

Clonal Development and Diversity in WIMCO's Poplar Programme

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Introduction

WIMCO - a safety match company with one of its factory located in Bareilly, Uttar Pradesh (U.P.) started working on poplars during 1970s to develop it as match wood plantation tree on farm land in North India. Field performance of WIMCO's introduced two poplar (*Populus deltoides*) clones, viz., G48 and G3 in 1969 from Australia (Chaturvedi, 1982) paved the way for its culture on farm land in the country. Fast growth of these clones impressed the management of the company to initiate a planned programme for promoting its plantations for matchwood production. Swedish Match, the parent company of WIMCO in those days, had keen interest in poplar and aspen plantations to support its match business in many countries. The promotion of poplar plantations in India was an extension of the company's commitment to develop matchwood resources with backward linkages to ensure sustained wood raw material production and availability. WIMCO created an Agroforestry Extension Division in 1976 with a strong team of field extension workers and a research facility in 1982 which later on was upgraded into an independent company – Wimco Seedlings Ltd. in 1984 for the focused research on poplar and a few other socially and industrially important tree species. Wimco Seedlings Ltd. was merged with WIMCO Ltd. in 2005 and is operating as one of its division since then. However, these organisational changes did not have any effect on its research and development activities including poplar improvement which maintained constant continuity till date.

WIMCO is employing a simple and realistic but exhaustive screening process for clone development in poplar and a few other tree species. In case of poplar, seed obtained from manipulated crosses and selected half-sib parents are germinated

Clonal Development Programme

WIMCO is employing a simple and realistic but exhaustive screening process for clone development in poplar and a few other tree species. In case of poplar, seed obtained from manipulated crosses and selected half-sib parents are germinated (Fig. 1) and the new populations are followed for 18-20 yrs; i.e., 3-4 yrs in nurseries, 8 years in local level and remaining period in multi-location trials for screening desired individuals. Poplar improvement is presently based on *P. deltoides* whose clones are well adapted throughout the region of intensive poplar culture (RIPC) (Dhiman, 2012), where none of the indigenous species have ever thrived before their introduction. The initial programme was restricted to screening of

seedling populations obtained from half-sib parents on noticing first time seeding on G48 clone in 1982 and later on, manipulated crosses were started among the available clones of *P. deltoides* w.e.f. 1989. Inter species crosses are now being made for over a decade period and their progenies are followed for favourable characters related to growth, form and resistance to diseases and insects. Most of the seedlings raised from crosses of *P. deltoides* with *P. ciliata*, *P. sauveolens* and *P. nigra* failed to tolerate the hot and dry weather conditions those exist in the RIPC. Some hybrids developed between *P. ciliata* and *P. sauveolens*; and *P. nigra* and *P. sauveolens* are neither well adapted nor productive in these locations. Some of these are maintained to attain reproductive phase for making backcrosses. During 2008-9, some seed were produced from crosses made between *P. gamblei* and *P. deltoides*, by manipulating delay in reproductive bud break in *P. gamblei*. Some seed and seedlings were also produced from the crosses between *P. gamblei* and *P. ciliata* and they also failed to survive warm and humid weather conditions in our operational area in plains.

Nursery Screening

Poplar program in the company employs traditional methods and materials to develop new clones. Each year, shoots with reproductive buds collected from trees of selected parents are cleft grafted on root stock already established in open nursery beds. Pollen collected from the identified parents is used for making crosses. Flowering shoots are covered with the muslin cloth bags during flowering and pollination. Capsules develop and expand quickly after fertilization. Mature capsules are collected during late April, May and June; seed on separation from the cotton is immediately sown in very light soil media. Seed germinate in two days period of sowing. Seedlings at 2-4 leaf stage are shifted in the cavities (root trainers). Seedlings are screened for disease and pest resistance in the first year itself. Selected seedlings are, then, planted in the nursery beds during the following February and are followed for further screening for diseases and insects resistance and form (Table 1). At the end of the growing period only the selected individuals are multiplied in good

number in next year nurseries for field trials in the following years when they are planted in 2-3 sites for local level field trials. Newly developed seedlings are also sometimes placed under the saplings of susceptible clones or sprayed with the water suspension of *Bipolaris* spp. fungus causing leaf blight. Field trials are monitored for a full rotation of 8 years when the selections of desired individuals is made. Selected trees are rejuvenated by serial propagation, clubbed with selections of some of those from preceding or following years and are grown and monitored in the multi-location trials in the entire RIPC. Selected individuals based on the performance in multi-location trials are rejuvenated and produced in commercial nursery for supply of saplings to the growers. Each year a new trial is added in the system as per the procedure outlined above. The actual multiphase screening of each population is illustrated with data in the following pages.

