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Growth Performance of Promising Poplar (*Populus deltoides* Bartr.) Clones under Semi-Arid Region of Haryana, India

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Abstract

The study was conducted to explore the growth performance of the 19 promising clones of poplar at 12 and 24 months after planting. Data were statistically analyzed for different growth parameters *viz*., colour of buds (after one month), total height, collar diameter, inter-nodal length, number of branches, volume index at first and second year. Taxonomic evaluation (colour of buds) revealed that the clonal characters further represent the source of germplasm from poplar of section Aigeirous. Results revealed that clone C-5 showed significantly better performance for total height, collar diameter, inter-nodal length and volume index, Clone C-7 and PL-5 had a higher number of branches in comparison to other clones. Clones SOLAN-13, SOLAN-8 FRI-72, FRI-100 and WIMCO-62 were also found to be the promising clones for growth parameters. Clones C-5 showed better performance for all above mentioned growth characters over other clones.

Key words : Poplar, volume production, height and growth performances.

Poplar (*Populus deltoides*) is a commercially important tree species which belongs to Salicaceae family and is well adapted to temperate regions all around the world. Over the world, total area of planted poplar is 8.6 million ha (IPCC, 2012), whereas 0.27 million ha area has been reported in India mostly in states like Uttrakhand, Uttar Pradesh, Haryana and Punjab etc. (ICFRE, 2016). Poplar is favored due to higher productivity (approximately 48 m^3 ha^{-1} yr^{-1}), short rotation (5-8 years), straightness and deciduous nature, making it more compatible to agro-forestry systems. The cultivation of poplar has generated huge employment in the rural areas of India and has improved the overall rural economy (Chavan and Dhillon, 2019). Its soft attractive, strong and easily workable wood is suitable for manufacturing of matches, furniture, packing cases, plywood, sports goods, pulp and paper, rayon, fiberboard and pencils (Sidhu and Dhillon, 2007). Nowadays, poplar is seen as the 'green gold' of the countryside, mainly due to its deciduous nature, fast growing habit, adaptability to different environmental conditions and silvicultural systems and above all high industrial demand. Genetically improved, true-to-type and uniform clonal planting stock of field-tested clones adaptable to specific sites, has revolutionized productivity of plantations of Poplars and Eucalyptus with major improvements in quality of produce and profitability (Raina *et al*., 2012; Lal, 2014).

The tree is harvested at a short rotation of 6-8 years, which provides a yield of 150-200 m^3 ha^{-1} (mean annual increment of 20-25 m^3 ha^{-1} $year^{-1}$) in block plantation and 12-20 m^3 ha^{-1} (mean annual increment of 2-3 m3 per ha per year) in boundary plantations (Kishwan and Kumar, 2013). The wood of the tree is mainly used for plywood manufacturing in India. The branches, tops and roots of the trees are also used by plywood industries as a fuel, which helps reduce fossil fuel use. Due to its fast growth and wider adoptability, the tree has huge potential to sequester carbon and mitigate CO_2 from the atmosphere (Dhiman, 2009; Singh and Lodhiyal, 2009; Chauhan *et al*., 2010 and Gera, 2012).

Keeping in view the ever-increasing demand of poplar wood and the interest of farmers in cultivation of poplar, different promising clones have been developed by various research organizations in the country, and are being tested in a number of locations under "All India coordinated research project on poplar improvement" (Kumar *et al*., 1999).

