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# AN OVERVIEW OF WORK ON GENETIC IMPROVEMENT OF SHISHAM IN PAKISTAN

Anwar Masrur[1]

## INTRODUCTION

Shisham (Dalbergia sissoo) occurs throughout the sub-Himalayan tract from Indus to Assam usually ending up at 1000 m but occasionally ascending to 1500 m above sea level. It is perhaps the most extensively planted tree in the plains of Pakistan and parts of India such as Punjab, Rajesthan, U.P., Bengal and Assam. In the natural habitat the absolute maximum shade temperature varies from 40-50 $^0$C and absolute minimum from 2 $^0$C to 4 $^0$C (Sheikh, 1989). Dalbergia sissoo is found extensively in pure stands or with associates, in natural habitat or fresh deposits in Burma and Nepal. Natural forests of shisham have also been reported in Iraq and Afghanistan (Nasir and Ali, 1977). Outside its indigenous habitat the species is cultivated in the United State (Arizona and Florida), Sudan (Khartoum), Northern Nigeria, Ghana, Tanzania, Senegal, Mali, Kenya, Niger Togo, Puerto Rico, Ceylon, Israel, South Africa, Bangladesh and Cameroon.

In its natural state, shisham grows most typically on alluvial grounds in the beds of rivers. The tree is, however, by no means confined to such sites but springs up freshly whenever the soil is exposed, as on land slips, on hill sides, on new embankments, etc. It also grows frequently along water channels as well as on grass-lands from wind blown/water carried seed.

Shisham is one of the most widely used species for a variety of end uses in different parts of the world. It is an excellent timber for high class furniture and cabinet making. On account of its great strength, elasticity and durability, it is valued as constructional and general utility timber. It is esteemed also for railway sleepers, musical instruments, electric casing, shoe heels, hammer handles, truck and bus body building and country boats. Good quality straight logs are peeled or sliced to make veneer for panelling, laminated skis and other composite construction. Shisham wood is classed among excellent fuels and is eminently suitable for making charcoal.

The average annual yield from shisham in various plantations is 75 to 150 cft per acre (Vidakovic,1969). This is quite low when compared with potentiality of the land and investment made in terms

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[1]Secretary, Forestry, Fisheries, Wildlife, Tourism and Youth Affairs, Government of the Punjab, Lahore.

of land and irrigation water value. The biggest drawback in sissoo is its extremely poor stem form. Its bole is not only crooked but also forked. Both these defects may appear in trees of all ages. Keeping this in view it is imperative that a large scale programme should be initiated to improve shisham. Work done so far on the various aspects of shisham genetic improvement in Pakistan is rather scanty.

## BOTANY AND PHENOLOGY

The leaves of sissoo are compound with 3-5 alternate leaflets. The bole is usually crooked and straight logs of sufficient length are difficult to obtain. Bark is 0.4 to 0.6 inches thick, grey, longitudinally and somewhat reticulately furrowed. The leaves begin to fall in November, turning brown prior to falling and the leaflets fall separately. In cold situations the tree may be leafless by the beginning of December while in some places the leaves have not altogether fallen by the end of January. The young leaves appear in the second half of the January or in the first of February (Troup, 1921;Vidakovic, 1969).

The young flower buds appear with the new leaves and the yellowish flowers, in axillary panicles of short racemes, open in March or April. They may be as much as two inches long, pale green and hanging in masses all over the tree. By july they are full-sized but remain unripe and yellowish green until November, when they commence to turn brown, ripening towards the end of that month and during December or early January. Pods are blown off the tree from the time they ripen onwards and are carried away some distance by winds (Champion, Seth and Khattak, 1965).

## NATURAL VARIATION

The furniture makers distinguish between two types of shisham logs, one with rough and thick bark and another with smooth ad thin bark. The latter has more dark heartwood than the former and is very much preferred.

A great deal of variability also exists in the growth and stem form of shisham. Trees with a fork are also very common but trees which have a very straight bole without fork can be found. This variability is very easily visible in road and canalside planted shisham trees. A great deal of variation has been found at the nursery stage. The coefficient of variation for the index of crookedness for 23 one year old open pollinated plants was found very high i.e. 24.86 to 51.14 percent (Vidakovic,1970). Knowing this the improvement work on shisham could first be aimed at improving its growth and stem form. The research on improvement of wood quality should start after gaining more information about the variability of its wood characters. In the future the demand will be for improving other characters, as for instance, resistance to insects or to drought and these objectives should be later included in the breeding programme.

## SELECTION

Selection of superior trees on the basis of growth is very uncertain and complex. Shisham is cultivated in the plains, with the help of irrigation. Therefore, difficulties exist when the plus trees of shisham are selected in the irrigated plantations or canalsides because the ratio of growth has been affected by irrigation water. The regeneration of shisham is obtained through coppice, root-suckers and supplemented by stump planting. Due to this practice the individuals in the stands are not from the same origin and they are not treated equally. Difference in growth is certainly affected a lot by these two factors.