An exhaustive multiphase screening process is followed for 18-20 years to make selection of suitable individuals from nursery and field trials. A major screening is carried out in the newly produced population on completion of first year growth in the nursery beds (2nd year from seedling production from seed). Some screening is already carried out during the first year when the seedlings are maintained in the cavities from their shifting from germination trays. Some individuals are also screened during the third and/or fourth year in nurseries when only the selected ones are moved for local level field trials. The screening percentage is quite high in the nursery stage itself. For example, the screening percentage carried forward after 1st, 2nd, 3rd and 4th screening were 80.11 per cent, 70.80 per cent 1.05 per cent, 1.05 per cent, and 0.12 per cent respectively, of the original population of year 2000 population (Table 1).

A liberal screening process is followed in case of populations produced from the manipulated crosses made between different species (Table 2). This is with the simple intention that most of the commercially grown clones still belong to introduced *P. deltoides* origin. The need is felt that if some of the crosses with other species especially with indigenous poplars are found suitable for commercial production or for back crosses, then it could significantly help in broadening the limited genetic base. *P. gamblei* is an

Table 1. Multistage screening of full and half-sib population (year 2000) in the nursery

Population	Seedling produced	Nursery screening (after yr)				
		1 st	2 nd	3 rd	4 th (Final; local level field testing)	5 th (for multi-location field trials)
Half-sib	-	17,220	15,315	129	128	19
Full-sib	-	406	261	103	102	7
Total	21,512	17,626	15,576	232	230	26
Selection (%)	489	80.11	70.80	1.05	1.05	0.12
Rejection (%)	22,001	19.89	29.20	98.95	98.95	99.88

Table 2. Multistage screening of full and half-sib population (year 2009) in the nursery

S. no.	Parent	Seedling produced	Nursery screening (after yr)			
			1 st	2 nd	3 rd	4 th (Final)
1.	G-48 X G-3	40	16	7	1	1
2.	WSL-39 X G-3	120	66	52	3	2
3.	WSL-39 X WSL-A/26	90	51	32	4	2
4.	WSL-39 X <i>P. ciliata</i>	10	8	8	0	0
5.	S7C8 X G-3	160	90	90	15	15
6.	S7C8 X WSL-A/26	330	233	191	20	20
7.	S7C8 X S7C15	160	136	136	9	15
8.	S7C8 X <i>P. ciliata</i>	240	202	194	7	5
9.	WSL-32 X G-3	80	10	46	12	11
10.	WSL-32 X S7C4	16	52	10	3	3
11.	Wimco-110 X G-3	28	11	20	13	13
12.	Wimco-110 X WSL-A/26	200	21	170	36	34
13.	Wimco-110 X <i>P. ciliata</i>	38	175	21	1	1
14.	Wimco-62 X <i>P. ciliata</i>	15	22	10	0	0
15.	<i>P. tricocarpa</i> X <i>P. ciliata</i>	96	66	35	0	0
16.	<i>P. ciliata</i> X G-3	12	8	8	0	0
Total		1635	1167	1030	124	116
Selection (%)			71.38	63.00	7.58	7.09
Rejection (%)			28.62	37.00	92.42	92.91

ideal but difficult material to handle in this regard. It has fast growth and adapted to low latitudinal locations in subtropical conditions. The species differs in rooting ability, flowering period and duration from most other introduced and indigenous species. A very early flowering in *P. gamblei* during late December relative to very late in March-April in all other indigenous and introduced species grown in the RPC has critically affected breeding programmes with this species. Further flowering period in *P. gamblei* at Rudrapur, Uttarakhand is restricted to around one week period compared to its staggered period for around 1.5 months in case of *P. deltoides* grown under different altitudinal locations. In 2009, full and half-sib population with crosses made between *P. deltoides*, *P. ciliata* and *P. tricocarpa*, 71.38 per cent, 63.0 per cent, 7.58 per cent and 7.09 per cent after 1st, 2nd, 3rd and 4th screening respectively of the original population was retained for the local level trial.

Screening at Local Level Field Trials

The second phase screening is carried out in the local level field trials. Individuals selected from the nursery screening are multiplied in adequate number and planted in 2-3 sites on the company's farms or in some farmers' field near our operational area. The individual tried in these trials are many and well replicated single tree plots with increased replications are established inside the normally grown poplar plantations to avoid the boundary and side effects. Data is mainly recorded for growth and form and the

selection is made at the end of the rotation mostly at 8 years on company's farms and for varying rotation on farmers' land. An example of such trial with selected individuals from multiple trials is given in Table 3. The individuals from such trials are selected based on a composite growth index of height and DBH+2SD.

Screening at Multilocational Field Trials

Third phase screening is carried out in the multi-location trials which are conducted simultaneously throughout the RPC or, sometimes, in certain isolated locations in view of specific objectives associated with that site. Presently, three multi-location trials established in the Region of Intensive Poplar Culture (RPC) during 2002, 2003 and 2007 on 12, 16 and 40 sites, respectively are being monitored. The overall ranking of the clones during different years and sites in 2002 trial is given in Table 4. The data in the Table indicate a variable harvesting time by the growers based on their financial needs. These trials are planted inside the normal plantations made on farmers' fields and, therefore, farmers start harvesting them as per their convenience. The data in the table indicate that the harvesting of the trial plantations was started from 4th years by one grower, by one more in 5th year, one in 6th year, three in 7th year and four in 8th year. Two of the plantations which are still maintained have been planted in the forest, are still growing and are likely to be harvested at 12 years of rotation age followed for such plantations. Overall ranking of the tested clones in these trials based on height and diameter growth clearly indicates a