Further, the results of this trial have shown that increased commercial planting of poplar in India has so far relied on the use of few clones of poplar *viz*. 'G-3', 'G-48', 'D-121', 'ST-67', 'S7C4' and 'S7C8' (Chaturvedi, 1992). About 90 percent of the poplar plantations in India are based on clones 'G-48', 'G-3' and 'S7C15' (Kumar *et al*., 1999). Several clones have shown promising growth rates and are grown in different parts of north India to meet the demand of industrial raw material. Subsequently, introduced clones were hybridized among themselves to produce new clones by Institutes like FRI, Dehradun and Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni (Solan). This has resulted in the mushrooming of private nurseries. Most of these nurseries are selling ETP (entered transplanting) of commonly known clones without proper authentication and purity. Since, these clones look morphological similar, sometimes mislabelling can also happen. In the recent past, the highly narrow genetic base of these poplar plantations has resulted in the outbreak of leaf defoliators, bark eating caterpillar, stem borers, etc. (Singh *et al*., 2004). The yield of clone G-3, which once used to be the most popular clone, is declining due to attack by leaf blight disease. This clone is giving way to other clones, e.g., S7C8, Uday, L-34/82 etc. Individual plantations are, however, monoclonal (Kumar *et al*., 1999). Luna *et al*., (2011) reported that clone WSL - 39 achieved the best growth and maximum volume in Punjab, attaining a diameter of 14.74 cm; height 14.42 m and volume 0.1040 m^3 $tree^{-1}$. This clone outperformed the clones for growth and volume since the beginning. The volume production of clone Udai was at par with WSL–39 at 2 and 3 years of age in Punjab.

Materials and methods

The present investigation was carried out in Department of Forestry, CCS Haryana Agricultural University Hisar (Haryana). The details of different poplar clones procured from different institution which were form the basic material for present study are as under,

Table 1. A list of different Clones of poplar (*Populus deltoides*)

C-5	WSL-110(W7)	L-48
C-7	PP9-(J1)	FRI-72
C-12	PP9-20	FRI-100
C-20	PP9-25	UDAY
C-26	PL-5	WG-108
Solan-8	WIMCO-62	
Solan- 13	FNR-605	

Hisar has a typical semi-arid climate with hot and dry summer and extremely cold winter. The soil at the planting site is sandy loam with an average pH of 8.5. were planted at 5×4 m in second week of February following randomized block design with three replications with standard package of practice. Six plants of each clone from each of the three replications were selected randomly for recording data on total height, collar diameter, inter-nodal length, number of branches and volume index at 12 and 24 months after planting colour of buds were observed after one month plantation of cuttings in the nursery. volume index was estimated as per Chauhan (2008). The replicated data recorded for all characters was analyzed statistically (Panse and Sukhatme, 1967). Significant differences were based on $P \leq 0.05$.

Results and Discussion

Plant height (m) and diameter at breast height (cm) : A perusal of data showed that significant variation was there among all the

clones at 12 MAP and 24 MAP. The clone C-5 showed better growth performance over other clones in respect of height and dbh. The differences in height and dbh among clones in present study may be due to the genetic variation among the clone and site quality. Lowest value for plant height and dbh was obtained in clone WG-108 both at 12 MAP and 24 MAP. The present study showed that ample variation exists among the clones for height and diameter. The reported variations among poplar clones under study are in line with the findings of Puri *et al*. (2002), Ozel *et al*. (2010) and Dhillon *et al*. (2020) in poplar.

Internodal length (cm) : Analysing the genetic characteristics of internodal length is critical for improving plant population structure and increasing photosynthetic efficiency. The clones under study varied significantly with each other in terms of their internodal length. The clone C-5 and C-20 showed higher internodal length than other clones. Internodal length among different clones varied from 3.50 to 6.00 cm and 8.00 to 21.33 cm at 12 and 24 MAP, respectively. The results of present study are similar with the findings of Kumar *et al*. (2017) and Tomar and Srivastva, (2020), in which they reported the internodal length of poplar ranges from 4.40 to 5.80 cm after one year of planting. Similarly, significant inter-clonal variation in poplar clones was reported globally in literature (Mir *et al*., 2017; Sidhu and Dhillon, 2007; Singh and Singh, 2013; Stener and Westin, 2017; Ahmed, 2020).

