Study of Variation in Quantitative Traits of Poplar (*Populus deltoides*) Clones in Different Environments

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

The present study entitled "Study of variation in quantitative traits of poplar (*Populusdeltoides*) clones in different environments" was undertaken in the Department of Tree Improvement and Genetic Resources, Dr. Y. S. P. U. H. F., Nauni- Solan 173230 (H.P.). The three experimental sites namely 1) DhaulaKuan, RH&TS, Dist. Sirmaur (H. P.), 2) Laddhowal farm, PAU, Ludhiana (Punjab) and 3) Naganji nursery, Nauni, Solan. Variations in quantitative traits significantly recorded at three locations among all clones, traits such as leaf blade length, width of leaf, midrib length, distance between petiole junction to base of leaf, plant height, basal diameter and stem volume recorded higher values at Ludhiana location follows by DhaulaKuan location. The effect of different locations significantly observed on clones of poplar (*Populus deltoides*) and the quantitative traits also makes the difference within same clone at different locations.

Keywords: Poplar; plant height; stem volume; basal diameter; clones.

1. INTRODUCTION

Crop variety improvement research and development based on conventional breeding and biotechnological methods require considerable investments in both scientific manpower and financial expenditure. 'Poplar ' belongs to the genus *Populus* and family *Salicaceae* order *Salicales* and group *Amentiferae*, with 35 identified species [1] occurs throughout warm temperate to cool temperate regions of world. An effective system of plant variety protection (PVP) will not only be a safeguard against unlawful commercial exploitation of the new varieties but also stimulate the development of new varieties. Testing the distinctness, uniformity and stability (DUS) of crop varieties is a statutory requirement before varieties can be entered into the Registers of Cultivars (National Lists) and/or granted Plant Breeder's Rights (PBR).

Genetically improved clones of *Populus deltoides* were introduced in India in 1950 for short rotation plantation designed to maximize wood production [2]. Wood from poplars is the backbone of vibrant plywood, board, match and paper industrial units. Poplars provide huge cash returns to individuals and communities engaged in their cultivation and management, contribute considerably to government exchequer, reduce pressure on forests and entail massive ecological and environmental benefits besides providing a wide range of other wood products and employment opportunities to various subsidiary sectors [3]. Due to increasing popularity of the clones of *Populus deltoides* because of their shortrotation and attractive price of wood, a large number of farmers have planted commonly known clones on their farm. All this has implication in hybridization programme, proper classification of clones, registration of clone with PVP and FRA etc. Morphological and molecular characterization is of key importance to develop descriptor of any species and to discriminate among different clones of a species.

2. MATERIALS AND METHODS

The present investigations were carried out in the Naganji nursery, Department of Tree Improvement and Genetic Resources, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.), RH& TS, Dhaula Kuan and Laddhowal farm, PAU, Ludhiana. The cuttings of 15 clones were obtained from different Institutes. 15 clones were planted with three replications in randomized blocks design. Genotype x Environment interactions are of major importance to the plant breeder in developing important varieties [4].

The variation for quantitative traits were studied in three different sites (Dhula Kuan, Ludhiana and Nauni) for leaf blade length, maximum width of leaf, distance between petiole junction to maximum width of leaf, mid rib length, petiole length, distance between petiole junction to base of leaf, total leaf length, leaf area, ratio between petiole length to width of leaf, ratio between midrib length to width of leaf, angle between midrib and second lateral lower vein, apex angle, plant height, basal diameter and stem volume of clones. Analysis of variance was found to be significant for four traits therefore further stability was analysis applied to test stable clones for different sites (environments).

3. RESULTS AND DISCUSSION

Maximum leaf blade length for site Dhaula Kuan was recorded in clone PL-3 (27.78 cm) was statistically at par with clone L-30/06 (26.06 cm), at Ludhiana was observed in clone G-48 (27.97 cm) was found to be statically at par with clones L-621/84 (26.74 cm), PL-6 (26.69 cm) and L-200/86 (26.34 cm) while at Nauni, maximum leaf blade length (23.49 cm) was found in clone PL-3 which was statistically at par with clones G-48 (23.35 cm) and L-200/86 (22.24 cm). Pooled data of the three sites, it was found that maximum leaf blade length was recorded in clone PL-3 (25.56 cm) was statistically at par with clone G-48 (25.52 cm). Interaction between clones and sites revealed a maximum leaf blade length was obtained in clone G-48 (27.97 cm) at site Ludhiana which was found to be statistically at par with clone PL-3 (27.78 cm) at Dhaula Kuan, L-621/84 (26.74 cm), PL-6 (26.69 cm) and L- 200/86 (26.34 cm) at Ludhiana site (Table 1).