Table 3. Performance of 25 clones in a local area trial at Chandain Farm, Bilaspur, Uttar Pradesh

Clone	Initial		Growth at 96 months (8 yrs)			
	Height (m)	DBH (cm)	Height (m)		DBH (cm)	
			MEAN (SD)	CV%	MEAN (SD)	CV%
Wimco-81	4.4	2.8	27.2(2.25)	08	28.8(3.47)	12
Wimco-98	4.6	2.7	25.5(2.16)	08	27.5(4.06)	15
Wimco-A/26	4.4	2.5	25.4(1.05)	04	24.9(1.97)	08
Wimco-85	4.5	2.6	24.9(2.08)	08	24.5(2.93)	12
Wimco-84	4.6	2.7	25.7(1.29)	05	24.4(2.14)	09
UDAI	4.2	2.3	24.9(1.88)	07	24.2(1.79)	07
Wimco-91	4.4	2.9	24.5(1.73)	07	23.9(1.98)	08
Wimco-82	3.6	1.9	23.9(0.49)	02	23.8(0.21)	01
Wimco-A/49	4.2	2.6	24.4(1.11)	04	23.5(1.75)	07
Wimco-103	4.0	2.4	23.9(1.05)	04	22.9(0.67)	03
Wimco-90	4.0	2.5	24.6(0.95)	04	22.9(1.72)	07
Wimco-94	3.9	2.4	23.3(1.71)	07	22.5(2.58)	11
Wimco-14/2	4.2	2.2	23.2(1.09)	05	22.4(1.31)	06
Wimco-88	4.4	2.6	23.6(2.50)	10	22.4(2.88)	13
Wimco-99	3.9	2.3	22.5(0.84)	04	22.2(1.22)	05
Wimco-96	3.9	2.2	23.4(1.66)	04	21.6(2.42)	11
Wimco-97	4.4	2.6	23.3(0.53)	02	21.4(0.39)	02
Wimco-102	3.6	2.1	22.6(1.54)	07	21.1(2.30)	11
Wimco-101	3.7	2.3	22.3(3.19)	14	21.0(4.62)	22
Wimco-6/24	4.5	2.5	21.8(1.35)	06	20.4(1.10)	05
Wimco-86	4.8	2.5	22.3(0.82)	04	19.9(0.74)	04
Wimco-87	3.9	2.3	21.9(1.65)	07	19.9(1.84)	09
Wimco-92	4.2	2.4	21.7(2.22)	10	19.0(2.68)	14
Wimco-89	3.7	2.2	21.3(1.57)	07	18.6(1.99)	11
Mean	4.1	2.4	23.7(1.44)	06	22.7(2.35)	10
SE Diff.			1.24		1.77	
CD (0.05)			2.43		3.47	

consistency for two clones, viz., Wimco 81 and Wimco 83 till 6th year of growth. The two remaining sites have produced trees of less height and DBH with very low management inputs which also indicates that appropriate cultural operations are necessary for exhibiting the actual potential of clones on tested sites. In addition to above, the screening of clones is also done for specific objectives like against red mite which is common in eastern locations due to warm and dry weather conditions (Dhiman, 2007). Wood testing for end use is also an isolated trial conducted in specific poplar based units (Dhiman and Gandhi, 2006).

From these trials, two clones Wimco 81 and Wimco 83 were selected based on six years performance, rejuvenated and multiplied for commercial production and for supply of the saplings to the growers. We prefer to monitor our clonal trials to full rotation of 6-8 years, though, some recommendations are available for early selection for fast mass multiplication of leading clones (Kumar and Singh, 2001). We also believe in conducting repeated clonal trials to avoid loss to growers from premature testing and release of new clones. Numerous growers have already had a very bad experience of growing tissue cultured poplar which repeatedly performed very poor (Dhiman and Gandhi, 2010).

The company includes selected clones from these trials in its germplasm and regularly updates and monitors them for various characters. The germplasm is maintained in the nursery by replanting five to 10 cuttings each year and also as a field plantation in one to two sites on company's