Table 2. Plant height, diameter at breast height (DBH) and Volume Index of different clones of poplar at 12 and 24 months after plantation (MAP)

Clones	Plant height (m)		DBH (cm)		Volume index (cm^3)	
	12 MAP	24MAP	12 MAP	24MAP	12 MAP	24MAP
C-5	6.90	10.42	5.52	12.84	16505.40	136834.10
C-7	5.57	9.50	4.77	9.13	10030.19	62560.51
C-12	5.60	7.03	4.19	6.26	7906.08	22409.12
C-20	5.40	9.13	3.77	8.71	6041.94	54128.45
C-26	5.53	9.10	3.68	8.39	5888.64	51214.97
SOLAN-8	6.07	10.11	4.14	11.46	8404.03	104516.90
SOLAN-13	4.45	10.12	3.71	12.10	4723.61	116819.50
WSL-110	5.07	9.34	3.50	10.19	4946.30	75881.71
PP9-(J1)	6.27	7.57	3.41	8.92	5836.95	47254.52
PP9-20	5.03	7.18	3.40	8.49	4564.60	40822.29
PP9-25	4.60	6.82	3.43	7.86	4494.27	33660.83
PL-5	5.27	9.12	3.87	10.93	6201.47	85739.01
WIMCO-62	6.06	9.10	4.19	9.45	8414.44	64621.81
FNR-605	5.20	8.40	3.82	8.07	5970.59	42833.33
L-48	5.17	7.13	3.71	9.66	5522.10	52264.06
FRI-72	6.10	9.41	4.51	8.71	10204.30	56461.42
FRI-100	6.07	9.83	3.85	11.15	7141.12	96928.60
UDAY	4.80	6.33	3.50	7.22	4594.75	26041.40
WG-108	4.43	6.03	3.39	7.01	4046.91	23162.15
Mean	5.45	8.51	3.91	9.29	4.75	6917.77
Range	4.43-6.90	6.03- 10.42	3.39-5.52	6.26-12.84	3.50- 6.00	4046.91-16505.4
SE(m)	0.37	0.72	0.28	0.49	0.08	3319.00
CD at 5 %	1.07	2.08	0.80	1.40	0.22	1629.87

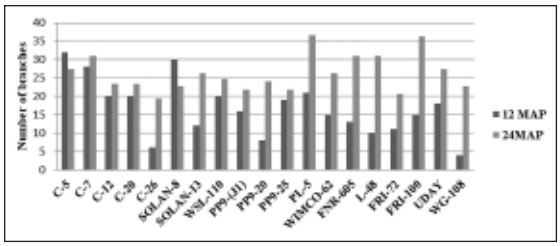

Fig. 1. Number of branches

Number of branches plant^{-1} : The number of branches plant^{-1} among different poplar clones varied significantly both at 12 and 24 MAP in field. The number of branches plant^{-1} at 12 MAP varied from 4-32 with the general mean of 17.16. The numbers of branches plant^{-1} were observed maximum in C-7 (32.00) and in PL-5 (36.67) after 12 and 24 MAP, respectively. Other clones in present investigation showed more number of branches are SOLAN- 8 (30.00), C- 5 (28.00), C- 12 (28.00), C- 20 (20.00) and WSL- 110 (20.00) after 12 MAP and FRI- 100 (36.33) C-5 (31.00), L-48 (31.00), FNR-605 (31.00) and C-7 (22.67) after 24 MAP. Minimum numbers of branches plant^{-1} were recorded clone UDAY (4.00) and C-26 (19.33) at 12 and 24 MAP, respectively (Table 2).

In the present study, the numbers of branches plant^{-1} were observed maximum in C-7 (32.00) and PL- 5 (36.67) after 12 and 24 MAP, respectively. The Minimum numbers of branches plant^{-1} were recorded in clone UDAY (4.00) and C-26 (19.33). A significant variation among the clones for number of branches was observed at 12 and 24 MAP. Number of branches are the characteristics of a plant species showing adaptation to a particular environment as reported earlier by Dhillon *et al*. (2010). Masoodi *et al*. (2014) also reported that the clones collected from three ecological environments exhibit great variation in number of branches. Similarly, significant differences in the number of branches among genotypes of Populus tremuloides have been reported by Burk *et al*., (1983).