Maximum width of leaf at the Dhuala Kuan site was obtained in clone PL-3 (21.47 cm) which was found to be statistically at par with clones L-30/06 (20.07 cm) and PL-6 (19.98 cm), at Ludhiana, site the maximum width of leaf (24.05 cm) was recorded in clone L-621/84 and maximum width of leaf at site Nauni was measured in clone PL-3 (21.01 cm) and was found to be statistically at par with clones G-48

(20.23 cm) and L-621/84 (20.11 cm). The pooled analysis for the three sites revealed that the maximum width of leaf (21.51 cm) was recorded in clone PL-3 was statistically at par with clones L- 621/84 (20.72 cm), PL-6 (20.67 cm) and L-30/06 (20.61 cm) (Table 1). The maximum distance between petiole junction to maximum width of leaf for site Dhaula Kuan and Ludhiana was obtained in clone L-30/06 (3.99 cm and 4.05 cm), respectively. However, pooled analysis of data revealed that the clone L-30/06 was observed the maximum distance between petiole junction to maximum width of leaf (4.08 cm) which was statistically at par with clone L-621/84 (3.79 cm). Maximum distance between petiole junction to maximum width of leaf (3.70 cm) was recorded in all clones at Nauni (Table 1).

Maximum midrib length at the site Dhaula Kuan was obtained in clones L-30/06 (22.89 cm) and PL-3 (22.89 cm) while at site Ludhiana, maximum midrib length was recorded in clone G-48 (24.26 cm) was statistically at par with clones PL-6 (23.32 cm), L-621/84 (22.99 cm), L-30/06 (22.90 cm) and L-200/86 (22.28 cm). Maximum midrib length at site Nauni was measured in clone and G-48 (22.50 cm) whereas, pooled analysis for all three sites revealed that maximum midrib length (22.01 cm) was observed in clone PL-3 which was found to be statically at par with clones L- 30/06 (21.78 cm), G-48 (21.78 cm) and PL-6 (21.08 cm). Interaction among clones and sites showed the maximum midrib length was recorded in clone G-48 (24.26 cm) for site Ludhiana was statistically at par with clones PL-6 (23.32 cm), L-621/84 (22.99 cm), L-30/06 (22.90 cm) at Ludhiana, PL-3 (22.89 cm) and L-30/06 (22.89 cm) at the site Dhaula Kuan (Table 2).

The maximum petiole length in the clones at Dhaula Kuan was obtained in clone S_7C_8 (11.72 cm) which was found to be statically at par with clones L-30/06 (11.43 cm), PL-3 (10.97 cm) and PL-6 (10.33 cm) whereas, at Ludhiana, maximum petiole length was showed in clone S_7C_8 (15.01 cm) which was statistically at par with clone L-30/06 (14.18 cm) and at Nauni it was recorded in clone PL-3 (14.03 cm). The pooled data for three sites, it was found that maximum petiole length in the clone S_7C_8 (13.55 cm) (Table 2).

Maximum distance between petiole junction to base of leaf at Dhaula Kuan was obtained in clone PL-3 (4.42 cm), at Ludhiana, maximum distance between petiole junction to base of leaf was recorded in clone PL-7 (4.97 cm) was statically at par with clone PL-6 (4.92 cm) and at Nauni it was calculated in clone L-6105 (3.32 cm) which was statically at par with clones 5503 (2.99 cm), WSL-39 (2.95 cm) and PL-3 (2.92 cm). Pooled analysis for three sites revealed that the maximum distance between petiole junction to base of leaf (3.83 cm) was measured in clone PL-3 which was statically at par with clone PL-6 (3.78 cm). Clones and sites interaction data revealed that the distance between petiole junction to base of leaf was obtained maximum in clone PL-7 (4.97 cm) at site Ludhiana was statistically at par with clone PL-6 (4.92 cm) at Ludhiana (Table 2).The maximum ratio of length of petiole to length of mid rib leaf at the site Dhaula Kuan was found in clone S_7C_8 (0.65), at Ludhiana was recorded in clone S_7C_8 (0.73) which was statistically at par with clones WSL-39 (0.71), 6503 (0.66), S_7C_{15} (0.65) and 5503 (0.64) whereas, at Nauni it was observed in clone S_7C_8 (0.77) was statically at par with clones S_7C_{15} (0.75), 6503 (0.75), L-6105 (0.73), PL-7 (0.73) and 5503 (0.70). The pooled data of the three sites revealed that, the maximum ratio of length of petiole to length of midrib (0.72) was observed in clone S_7C_8 (Table 3).