Table 4. Ranking of clones in 2002 multi-location trial on 12 trial sites

Clone	Ranking among the tested clones										1 st position among the tested sites							
	Nry	1	2	3	4	5	6	7	8	Nry	1	2	3	4	5	6	7	8
Wimco-27	V	VI	V	III	V	II	IX	VII	V	2	-	1	-	-	-	-	-	-
Wimco-28	VII	II	II	II	II	VII	V	IV	IV	-	-	-	-	-	1	1	-	-
Wimco-38	XI	VIII	VIII	V	III	V	VII	VII	VII	-	1	-	-	2	2	1	1	-
Wimco-39	VI	IV	IV	III	III	IV	IV	III	VI	2	1	-	-	1	-	-	2	1
Wimco-80	III	VII	VI	VIII	VIII	VIII	III	II	III	1	2	-	-	-	-	-	-	-
Wimco-81	IV	IX	IX	VIII	VI	III	II	VI	VII	1	-	1	-	1	2	4	1	-
Wimco-82	XII	XI	XII	XII	VII	XII	VII	X	X	-	-	1	-	-	-	-	-	-
Wimco-83	VII	I	I	I	I	I	I	I	I	-	5	6	6	7	2	3	1	1
Wimco-84	IX	XII	X	X	XI	X	XI	XI	XI	-	-	1	2	-	1	-	-	-
Wimco-A/26	X	X	X	XI	X	XI	X	IX	IX	-	1	-	-	-	-	-	-	-
Wimco-A/49	II	III	III	VI	VII	VI	VI	XII	XII	4	1	-	-	-	1	-	1	-
G-48	I	V	VII	VII	IV	IX	VIII	VIII	II	2	1	2	4	-	1	-	-	-
Site (no.)										12	12	12	12	11	10	9	6	2

A Case Study of 1997 Full-Sib and Half-Sib Population

Nineteen thousand one hundred ninety five seedlings were produced from manipulated crosses involving 9 female clones (G48, Wimco 62, St121, 3201, S7C13, S7C8) and 6 male clones (St3, St63, S7C3, S7C4, S7C20, 112910) of *P. deltooides* in 39 attempts made between 17-2-1997 to 26-3-1997. There were 36 unsuccessful attempts of making crosses between 22nd February to 26 March, 1997 with some female clone's mainly; St12, St75 and L34 and some male clones. One lakh thirty six thousand seven hundred forty two seedlings were also grown from the seed collected from open pollinated G48 (117577 number seedlings) and S7C13 (19195 seedlings) parents. During nursery screening (4 time screening) in three years, 41.39 per cent, 0.16 per cent, 0.16 per cent and 0.04 per cent individuals were selected after the screening process for overall disease rating (scale 0-4) against fungal pathogens viz., *Phoma* spp., *Bipolaris* spp., *Cercospora* spp.), and stem straightness (scale 0-4). Fifty four individuals from this population were selected and planted in two local level field trials in Uttarakhand. The trials were monitored for growth, form and reproductive behaviour for full rotation; i.e., 8 years. A female individual flowered in third year, 29 individuals (53.7 per cent) by 5th year, 35 (64.8 per cent) by 6th year and 53 (98.1 per cent) by 7th year. Out of the total of 53 individuals attaining reproductive age by 7th year, 30 (58.5 per cent) were male and 23(41.5 per cent) were female. Individual number 86 was leading performer producing 1.438 m³ timber volume (down to 30 cm mid girth merchantable log thickness) with 30.8 m height and 41.5 cm DBH at 8 years rotation. Nine individuals were selected out of this trial for multi-location trial which was established on 40 sites across the entire RIPC. Three individuals now named as WIMCO 108, WIMCO 109 and WIMCO 110 have been selected based on overall performance in multi-location trials for the commercial production. These clones were also screened for red mite infestation which is very common in warm locations towards eastern limits of RIPC. WIMCO 110 (earlier coded as individual No. 163) has been found highly resistant to red mite infestation (Dhiman, 2007). These three clones are now commercially produced and being supplied to the growers.

