level effects were negative. Therefore, plant height and crown diameter are important characters for selection of plant type having high biomass accumulation potential.

In *P. flexuosa*, the maximum direct effect (0.51) was contributed by the crown diameter at the phenotypic level. The indirect effect of plant height and collar diameter via crown diameter at the phenotypic level was also positive and high however, at the genotypic level the effects were negative. The direct effect of collar diameter, and indirect effects of plant height and crown diameter via collar diameter were negative at the phenotypic level,

Table 1. Phenotypic (above diagonal) and genotypic (below diagonal) correlation coefficients of tree structural parameters in different *Prosopis* species at 3 years of growth

Character	*P.nigra*				*P.chilensis*				*P.flaxuosa*				*P.alba*				*Prosopis* spp. *peruvian*			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
1. Plant height	-	0.83**	0.72**	0.54	-	0.79**	0.74**	0.64**	-	0.81**	0.70**	0.41*	-	0.82**	0.61**	0.41*	-	0.87**	0.74**	0.51*
2.Collar diameter	0.94	-	0.76**	0.54	1.19	-	0.72**	0.60**	0.86	-	0.77**	0.36	0.88	-	0.75**	0.54**	0.31	-	0.72**	0.55**
3.Crowndiameter	0.89	0.92	-	0.31	0.92	0.97	-	0.58**	0.92	1.00	-	0.50*	0.91	1.13	-	0.54**	0.79	0.60	-	0.49*
4. Dry biomass	0.78	0.73	0.28	-	0.66	1.02	0.86	-	0.46	0.77	0.82	-	0.11	0.67	0.52	-	1.26	1.34	0.54	-

* P<0.05; ** P<0.01

Table 2. Path coefficient analysis of dry biomass vs other contributing characters in 3-years- old *Prosopis* species.

Character		*P. nigra*				*P. chilensis*				*P. flexuosa*				*P. alba*				*Prosopis* species - *peruvian*			
		(1)	(2)	(3)	r	(1)	(2)	(3)	r	(1)	(2)	(3)	r	(1)	(2)	(3)	r	(1)	(2)	(3)	r
1.Plant height	G	0.38	0.39	-0.23	0.54	0.36	0.15	0.13	0.64	0.25	-0.20	0.36	0.41	-0.07	0.29	0.19	0.41	0.04	0.33	0.14	0.51
	P	1.36	1.97	-2.55	0.78	0.81	-1.03	0.88	0.66	4.15	14.50	-18.19	0.46	-1.59	0.54	1.16	0.11	3.28	0.76	-2.78	1.23
2.Collar diameter	G	0.31	0.48	-0.25	0.54	0.28	0.19	0.13	0.60	0.20	-0.25	0.40	0.36	-0.06	0.36	0.24	0.54	0.03	0.38	0.14	0.55
	P	1.28	2.10	-2.65	0.73	0.96	-0.87	0.92	1.02	3.59	16.80	-19.62	0.77	-1.39	0.62	1.44	0.67	1.02	2.43	-2.11	1.34
3.Crown diameter	G	0.27	0.37	-0.33	0.31	0.27	0.13	0.18	0.58	0.18	-0.19	0.51	0.50	-0.04	0.27	0.31	0.54	0.03	0.27	0.19	0.49
	P	1.21	1.94	-2.87	0.28	0.75	-0.84	0.95	0.86	3.83	16.71	-19.72	0.82	-1.45	0.70	1.27	0.52	2.60	1.46	-3.52	0.54
		Residual P = 0.64				Residual P = 0.56				Residual P = 0.73				Residual P = 0.67				Residual P = 0.68			
		G = 0.79				G = 0.53				G = 2.27				G = 0.10				G = 4.50			

r = Correlation coefficient with total dry biomass; P = Phenotypic; G = Genotypic; Direct effect are underlined while at the genotypic level, it was found to be positive. This trend might be attributed to environmental influence of some kind. The direct effect of plant height at the phenotypic level was 0.25 and, indirect effects of collar diameter and crown diameter via plant height were also positive at phenotypic level. At the genotypic level, the magnitude of these effects were positive and high therefore, more emphasis should be given to height growth for the selections of potentially high biomass yielding plant types in this species.

In *P. alba* the maximum direct effect (0.36) at the phenotypic level was contributed by collar diameter. The indirect effects of plant height and crown diameter via it were also high, and at the genotypic level, effects were highly positive. The direct effect of crown diameter was 0.31 at phenotypic level and indirect effects of collar diameter and plant height via it were also positive. All the effects were positive and of the high order at the genotypic level than that of the phenotypic level. The direct effect of plant height and indirect effect of collar diameter and crown diameter via plant height were negative. Therefore, it can be concluded that collar diameter and crown diameter are equally important and reliable character when selecting plant types of this species for higher biomass production.