Straightness of stem and form are much less influenced by the above-mentioned factors and, therefore, to select quality plus trees in irrigated plantations and canalside is safer. Ahsan (1970) laid down the following criteria for selecting plus trees of shisham:

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| -Vigorous growth | -Straight stem |
| -No forking | -Thin, fine branches |
| -Symmetrical crown | -Cylindrical stem with 2/3rd clear bole of the total height of the tree. |
| -Resistant to biological and physical injuries | -Capable of producing seed |

-He advocated selection at nursery stage

In selecting plus trees it is difficult to get the right estimate of the straightness of the bole by ocular observation. The trees should be scrutinized by measuring the crooks. Vidakovic and Ahsan (1970) have described the methodology for measurement of the crooked trees.

Schreiner (1950) recommends that selection be restricted to those trees which exceed the mean by 2 or 3 standard deviation, while some others have desired that selected trees should be four standard deviations above the mean (Vidakovic and Ahsan 1970).

## SEED ORCHARDS

Establishment of seed orchards is one way of gaining benefits of practical importance for genetic improvement programmes of tree species. Although the first plantation of shisham in Pakistan was establish more than a century ago, and more than 100000 ha have been raised, yet the seed for raising nurseries continues to be collected from whatever source it is available.

Since it is known that variability in shisham is very high, improvement of future plantations is possible by using genetically better seed. The best and most practical method for organizing seed collection of shisham has to be the establishment of seed-orchards.

Siddiqui (1975) established an experimental seedling seed orchard of shisham for field planting. Each of 24 blocks contained one plant from each of 40 open pollinated families of selected trees. Selection thinning was performed to leave only the best individuals to produce seeds. Selection was made on morphological characteristics to remove the minus variants. In designing the seed orchard factors like position of trees to avoid inbreeding, distance and size of surrounding stand to check outside contamination, extent of seed orchard, etc were considered.

Vidakovic and Williamson (1968) have suggested that establishment of seedling seed orchard should start after getting information about the hybridization patterns, i.e. whether shisham is completely allogamous or not. If it is not completely allogamous, then it is necessary to find out to what extent it is self-pollinated tree. If shisham is a completely or nearly completely allogamous species, then it is necessary to have plants from at least 40 progenies in one seed-orchard. If the species is, in a very high degree, a self-pollinated tree, then a good seed orchard can consist of plants from one or just a few progenies. In both cases the progenies should be raised from plus trees. Established progeny trials can be used as seed orchard, especially if shisham is completely or largely a self-pollinated tree. If in a progeny test more than 50% of the plants are of superior quality and have very good growth, then in the case of self-pollination, such a trial can be converted into seeding seed orchard by removing the poor phenotypes. If shisham is a completely or nearly completely allogamous species, then it would be advisable to convert progeny trials into seed orchards, but to establish separate plantations as seed orchards.

## PROVENANCE AND PROGENY TESTING

In view of the importance of shisham primarily as an industrial wood, studies on the performance of different geographic sources and frequency of occurrence of various stem forms in the species were initiated at the Pakistan Forest Institute, Peshawar in 1975. 184 phenotypically best trees were selected in five geographic areas of Punjab and N.W.F.P. and seed was collected from 84 individual trees. Early screening was done in the nursery and seedlings of 40 best progenies were out planted as single - tree-plot in 24 replications at 2x3 m spacing.

In another field trial in Peshawar selection among progenies was done following slightly different approach than the one described above. Out of 80 progenies, 55 were selected on the basis of mean + 2 standard Deviation multiplied through root/shoot cuttings. Cuttings were planted single-tree-plot at 2 x 2 m spacing in 9 blocks in 1978.

Periodic cleaning and thinning operations were done in both the trials and all other silvicultural treatments were uniformly practiced throughout the period of investigation. Diameter-growth and frequency of occurrence of five stem forms viz. Rosette, Multifid, Forked, Herring bone and Unifid were noted down. Trials at both the sites had 15 common progenies which include 9 from Mardan, 5 from Chichawatni and one from Changa Manga and these were used in the evaluation.

The diameter growth data of 40 progenies indicated that progenies of Mardan 18, and Chichawatni 28 had shown maximum diameter of 15.2 cm among all other progenies. Generally the progenies of Pirawala and Daphar gave poor performance. Comparing these sources in another trial of root/shoot cutting it was found that the trees from Chichawatni (Diameter-11.3 and 10.9 cm) were again at the top. In another study reported in 1987, (Rehman and Hussain, 1987) a geographic source from Chichawatni had also given the highest value for the mean diameter as compared to Changa Manga and Mardan. The growth data of 15 common progenies at both the sites had also shown that progenies Chichawatni 28, and Mardan 5 had given the highest dia/age ratio. This ratio had to be calculated because these trials were established at different periods and measurements were recorded at different intervals. It was further observed that geographic sources from Chichawatni and Mardan had shown maximum frequencies of unifid stem which is the most desirable stem form of the species. The Pirawala plantation had the lowest number.