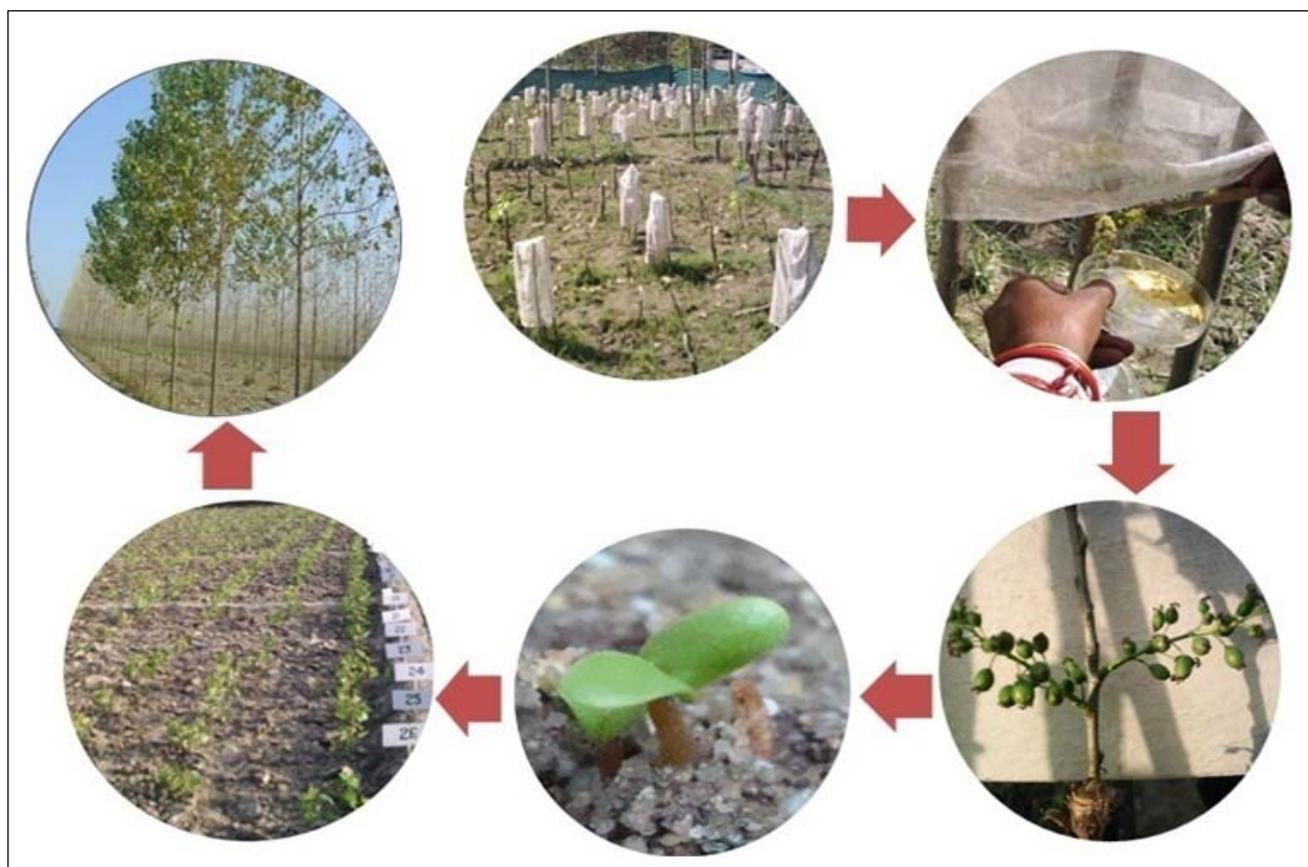


Fig. 1. Hybridization work followed at WIMCO.

farm. We closely and regularly monitor the clones numbering 492 maintained in germplasm, out of which 344 were included from our own poplar improvement programme, 57 procured from UHF, 15 from Uttarakhand Forest Department and 76 exotic clones introduced at different periods. These clones exhibit wide variation in growth, form and their response to diseases and insect attack. For example, the nursery performance of these clones during the year 2011-12 indicates three clones with a height: DBH ratio of 125-150, six with 151-175 ratio, 93 with 176-200 ratio, 228 with 201-225 ratio, 149 with 226-250 ratio and 13 with more than 250 ratio at one year seedling production phase. These clones are also regularly monitored for disease resistance every year. The ranking index (Kotle, 1985) for diseases for all these clones is given in the Table 5. Leaf blight caused by *Bipolaris* spp. is a serious disease and is rigorously monitored in our tree improvement programme. Most of the clones in our tree improvement programme are screened out against its infection and, therefore, it includes only a few susceptible clones for this fungus. Blistering and *Sclerotium* leaf spots are posing new threat and these have now been included for screening in the poplar improvement programme. *Phoma* leaf spots are now recorded widespread towards the fag end of the growing season when most of the lower leaves start dropping prematurely. Blistering is developing as a potential damaging disease wherein some mortality of field planted saplings is carried forward from the infected nurseries. It now finds equally good space in poplar improvement programme. Other diseases are though noticed widespread but their damage on the existing clones has not been found very serious and is being monitored for maintaining the history of disease in reference to clones. *Phoma* leaf spot is also on the watch list in the improvement programme.

Clonal Diversity

Numerous poplar species, hybrids and clones have been introduced in India from various countries during the last 60 years. Out of these, clones of *P. deltoides* developed from its

low latitudinal populations have proved successful in the country. Clones presently that find mention in India belong to many series, viz., WSL, Wimco, G, L, EL, D, St, S, I, IC, FRIAM, FRIFS, PL, Pant, UFC, UCM, UD, and even simple named and numbered series (D series clones are also mentioned as St series in some publications). G, St, D, S, I and IC are introduced series clones and the remaining are indigenously developed ones. Many clones especially picked up from WIMCO are used in research trials before their final release and are quoted by their original numbers. WSL, Wimco and named series like Udai, Kranti and Bahar clones have been released by WIMCO and many of these are widely grown and preferred clones throughout the RIPC. The next preferred series of poplar clones is S series which were introduced from the USA. Numerous clones under this series were tested across the RIPC and two widely grown ones are S7C15 and S7C8. The former is widely grown throughout RIPC, whereas, S7C8 finds preference with growers in UP and UK states. L and EL series clones are from Uttar Pradesh (UP) Forest Department; FRIAM and FRIFS from the Forest Research Institute (FRI), Dehradun; PL from Punjab Agriculture University, Ludhiana, Punjab; Pant series from G.B. Pant University of Agriculture and Technology, Uttarakhand; and UFC, UCM, and UD series clones from the University of Horticulture and Forestry Solan, Himachal Pradesh. Performance of introduced G3 and G48 clones laid down the base for the poplar culture in plain areas in India. G3 was the main clone till mid 1990's whereas G48 became widely preferred clone thereafter. Some space created by the exit of G3 on developing susceptibility to leaf blight, was quickly occupied by Udai clone. Of late, the share of G48 in field plantations is decreasing on developing susceptibility to many pathogens and insects. Besides, there are now many other equally good indigenously developed clones, some of which have both wide scale and endemic acceptability. Some L series clones especially L34, L13 and L49 were also grown in some locations during some period. Saplings of L34 clone produced from tissue culture originated mother plants were also supplied in large number across the RIPC and their performance was