The maximum ratio of length of mid rib to maximum width of leaf for Dhaula Kuan was recorded in clone 6503 (1.16) was statistically at par with clones WSL-22 (1.15), L- 30/06 (1.14), G-48 (1.10), 1007 (1.10), L-621/84 (1.07), L-200/86 (1.07) and PL-3 (1.07) whereas for Nauni maximum value records in clone G-48 (1.11) which was statistically at par with clones L-30/06 (1.09). At Ludhiana, ratio of length of mid rib to maximum width of leaf was observed in clone L-30/06 (1.06) which was statically at par with clones G-48 (1.03) and PL-6 (1.03). The pooled analysis for all the three sites revealed that the maximum ratio of length of mid rib to maximum width of leaf (1.10) was found in clone L-30/06 was statistically at par with clone G-48 (1.08) (Table 3). The maximum total leaf length at site Dhaula Kuan was obtained in clone PL-3 (38.76 cm), at Ludhiana, maximum total leaf length was recorded in clone G-48 (37.36 cm) and at Nauni was measured in clone G-48 (36.53 cm). The pooled data of the three sites, it was found that the total leaf length (36.20 cm) was maximum in clone PL-3 which was statistically at par with clones G-48 (35.96 cm) and L-30/06 (35.67 cm). Interaction data of clones and sites maximum total leaf length was obtained in clone PL-3 (38.76 cm) at site Dhaula Kuan which was found to be statistically at par with clones PL-3 (37.52

cm) and G-48 (37.12 cm) at Nauni, L-30/06 (37.49 cm) at Dhaula Kuan, G-48 (37.36 cm), L-30/06 (37.27 cm) and PL-6 (36.73 cm) at Ludhiana (Table 3).

The maximum leaf area in Nauni was obtained in clone G-48 (357.93 cm^2) which was statistically at par with clone PL-3 (329.34 cm^2), at Dhaula Kuan was recorded in clone PL-3 (320.45 cm^2) while the minimum was recorded in clone WSL-39 (133.19 cm^2) and at Ludhiana, maximum leaf area was observed in clone G-48 (397.11 cm^2). The pooled analysis for all the three sites revealed that maximum leaf area was found in clone G-48 (321.45 cm^2) which was statistically at par with clones PL-3 (313.17 cm) and L-30/06 (294.39 cm^2) (Table 4). The maximum angle between midrib and second lateral lower vein at site Dhaula Kuan was recorded in clone L-6105 (78.56^0), at Ludhiana was measured in clone PL-7 (79.55^0) and at Nauni was calculated in clone WSL-39 (85.07^0). The pooled data of three sites, it was found that maximum angle between second lower lateral vein (79.47^0) was observed in clone WSL-39 which was statistically at par with clones PL-7 (78.85^0) and WSL-22 (77.96^0) (Table 4). The maximum apex angle at the site Dhaula Kuan was obtained in clone 5503 (57.19^0), At Ludhiana, maximum apex angle was recorded in clone S_7C_8 (88.69^0) and maximum apex angle at Nauni was measured in clone S_7C_{15} (73.28^0) was statistically at par with clones L-621/84 (68.77^0) and G-48 (68.24^0) respectively. The pooled analysis for the three sites revealed that the maximum apex angle (68.52^0) was found in clone 5503 which was statistically at par with clones S_7C_{15} (67.43^0), S_7C_8 (65.91^0) and WSL-39 (64.31^0) (Table 5).