It may be concluded that selection of phenotypically best trees should be concentrated amongst the plantations established at Chichawatni. The establishment of clonal orchards in the irrigated plantations of the area may bring about further improvement in stem form and growth rate in shisham. The seed collected from Pirawala gave poor performance and should not be used in afforestation programmes.

## BREEDING AND HYBRIDIZATION

It is not known if shisham is an insect or wind-pollinated plant or whether both the agencies play their role in nature. It is also to be ascertained whether it is self-pollinating or out-crossing species or both; and when pollination and fertilization occur. Flowers of shisham are rather small and delicate. They are bisexual and, therefore, it is important to find out the best method for emasculation. The pollen is sticky and it is difficult to isolate it from anthers. Flowering in shisham occurs during the month of April when the temperature is rather high.

Vidakovic and Ahsan (1970) observed that isolated flowers suffer from high temperature and high moisture content in the conventional type of isolation bags and this leads to premature dropping off. It is thus important to find out a suitable isolation material and a suitable size of bags. Till the proper technique for artificial hybridization is developed, one parent progeny tests should be developed. By combining breeding of shisham with vegetative propagation by cuttings, great improvement in the stem form and in the growth can be made.

It was observed that archesporia development is hypodermal in shisham. The megaspore mother cell undergoes meiotic divisions to form a tetrad of megaspores which are arranged in tetrahedral fashion. Out of four megaspores, only one functions while the other three degenerate. The mode of formation of microspores in shisham is same as in other members of family. The only difference between shisham and other members of Papilionaceae is that the divisions of the microspores mother cells are simultaneous in former and successive in the latter. While undertaking any hybridization programme besides other technicalities the similarities and dissimilarities mentioned in the embryological studies must be taken into account. (Siddiqui and Akhtar, 1974).

## HERITABILITY

A major part of any forest tree breeding and improvement programme is based on the selection of superior phenotypes, on the assumption that they would pass some of their superiority to their offsprings. The superiority of the selected phenotypes is due to genotype environment interactions.

Vidakovic and Siddiqui (1968) made a study about heritability of height and diameter growth in shisham using one parent progeny test. A number of candidate plus trees of shisham with apparent higher rate of growth of diameter and height were selected in the irrigated plantations of Daphar, Pirawala and Chichawatni in 1963. The seed from these trees was collected in 1966. The plants were grown in rows so that progeny of every mother tree was represented by one or two rows of plants. About 30 to 35 plants were selected at random from the progeny of each mother tree. Measurements of progenies were undertaken from 19th to 21st January, 1967, i.e. at the end of first vegetation period. Calculations of heritability for diameter and height was carried out by using regression for one parent-progeny test.

The calculation of heritability was carried out separately for each plantation. The h2 in these calculations signify only narrow-sense heritability, i.e. the portion of variance due to additive genetic factors. The reasons for such a low degree of heritability in case of height and diameter were considered to be inadequacy of one parent progeny test; effect of irrigation on the growth of mother trees; management practices in the irrigated plantations, low age of the progenies, and absence of properly designed experiments for the progenies. It was suggested to raise progenies from a large number of parent trees under the same environmental conditions and subsequently to carry out intensive selection within and between the progenies.

Vidakovic and Ahsan (1970) estimated the heritability of crookedness of the bole in shisham by using one parent progeny regression. They selected 23 mother trees from Dapher (Gujrat District) and Pirawala (Multan District) plantations. The heritability was found 42 percent for pirawala and 65 percent for Dapher plantation. Correlation (r) and regression (bi) coefficients were highly significant for both the plantations. It was concluded that the environments, particularly the irrigation affects the growth much more than the straightness of stem in shisham.

The results of a study of growth and heritability estimates among 6 year old three geographic sources of shisham in Pakistan have been reported (Rehman and Hussain, 1987). The trial indicated that the average diameter of the trees originating from Chichawatni, Changa Managa and Mardan were 7.1, 7.0 and 6.4 cm respectively. The standard deviation for all the locations did not show much dispersion as it ranged between 2.5-38. These preliminary results have shown that generally the trees originating from Chichawatni are significantly different from Mardan. Similar observations have been endorsed by Hussain and Abbas (1974) while preparing the volume tables for the irrigated plantations of shisham in the Punjab.