Table 5. Annual screening (2011-12) of germplasm clones for major diseases

Infection (%)	No. of plant infected with disease					
	Blistering	<i>Sclerotium</i> leaf spots	<i>Phoma</i> leaf spots	<i>Cercospora</i> leaf spots	<i>Aletrnaria</i> leaf spots	<i>Bipolaris</i> leaf blight
No infection	281	488	1	47	291	486
0-20	52	3	1	39	80	3
21-40	54	0	3	38	64	1
41-60	36	1	10	57	32	0
61-80	37	0	35	94	18	0
81-100	32	0	442	217	7	2
Total	492	492	492	492	492	492

subnormal compared to the traditionally propagated saplings from stem cuttings (Dhiman and Gandhi, 2010). Clones which were introduced in the initial phase of poplar planting or field trials, viz., *P. deltoides* 'IC', I, D series and even 65/27 are still spotted in some field locations and are grown by some private nurseries ignorantly or even may be regenerating from root suckers. The present nomenclature of poplar clones creates a lot of confusion and the use of different names for the same clones by different organization is also not ruled out.

WIMCO raised first ever poplar nursery outside government sector with its introduced G48 and G3 clones at Bareilly, U.P. during 1969. A few saplings out of this production were planted on farmers fields around Bareilly during the following years. The early performance of these saplings on farmer's fields boosted the confidence of the management of the company to initiate a planned programme for poplar culture on farm land. U.P. Forest Department was already conducting trials on forest land with the introduced clones of *P. deltoides*, viz., I-488, I-214, I-215 and I-15-II initially (1965-1968) and then with 'IC', St121, G3 and G48 clones (Chaturvedi, 1982). The department introduced G3 clone in its programme in 1972 and G48 in 1975. A total of 1,355 hectare forest area in U.P. was planted with 29 poplar clones till 1981, of which the maximum 35.21 per cent area was with clone 'IC' followed by 21.80 per cent with G3, 8.62 per cent with D121, 6.64 per cent with D124 clone and remaining with others. The share of G48 was only 3.36 per cent during this period (Chaturvedi, 1982). WIMCO also supplied saplings of St121, and 'IC' clones initially to the growers in the states of Punjab, Haryana, U.P. and elsewhere under its regular extension programme w.e.f. 1976. The share of St and 'IC' series clones

sharply declined and G3 and G48 clones developed preference among the growers. During 1990's clone G3 constituted more than 90 per cent planting stock in many locations including in Yamunanagar district of Haryana which is the main poplar wood trading centre in the country. Clones G-3, St-100, St-121, L-34, etc. have now some isolated presence but are not recommended for plantations in greater part of RIPC because of low productivity, threat of insect and disease infestations to these clones.

Presently, around two dozen clones are commercially grown in the country. WIMCO this year (2012) is growing approximately 6.5 million saplings in around 40 nurseries throughout the RIPC. These will be supplied to the growers and a few thousands of them would be used for planting in its own farms and multiplication. Share of different clones in the company's poplar programme implemented throughout the major part of its growing region in the country especially in the RIPC (between and within states, Table 6) indicates a complex matrix of their acceptability. Company's developed and introduced clones including clone G48 are still the leading clones demanded by the growers. G48 followed by WSL 22, Udai, WSL 39, S7C15, Wimco 81, WSL 32, S7C8, Kranti, Wimco 108, WSL A/26, WSL A/49 and around a dozen others are grown by the company. Clones G48, WSL 22, Udai, WSL 39 and WSL 32, Wimco 81 and S7C15 together constitute over 90 per cent of the total planted poplar in the country. Out of 6 recently released clones, viz., Wimco 81, Wimco 83, Wimco 108 and Wimco 110 are now being demanded by the progressive farmers. Some clones like L34 developed by Uttar Pradesh Forest Department and introduced S7C4, St 121 also demanded by a very few growers and are grown and supplied

Table 6. Share of clones in sapling production between and within states in WIMCO's poplar programme (2012)