Colour of buds : A perusal of the data in Table 3 showed that each clone had a distinct pattern of buds and variation in colour. Light red brown colour of buds was observed in clones C-5, C-7, C-12, C-26, WSL-110, PL-5, Wimco-62 and light greenish red brown colour was observed in Solan-8, Solan-13, PP9 (J1), PP9-20, PP9-25, FNR-605, FRI-72, FRI-100, Uday and red brown in C-20 and WG-108. The variation in colour of buds makes the clonal material diagnostically recognizable in the field. The substantial variation in colour of buds available on stem branch^{-1} in present study indicates that there is lot of genetic variability in the clones. Further, colour of bud is a good indicator to identify the poplar clones and also helpful in subsequent improvement of this versatile industrial tree species. A similar pattern of distinct colouration of buds among 19

Table 3. Leaf fall duration and colour of buds in different clones of Poplar in field

Clones	Colour of Buds
C-5	Lightly Red Brown
C-7	Lightly Red Brown
C-12	Lightly Red Brown
C-20	Red Brown
C-26	Lightly Red Brown
SOLAN-8	Greenish brown
SOLAN-13	Greenish brown
WSL-110(W7)	Lightly Red Brown
PP9-(J1)	Greenish brown
PP9-20	Greenish brown
PP9-25	Greenish brown
PL-5	Lightly Red Brown
WIMCO-62	Lightly Red Brown
FNR-605	Greenish brown
L-48	Lightly Greenish brown
FRI-72	Greenish brown
FRI-100	Greenish brown
UDAY	Greenish Brown
WG-108	Red Brown

different clones was reported by Kumar *et al*. (2017). Additionally, Chaudhari and Tewari (2006) also reported systematic detail leading to identity 20 poplar clones through morphological characterization. Information on phonological characters is useful for understanding genetic and taxonomic relationships and such data are prerequisite for initiating meaningful breeding programmes (Kearns and Inouye 1997). Information generated in the present study may be used as a morphological marker to identify the clones under study. Earlier, Alpana and Biswas (1999) also reported that bud colour is the potential trait for germplasm characterization of poplar.

Volume : Data recorded on volume of different poplar clones at 12 and 24 MAP is shown in Table 4.4. In present study, there was a significant variation for volume which ranged from (4046.91 to 16505.4 cm^3). Clone C-5 showed maximum volume (16505.40 cm^3) followed by clone FRI-72 (10204.30 cm3), C-7 (10030.19 cm^3), Wimco-62 (8414.44 cm3) and Solan-8 (8404.03 cm^3). The minimum volume was recorded in clone WG-108 (4046.91 cm^3) at 12 MAP. During second year, the values of volume ranged from 22409.12 to 136834.10 cm^3). Clone C-5 (136834.10 cm^3) retained its supremacy after 24 MAP and recorded higher volume index over other clones. The higher volume index of clone C-5 may be attributed to its genetic potential. The results of present study are in conformity with the finding of Kumar *et al*. 2017 and Tomar and Srivastva, 2020 in poplar clones. The volume productions in the present study ranged from 22409.12 to 136834.10 cm^3 at 24 MAP which is comparable with the previous studies carried out in Punjab (Dhillion *et al*., 2013). Various workers had also studied significant variation for root length and volume among poplar clones under field conditions (Singh, 2001; Puri *et al*., 2002; Sidhu and Dhillon, 2007, Ozel *et al*., 2010 and Dhillon *et al*., 2010).

Conclusion

C-5 clone was superior than the rest in terms of total height, dbh, number of branches, , volume, and leaf biometrical. Other clones in present investigation, Solan-13, Solan-8, FRI-72, FRI-100, Wimco-62, also showed promising performance in the study for all the above-mentioned growth parameters.

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