In *Prosopis* spp. - *peruvian*, collar diameter had maximum direct effect at both levels (0.38 at phenotypic level and 2.43 at genotypic level); and indirect effects of plant height and crown diameter via it were also positively high at both levels. Crown diameter had small positive direct effect; and indirect effects of plant height and collar diameter via crown diameter were also positive at the phenotypic level but the effects were negative at the genotypic level. The direct effect of plant height; and indirect effects of collar diameter and crown diameter via it were negligible at the phenotypic level however, the effect were high at the genotypic level. The plant height and crown diameter had a sizable positive indirect effect via collar diameter indicating thereby that all three characters had significant contribution to biomass.

In some cases, the direct effects were either less or negative but the indirect effects of these characters were positive and high via other characters. Therefore, these characters may also be considered when selecting plant types for higher biomass. The high residual effects in all the cases indicate that there were certain other characters, which also contributed to biomass. Some of these might be related to stem number, branches, leaves and other tree form factor.

ACKNOWLEDGEMENT

The Authors are highly thankful to Dr. Pratap Narain, Director CAZRI, Jodhpur, India for providing all the necessary facilities to carry out the work and, also for his valuable guidance and encouragement's. Financial support from Indo-US, PL-480 project, Grant No. FG-IN-749 is gratefully acknowledged.

REFERENCES

Burton, G.W. 1951. Quantitative inheritance in pearl millet (*Pennisetum glaucum*). *Agron J. 43 : 409-417.*

Dewey, D.R. and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J. 51 : 515-518.*

Flconer, D.S. 1960. *Introduction of Quantitative Genetics*. Ronald Press Co., New York, USA.

Felker, P. 1984. Economic, environmental and social advantages of intensively managed short rotation mesquite (*Prosopis* spp.) biomass energy farms. *Biomass 5 : 65-77.*

Felker, P., Smith, D., Wiesman, C. and Bingham, R. L. 1989. Biomass production of *Prosopis alba* clones at two non irrigated field sites in semi-arid south Texas. *For. Ecol. and Manage. 29 : 135-150.*

Grafius, J.F. 1959. Heterosis in Barley. *Agron J. 51 : 551-554.*

Jindal, S.K., Kackar, N.L and Solanki, K.R 1987. Interrelationship between shoot dry weight and components in *Acacia senegal* progeny. *N F T R R 5 : 16-17.*

Johnson, H.W., Robions, H.F. and Comstock, R.E. 1955. Genotypic and phenotypic correlations in soybeans and their implications in selection. *Agron. J. 47: 477-483.*

Khosla, P.K., Sehgal, R.N., Dhar, S.P. and Chahan, K. 1985. Path coefficient analysis and correlation between shoot dry weight and other characters in *Pinus proxburghii* progeny. *J. Tree Sci. 4: 15-19.*

Ledig, F.T. and Whitomore, J.I. 1981. Heritability and genetic correlation for volume foxtool and other characteristics of caribean pine in Puerto Rico. *Silvae Genetica 30 : 88-89.*

Malan, F.S. 1988. Genetic variation in some growth and wood properties among 18 full sib families of South African grown *Eucalyptus grandis* : a preliminary investigation. *African For. J. 146 : 38-43.*

Prabhakar, M., Singh, J. and Srivastava, L.J. 1994. Genetic variation and correlation studies for some important characters associated with solasodine yield in *Solanum khasianm. Indian J. For. 17 : 26-31.*

Saini, H.C. and Kackar, V.S. 1982. Modal plant architecture through association and path coefficient analysis in Opium poppy. *Indian J. Agri. Sci.52 : 744-747.*

Sharma, N. K., Harsh, L.N., Tewari, J.C. and Bohra, M.D. 1993. Variability and change in genetic parameters for plant in *Prosopis pallida*. *Annals of Arid Zone 32 : 273-275.*

Sharma, N. K., Burman, U., Tewari, J.C., Bohra, M.D and Harsh, L.N. 1994. Variability studies in pod and seed characteristics of *Prosopis juliflora* (SW) DC. *Indian J. For.17 : 161-165.*

Tewari, S.K., Pandey, V. and Tripathi, S. 1994. Intercharecter correlation in *Populus deltoids. Indian J. For. 17 : 61-63.*

Wright, S. 1921. Correlation and causation. *J. Agri. Res. 20 : 557-585.*