Clone	Clone share (%) among states				Clone share (%) within states				Total
	UP	UK	Pb	HRY	UP	UK	Pb	HRY	
G-48	19.41	37.31	32.87	10.41	19.98	47.18	52.58	27.89	36.22
Udai	43.49	15.51	19.06	21.93	14.71	6.44	10.02	19.30	11.90
S7C8	75.55	14.18	1.65	8.63	3.97	0.91	0.13	1.18	1.85
S7C15	85.13	2.97	10.35	1.55	13.93	0.60	2.63	0.66	5.76
WSL 22	41.01	24.08	20.44	14.47	21.87	15.77	16.94	20.07	18.76
WSL 32	34.32	42.85	2.61	20.22	2.85	4.36	0.34	4.36	2.92
WSL 39	39.60	40.61	12.72	7.07	10.19	12.83	5.08	4.73	9.05
WSL A/49	87.87	12.13	0.00	0.00	2.61	0.44	0.00	0.00	1.04
WSL A/26	0.00	31.04	52.33	16.58	0.00	1.16	2.47	1.31	1.07
Kranti	50.92	4.24	4.22	40.63	2.31	0.24	0.30	4.79	1.59
Bahar	98.03	1.97	0.00	0.00	1.42	0.04	0.00	0.00	0.51
Wimco-81	25.05	41.39	16.95	16.61	3.80	7.71	4.00	6.56	5.34
Wimco-108	14.39	9.56	30.71	45.34	0.56	0.46	1.85	4.57	1.36
Wimco-110	45.13	12.90	22.37	19.59	1.15	0.40	0.88	1.30	0.90
G-3	100.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.17
Wimco-83	4.76	33.63	37.77	23.84	0.09	0.82	1.16	1.23	0.70
Wimco-109	0.00	9.40	51.43	39.17	0.00	0.23	1.62	2.06	0.71
Others	21.02	78.98	0.00	0.00	0.09	0.42	0.00	0.00	0.15
Total	35.18	28.65	22.64	13.52	100.00	100.00	100.00	100.00	100.00

UP=Uttar Pradesh, UK=Uttarakhand, Pb=Punjab and HRY=Haryana

to them on their demand. Data on location-wise clonal production and supply from so many field sites is difficult to accommodate in this paper. The data in the Table 6, however, clearly indicates wide spread and endemic acceptability of many clones. Whereas, G48, WSL22, WSL39 have widespread acceptability, many others are restricted to a few locations. Clone G3, once a dominate clone in poplar culture over the greater part of the poplar growing region, is now restricted to U.P. and that too to only Aligarh/Bulandshahar locations in U.P. where it does not attract infestation from *Bipolaris* spp. due to drier weather conditions. Some saplings of G3 clones are also reported to be grown in the drier part of Haryana. Similarly, clone G48 the most preferred clone among the growers over the great part of RPC is not grown towards eastern limits of poplar culture especially eastward of Bareilly (U.P.) because of its high susceptibility to sap sucking insects including red mite (Dhiman, 2007). WSL22 is now becoming more acceptable in its place in many locations. Similarly, S7C8, WSL A/49 and Bahar are mainly grown in the states of U.P. and Uttarakhand and they are almost non-existent in the states of Punjab and Haryana.

WIMCO has released 15 indigenously developed clones from its improvement programme and two introduced clones (G48 and G3) for field planting. Three clones, viz., Udai, Kranti and Bahar were released during the year 1992, six clones, viz., WSL 22, WSL A/26, WSL 27, WSL 32, WSL 39, WSL A/49 were released during the year 2000 and six others, viz., Wimco 62, Wimco 81, Wimco 83, Wimco 108, Wimco 109 and Wimco 110 were released during the year 2010. Many of these clones are in the data base of IPC whereas the last lot of five Wimco series clones has been sent for registration. G48 has already phased out from some locations and is declining in many others.

Choice of clones being grown is specifically driven by the demand from the growers. The fact that the company still grows a few thousands saplings of some introduced and those developed by other agencies, viz., L34, S7C15, S7C8, S7C4, etc. indicates that there is some demand of these clones from the growers and are produced to meet the requirement of growers. The demand for the above mentioned clones is realistic as has been found from an exhaustive survey that was conducted in all the poplar growing nurseries in that state by the Haryana Forest Department during 2011-12 (Dhiman and Jagdish Chander, 2012). The survey confirms that G48, WSL 22, Udai were the leading clones with 95 per cent of the total stock production belonging to these clones. Yamunanagar District in Haryana is one of the main centres of poplar nursery and plantation culture and also as a main centre of poplar wood trading and its processing in the country. The outcome

of the survey on sapling production of clones in demand is, therefore, a realistic indicator of the choice of clones being grown. Some other interesting observations from this survey indicates that St121 and IC clones are still being grown in many nurseries and these were not recorded by the field staff during this survey. On the other hand, WSL34 and SAI43 clones recorded in the survey are not standard clones and are being ignorantly mentioned by some of the nursery growers. It is believed that most nursery growers lack knowledge and identification of the clones and they name their ETPs to any standard clone which finds market. Most poplar growers and its wood users know mainly G48 clone and many nursery growers supply their unknown origin saplings on the name of this clone. The percentage and share of clones as shown in the Fig. 2 is just indicative trend and G48 is not necessarily occupying 56 per cent share in clonal culture in the state as appeared from the data of the survey.