The maximum plant height for site Dhaula Kuan maximum (4.22 m) was obtained in clone L-30/06 which was statistically at par with clones WSL-22 (3.94 m), L-200/86 (3.86 m), PL-6 (3.61 m), S_7C_8 (3.57 m), PL-7 (3.57 m), 6503 (3.55 m) and PL-3 (3.52 m). At Ludhiana site, maximum (4.93 m) plant height was recorded in clone S_7C_{15} was statistically at par with clones 1007 (4.81 m), WSL-22 (4.76 m), L-200/86 (4.71 m), L-621/84 (4.7 m) and S_7C_8 (4.68 m). Maximum (4.03 m) plant height at Nauni was observed in clone 6503. The pooled data of three sites, it was revealed that the clone WSL-22 recorded maximum plant height of leaf (4.22 m) which was statistically at par with clones L- 200/86 (4.13 m), L-30/06 (4.11 m), S_7C_{15} (4.05 m), 6503 (4.04 m), 1007 (3.97 m) (Table 4). Maximum basal diameter (31.72 mm) at the site Dhaula Kuan was recorded in clone L-200/86 which was found to be statistically at par with clones WSL-22 (30.39 mm), Maximum basal diameter at sites Ludhiana and Nauni was observed in clone S_7C_{15} (33.32 mm) and L-200/86 (29.33 mm), respectively. Whereas, the mean of the three sites depicts maximum basal diameter (31.33 mm) was obtained in clone L-200/86 was statistically at par with clones L-30/06 (28.81 mm), 6503 (28.46 mm) and WSL-22 (28.44 mm) (Table 5). The maximum stem volume at site Dhaula Kuan was calculated in clone L-200/86 (3486.28 cm^3), Maximum stem volume was measured at sites Ludhiana and Nauni in clones S_7C_{15}(4343.36 cm^3) and L-200/86 (2660.27 cm^3), respectively. Data of the three sites, it was found that maximum main stem volume was calculated in clone L-200/86 (3390.76 cm^3) which was statistically at par with clones WSL-22 (2862.72 cm^3), L-30/06 (2766.13 cm^3), 6503 (2738.72 cm^3) and S_7C_{15} (2684.58 $cm^{3)}$ (Table 5).

Growth parameters of *Populus deltoides* and *P. ciliata* clones were studied in sub-tropical (Naganji) and sub-temperate (Shilli) nurseries and found significant differences among clones for plant height, basal diameter and volume index [5]. Similarly, superior *Populus deltoides* clones were screened in the nursery by Sharma et al. [6] and found 23 clones in plant height and volume index and 22 clones in basal diameter significantly different against check clone G-48. Selected tree willow clones were found significantly different in growth parameters [6]. Variation in leaf, stem and root weight was statistically significant, as were genotype x environment interactions; some clonal variation under the moisture–stress regime was probably related to watering procedure. Shoot/root ratio showed clonal differences under both regimes, as did production of stem and root per unit final leaf weight. Moisture stress reduced both wood specific gravity and fibre length, but there was little clonal variation in these effects. Statistically significant differences among clones, regardless of site, indicated that the majority of study characters are controlled by genetic factors, specific to each clone. Most characteristics showed a statistically significant interaction, the similar findings were proposed by Farmer [7], Sanitini *et al.* [8] Vinod *et al.* [9], Lone *et al.* [10], Zahidi *et al.* [11] and Ma *et al.* [12].

Table 1. Variation in leaf blade, maximum leaf width and Distance between petiole junction and maximum width of leaf of poplar clones