The F-ratio was also significantly different. The LSD test indicated that Chichawatni was significantly better than Mardan at 5% p-level. The h2 (b.s) in the present investigations was 0.83 indicating that the trait is highly heritable. On the other hand low heritability value on the basis of parent-progeny relationship in shisham was reported by Vidakovic and Siddiqui (1968).

## VEGETATIVE PROPAGATION

Vegetative propagation of forest trees is very important to the silviculturist and especially the tree breeders. The importance of the clone for forest tree improvement and for the mass clonal propagation of superior genotypes for afforestation is well known. If the vegetative propagation of shisham by macropropagation or micropropagation is successful and feasible, then new possibilities in breeding are available and mass clonal production is possible. By selection and clonal tests it is possible to achieve a high genetic gain. This is particularly true with species like shisham which need quite an improvement in respect of stem form, growth and wood quality besides other characters to be followed like resistance to diseases, drought, etc.

In the past numerous attempts were made to propagate shisham by cuttings. Khan (1963) used hormones for vegetative propagation of shisham. No final conclusions were, however, drawn.

Khattak (1961 and 1963) planted 15 cm long semi-hardwood shoot cuttings of about 2.5 cm dia. from shisham trees ranging in diameter from 31-51 cm on April 15, 1962, in two wooden boxes filled with sand. These were treated with different strengths of Rhizopon and Seradix prior to planting. The boxes were placed in light shade of citrus hedge and watered with a rose can daily to keep the sand moist. The cuttings were checked for rooting after 51 days. The maximum rooting was obtained with Seradix, strength 223 and Rhizopan strength 2. The number f roots per cutting and their length and thickness appeared to be greater in case of treated cuttings as compared to untreated cuttings. The author is of the opinion that it is possible to root semi-hardwood cuttings with and without growth-promoting hormones. The rooting of semi-hardwood cuttings takes about 45 days as against 120 days for dormant hardwood cuttings.

Vidakovic (1968) carried out a detailed study and experimentation on propagation of shisham by cuttings. He took into consideration several factors which could influence the rooting ability. These are: hardwood, semi-hardwood, and softwood cuttings, root cuttings, age of the tree, part of the crown, time of planting and the individual tree from which the cuttings were taken. Hardwood cuttings taken from one year old plants gave the best results. The rootability was from 34% to 73%. Cuttings from 4 and 5 year old trees gave much lower rootability percentage. Semi-hardwood cuttings planted in May and June failed completely, while those planted in August rooted from 8.3 to 20%. Root cuttings from one year old plants rooted from 46 to 62% while those taken from 4 years old plants rooted from 18 to 38%.

All hardwood and semi-hardwood cuttings were 21 cm long and at least of pencil size in thickness. Softwood cuttings were in some cases shorter but were not less than 15 cm. The length of root cuttings was about 13 cm (5") and the diameter about 6 mm (1/4"). The root cuttings were planted in horizontal position and covered with 3-5 cm of sand. The results indicate that besides the type of the cuttings, the age of the tree from which the cuttings are taken and time of planting are also very important factors for rootability. The maximum rootability in root cuttings was obtained from one year old plants (62%) when planted during the first week of February.

Vidakovic and Ahsan (1970) have mentioned that experiments to investigate the feasibility of propagating shisham vegetatively would be a great asset to shisham improvement programme. Crookedness of stem in shisham appears to be under a high degree of genetic control. It was considered that selection of enough quality plus trees, improvement in the technique of vegetative propagation, besides other practices should constitute the first phase of investigations in order to achieve an effective improvement in stem form and a moderate improvement in the growth. Experiments with shisham root and stem cuttings should also aim to answer the following two points:

- Whether or not, it is possible to grow shisham in the plantations by cuttings.

- To what extent, propagation of shisham by cuttings can be of any use in the improvement of the species.

The elite trees of Dalbergia sissoo are scanty. When mature vegetative propagation by cuttings or other method of macropropagation is difficult. Tissue culture thus could provide a good tool for mass propagation of superior mature trees once these can be reliably identified. Some work on tissue culture on shisham has been done in India. According to the available literature there are still problems with tissue culture of this species.

## FUTURE RECOMMENDATIONS

- Identify, demarcate and collect seed from superior stands and/or single tree to secure supplies of marginally improved seed.
- Design, layout and assess progeny and provenance trials on major sites throughout the country.
- Establish clonal and seedling seed orchards for assured supply genetically improved seed and to secure genetic base.
- Conduct basic research on cytology, germplasm and other basic genetic principles.
- Hybridize selected individuals for new genotypes having desirable characteristics such as straight bole, vigorous growth, free from disease/pest, etc.
- Develop breeding strategy keeping in view the target for genetic improvement in sissoo.
- Develop international collaboration for progeny trials and other genetic research in shisham.
- Secure improved genotypes in several locations available for all collaborators to incorporate in national programme.

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