The grower's choice for clones has been slowly changing over the time. Poplar is now grown by numerous growers numbering a few hundred thousands in India. Many of them have planted and harvested poplar numerous times. They, therefore, have developed likings for some clones which have been grown on their fields and avoid taking risks with new clones. The farmers show great interest in new clones yet follow a conservative approach in view of emergence of many nursery growers supplying spurious planting material on the name of hybrids and tissue cultured poplar. The acceptability and adoption of new clones is, therefore, very slow and highly complex mechanism among so many growers in the country. WIMCO released its six clones, viz., WSL 22, WSL A/26, WSL 27, WSL 32, WSL 39, WSL A/49 during the year 2000 for supply to the farmers. The slow progression in the adoption rate of individual clones in this complex farmer based poplar farming is indicated in Fig. 3. It is only after a successful and better production of new clones on farmer's fields that they start accepting good performing ones.

Poplar is the most domesticated forest tree in India and has better synergy with agriculture system than forestry operations. Replacement of old clones is expected fast in this domesticated tree than in many slow growing trees. Like agricultural crops, it is strongly felt that poplar farming also needs to have continuous development of new clones which are site matched, more productive and resistant to pests. WIMCO's poplar programme is simple but realistic technical programme which is immensely helping in sustaining poplar culture supported by numerous growers in the country. It is also a mean for livelihood for thousands of nursery growers who freely grow WIMCO's developed clones as a part time

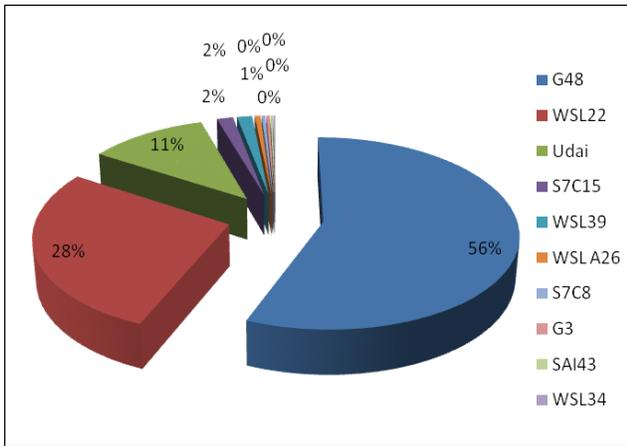


Fig. 2. Share of major clones in poplar sapling production in the state of Haryana.

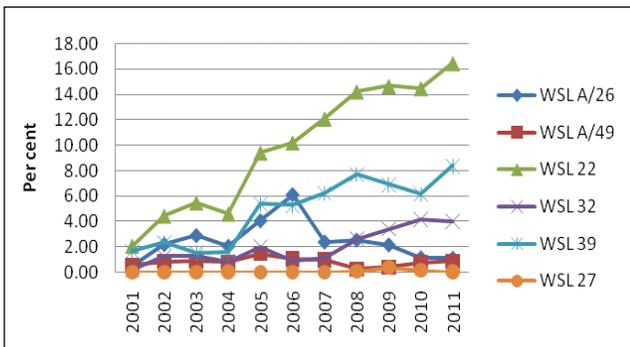


Fig. 3. Adoption rate of new clones over a decade among growers in WIMCO's programme.

business activity. WIMCO's poplar programme is a complete package of its improvement, nursery and plantation culture integrated with agriculture crops on farm land and wood procurement. Its backward and forward linkages with nursery

production and wood usage helps in developing operationally acceptable technologies. Integration of research and development at every level adds value to the programme. Multi-location trials being conducted on farmer's fields act as demonstration plots and as a mean for fast acceptance of good performing clones. Further the testing of the new clones is on the actual land use where they are grown after the release. Acceptance of its numerous clones in nursery and plantation culture over its entire growing locations in the country is an indication of the success of this programme.

References

- Chaturvedi, A.N. 1982. Poplar for farm forestry in Uttar Pradesh. *Indian Forester*, 107: 661-664.
- Dhiman, R.C. 2007. Infestation of leaf curl mite (*Tetranychs urticae* Koch) in poplar nurseries. *ENVIS Forestry Bulletin*, 9(1): 132-137.
- Dhiman, R.C. 2012. Diagnosis of intercrops in poplar based agroforestry. *Indian Forester*, (Accepted).
- Dhiman, R.C. and Gandhi, J.N. 2006. Clonal variation in poplar wood for making match splints. *Journal of the Indian Timber Development Association of India*, 52(1-2): 22-25.
- Dhiman, R.C. and Gandhi, J.N. 2010. Field performance of traditionally propagation vis-à-vis tissue cultured poplar. *Annals of Forestry*, 18(2): 223-230.
- Dhiman, R.C. and Jagdish Chander. 2012. Expanding poplar culture and plywood industry. *Plyworld*, 4-5: 29-31.
- Kolte, S.J. 1985. Disease of annual edible oilseed crops. Vol. 3: Sunflower, safflower and nigerseed diseases. Boca Raton, CRC Press. pp. 9-96.
- Kumar, D. and Singh, N.B. 2001. Age-age correlation for early selection of clones of *Populus* in India. *Silvae Genetica*, 50(3-4): 103-108. ●