Name of Clones	Leaf blade length (cm)				Maximum width (cm)				Distance between petiole junction and maximum width of leaf (cm)			
	DhaulaKuan	Ludhiana	Nauni	Mean	DhaulaKuan	Ludhiana	Nauni	Mean	DhaulaKuan	Ludhiana	Nauni	Mean
L-30 / 06	26.06	26.04	20.83	24.31	20.07	23.93	17.84	20.61	3.99	4.05	4.20	4.08
L-62/ 84	22.48	26.74	21.58	23.60	17.99	24.05	20.11	20.72	3.48	3.67	4.21	3.79
G-48	25.24	27.97	23.35	25.52	16.87	23.55	20.23	20.22	3.15	3.69	4.20	3.68
L-61/05	18.31	24.07	21.58	21.32	15.13	20.45	18.63	18.07	2.75	3.13	4.39	3.42
S_7C_{15}	18.48	23.60	19.52	20.54	16.46	20.66	18.18	18.43	2.92	3.20	3.55	3.22
S_7C_8	21.56	24.06	19.91	21.84	18.82	22.33	18.30	19.82	3.33	3.58	3.28	3.40
WSL-22	18.10	21.88	19.57	19.85	14.73	18.76	17.35	16.95	2.85	3.30	3.28	3.14
WSL-39	16.69	22.83	21.27	20.26	13.98	19.33	17.99	17.10	2.62	3.06	3.62	3.10
6503	15.73	22.14	18.02	18.63	13.30	20.14	17.97	17.14	2.83	3.33	3.74	3.30
5503	16.76	20.37	18.73	18.62	17.21	19.14	17.89	18.08	2.58	2.83	3.56	2.99
1007	18.88	22.72	20.65	20.75	14.49	19.34	17.68	17.17	2.98	3.17	3.38	3.18
L-200/86	20.04	26.34	22.24	22.87	15.98	22.99	19.35	19.44	3.22	3.65	3.40	3.43
PL-3	27.78	25.42	23.49	25.56	21.47	22.04	21.01	21.51	3.60	3.35	3.73	3.56
PL-6	24.95	26.69	21.49	24.37	19.98	22.64	19.39	20.67	3.44	3.44	3.48	3.45
PL-7	20.74	26.07	20.27	22.36	16.62	22.15	18.43	19.07	3.16	3.22	3.53	3.30
Mean	20.79	24.46	20.83		16.87	21.43	18.69		3.13	3.38	3.70	

Table 2. Variation in midrib of leaf, petiole length and Distance between petiole junction to base of leaf of poplar clones

Name of Clones	Midrib of leaf (cm)				Petiole length (cm)				Distance between petiole junction to base of leaf (cm)			
	DhaulaKuan	Ludhiana	Nauni	Mean	DhaulaKuan	Ludhiana	Nauni	Mean	DhaulaKuan	Ludhiana	Nauni	Mean
L-30 / 06	22.89	22.90	19.53	21.78	11.43	14.18	12.71	12.77	2.67	2.87	1.96	2.50
L-62/ 84	19.26	22.99	20.05	20.76	7.78	11.62	11.53	10.31	2.68	3.69	1.76	2.71
G-48	18.58	24.26	22.50	21.78	8.76	13.10	13.77	11.88	3.00	3.87	2.29	3.05
L-61/05	14.95	19.65	18.04	17.55	8.19	12.36	13.09	11.21	3.12	4.07	3.32	3.50
S_7C_{15}	15.94	19.71	17.62	17.76	9.11	12.83	13.13	11.69	2.36	3.54	2.41	2.77
S_7C_8	18.09	20.57	17.96	18.88	11.72	15.01	13.90	13.55	2.82	3.60	1.73	2.72
WSL-22	16.95	18.21	17.23	17.46	7.21	10.94	10.64	9.60	2.59	3.47	2.70	2.92
WSL-39	16.95	18.21	17.23	17.32	7.57	12.81	11.66	10.68	2.45	4.04	2.95	3.15
6503	14.44	18.48	19.03	16.75	7.17	12.65	12.73	10.85	1.50	2.67	1.65	1.94
5503	13.73	19.50	17.02	15.87	7.56	11.09	11.89	7.33	2.80	3.66	2.99	3.15
1007	13.91	17.45	16.24	17.84	7.33	11.32	12.20	10.28	2.44	3.53	2.43	2.80
L-200/86	15.95	19.14	18.42	19.97	4.09	11.86	11.89	9.28	2.08	3.84	2.17	2.69
PL-3	17.13	22.28	20.49	22.01	10.97	12.92	14.03	12.64	4.42	4.15	2.92	3.83
PL-6	22.89	21.02	22.11	21.08	10.33	13.42	12.67	12.14	3.77	4.92	2.63	3.78
PL-7	20.60	23.32	19.33	19.11	7.85	12.49	13.22	11.19	2.92	4.97	2.31	3.40
Mean	20.76	18.92	19.06		8.47	12.56	12.57		2.77	3.79	2.41	

