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VARIABILITY AND ASSOCIATIONS FOR SEED YIELD, OIL CONTENT AND TREE MORPHOLOGICAL TRAITS IN NEEM (*AZADIRACHTA INDICA*)

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Variation is a basis for selection and assessment in any tree improvement programme. Neem (*Azadirachta indica* A. Juss.), a native of India, Pakistan, Sri Lanka, Thailand, Lao P.D.R. and Myanmar (Tewari 1992), is very suitable for the hot arid regions of India, because it shows good growth on dry and infertile sites. It is a valuable multipurpose tree. Extracts from its extremely bitter seeds which act as ideal insecticides are biodegradable and do not seem to quickly lose their potency in the genetic resistance of the pests. Much work on the insecticidal properties has been reported (Ketkar 1976, Schmutterer & Freres 1990, Tewari 1992, Randhawa *et al.* 1996), but no efforts have been made on its genetic improvement regarding its growth, tree form, seed yield and oil content, suitable for arid zones. The *ex situ* variability of various tree morphological traits, seed yield and oil content and their associations were assessed and are presented in this paper.

Twenty-five trees were randomly selected from about 200 13-y-old trees grown at the Central Research Farm in Jodhpur, India, where frequent droughts are common. Trees had been grown from seeds collected from random sources in Rajasthan state. Tree height, collar diameter, DBH, clear bole length and canopy diameter were recorded in June 1994. For inflorescence length and number of fruits per inflorescence, ten inflorescences from each selected tree were taken randomly. For fruit yield per tree, fruits were collected on alternate days from the ground under the canopy of each tree, sun dried and then weighed. For 100-fruit weight, 100-seed weight and 100-kernel weight, 100 respective samples were taken and these 100 seeds were broken to estimate the number of kernels per 100 seeds. Kernel oil content was estimated on 1.0 g kernel using the cold percolation technique (Kartha & Sethi 1957).

The data were analysed for estimation of mean values, coefficient of variation and correlation coefficients among the characters (Panse & Sukhatme 1978).

Mean, range, standard deviation (S.D.) and coefficient of variation (C.V.) for tree morphological and seed yield related parameters and oil content are given in Table 1. A large range of the number of flowers per inflorescence with very low reproductive capacity has been reported in neem (Jindal & Vir 1994). The number of fruits per inflorescence is an important parameter of fruit yield. Most seeds contain one kernel each but some seeds showed more than one, thus the mean number of kernels per seed was 1.03.

The coefficient of variation (C.V.), a parameter of variability, showed that variation was maximum for fruit yield per tree. Similarly the number of fruits per inflorescence showed more than 40% C.V. indicating that selection for these two traits, i.e. fruit yield per tree and reproductive capacity from this population, will be effective. For collar diameter, DBH, clear bole length, canopy diameter and inflorescence length, the C.V. ranged from 20.0 to 26.0%. For other characters the C.V. was very low. Tewari (1993) reported a large variation for seed weight (10.5 to 34.7 g/100 seeds) at Dehra Dun, which may be due to its different agro-climatic zone.

Table 1. Mean, range, standard deviation (S.D.) and coefficient of variation (C.V.) for tree morphological and seed yield related parameters and oil content in neem

Characters	Mean	Range	S.D.	C.V.
Tree morphological parameters:				
Tree height (m)	6.0	4.3 - 6.9	0.67	11.1
Collar diameter (cm)	18.4	12.0 - 24.4	3.7	20.1
DBH (cm)	15.3	9.8 - 21.4	3.9	25.5
Clear bole length (cm)	177.8	100.0 - 250.0	40.9	23.0
Canopy diameter (cm)	618.6	390.0 - 805.0	130.5	21.1
Seed yield related parameters:				
Inflorescence length (cm)	15.1	7.4 - 20.6	3.5	23.2
No. of fruits/inflorescence	2.84	1.4 - 7.1	1.23	43.3
Fruit yield/tree (kg)	0.88	0.14 - 1.46	0.44	49.8
100-fruit weight (g)	35.8	24.0 - 47.0	5.76	16.1
100-seed weight (g)	14.6	10.7 - 19.4	2.35	16.1
100-kernel weight (g)	6.96	4.5 - 8.9	1.15	16.5
No. of kernels/100 seeds	102.8	94 - 110	5.26	5.1
Kernel oil (%)	36.9	27.8 - 45.1	4.48	12.1

The correlation matrix of tree morphological characters, inflorescence length, number of fruits per inflorescence and fruit yield per tree is given in Table 2. Tree height showed positive and significant associations with collar diameter, DBH, canopy diameter and fruit yield per tree. Fruit yield was also significantly positively related with collar diameter, DBH and canopy diameter. Number of fruits per inflorescence showed negative, very small correlations with tree morphological traits, but it was positive and significant with inflorescence length. Positive and significant relationships among tree height, collar diameter and DBH have been reported in *Eucalyptus tereticornis* of different ages (Kedharnath & Vakshasya 1977), and tree height with DBH and pod production in *Acacia tortilis* (Jindal *et al.* 1990).

Table 2. Correlation matrix of tree morphological characters, inflorescence length, number of fruits/inflorescence and fruit yield/tree in neem

Character	1	2	3	4	5	6	7	8
1. Tree height	1.00	0.76**	0.72**	0.22	0.86**	- 0.04	- 0.07	0.55**
2. Collar diameter		1.00	0.93**	- 0.01	0.91**	- 0.02	- 0.13	0.63**
3. DBH			1.00	- 0.16	0.87**	- 0.09	- 0.10	0.58**
4. Clear bole length				1.00	0.02	0.08	- 0.14	- 0.04
5. Canopy diameter					1.00	- 0.04	- 0.12	0.59**
6. Inflorescence length						1.00	0.44*	0.12
7. No. of fruits/inflorescence							1.00	0.18
8. Fruit yield/tree								1.00

* $p < 0.05$, **$p < 0.01$.

The correlation matrix of seed yield related characters, oil content and tree height is given in Table 3. Oil content showed positive and small correlations with all the characters

except fruit, seed and kernel weights where they were negative but not significant. Associations among fruit, seed and kernel weights were positive and highly significant. The other relationship which was positive and significant was fruit yield with fruit weight.

Table 3. Correlation matrix of seed yield related characters, oil content and tree height in neem

Character	1	2	3	4	5	6	7	8
1. No. of fruits/ inflorescence	1.00	0.19	- 0.25	- 0.29	- 0.25	- 0.13	0.09	- 0.06
2. Fruit yield/tree		1.00	0.44*	0.36	0.32	- 0.06	0.09	0.55**
3. 100-fruit weight			1.00	0.75**	0.77**	- 0.11	- 0.26	0.13
4. 100-seed weight				1.00	0.90**	0.03	- 0.27	0.14
5. 100-kernel weight					1.00	- 0.09	- 0.23	0.24
6. No. of kernels/100 seeds						1.00	0.23	0.10
7. Kernel oil (%)							1.00	0.02
8. Tree height								1.00

*$p < 0.05$, ** $p < 0.01$.

Selection criteria such as health of the trees, yield and form are universal. However, additional criteria such as oil content and azadirachtin content can be included in neem. Oil content per tree and reproductive capacity can be increased by selecting genotypes with good fruit yield. These characters, available but scattered over different genotypes, can be combined into one genotype with appropriate breeding.

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