Table 3. Variation in Ratio of petiole length to midrib of leaf, Ratio of length of mid rib to maximum width of leaf and Total length of leaf of poplar clones

Name of Clones	Ratio of petiole length to midrib of leaf				Ratio of length of mid rib to maximum width of leaf				Total length of leaf (cm)			
	DhaulaKuan	Ludhiana	Nauni	Mean	DhaulaKuan	Ludhiana	Nauni	Mean	DhaulaKuan	Ludhiana	Nauni	Mean
L-30 / 06	0.50	0.62	0.67	0.60	1.14	1.06	1.10	1.10	37.49	37.27	33.54	36.10
L-62/ 84	0.41	0.51	0.58	0.50	1.07	0.96	1.00	1.01	30.27	34.60	33.11	32.66
G-48	0.47	0.54	0.61	0.54	1.10	1.03	1.11	1.08	34.00	37.36	37.12	36.16
L-61/05	0.55	0.63	0.74	0.64	0.99	0.96	0.97	0.97	26.50	32.01	34.66	31.06
S_7C_{15}	0.58	0.65	0.76	0.66	0.97	0.96	0.97	0.97	27.60	32.54	32.65	30.93
S_7C_8	0.65	0.73	0.78	0.72	0.96	0.92	0.99	0.96	33.28	35.59	33.82	34.23
WSL-22	0.47	0.60	0.62	0.56	1.15	0.97	1.00	1.04	26.51	29.15	30.21	28.62
WSL-39	0.55	0.71	0.62	0.62	1.00	0.96	1.06	1.01	24.25	31.29	32.93	29.49
6503	0.53	0.06	0.75	0.65	1.16	0.97	0.95	1.03	22.60	32.15	30.75	28.50
5503	0.54	0.64	0.70	0.63	0.88	0.91	0.91	0.90	24.73	28.54	30.04	27.77
1007	0.52	0.59	0.67	0.59	1.10	0.99	1.05	1.04	26.20	30.46	32.85	29.84
L-200/86	0.42	0.54	0.58	0.51	1.07	0.97	1.06	1.03	27.13	34.14	34.13	31.80
PL-3	0.48	0.62	0.64	0.58	1.07	0.96	1.06	1.03	38.76	33.95	37.52	36.74
PL-6	0.50	0.58	0.66	0.58	1.03	1.03	1.00	1.02	35.27	36.73	34.17	35.39
PL-7	0.46	0.57	0.73	0.59	1.04	0.99	0.99	1.00	28.59	34.36	33.47	32.14
Mean	0.51	0.61	0.67		1.05	0.98	1.01		29.55	33.34	33.40	

Table 4. Variation in leaf are, angle between midrib and second lateral vein and plant height of poplar clones

Name of Clones	Leaf area (cm^2)				Angle between midrib and second lateral vein (^{0})				Plant height (m)			
	DhaulaKuan	Ludhiana	Nauni	Mean	DhaulaKuan	Ludhiana	Nauni	Mean	DhualaKuan	Ludhiana	Nauni	Mean
L-30 / 06	281.44	324.68	277.04	294.39	66.72	62.99	62.47	64.06	4.22	4.46	3.65	4.11
L-62/ 84	206.00	370.97	297.26	291.41	69.27	69.04	61.83	66.71	3.21	4.70	3.13	3.68
G-48	209.31	397.11	357.94	321.45	73.20	71.56	68.83	71.20	3.21	4.18	3.51	3.63
L-61/05	145.32	272.93	297.34	238.53	78.56	78.33	71.77	76.22	2.71	4.56	3.81	3.69
S_7C_{15}	156.83	271.55	269.30	232.56	72.75	75.56	76.80	75.04	3.47	4.93	3.75	4.05
S_7C_8	202.48	330.53	253.74	262.25	72.31	70.28	70.95	71.18	3.57	4.68	2.88	3.71
WSL-22	162.27	233.92	240.86	212.35	75.36	75.59	82.93	77.96	3.94	4.76	3.97	4.22
WSL-39	133.19	252.08	257.98	214.42	75.01	78.33	85.07	79.47	2.39	4.11	2.85	3.11
6503	135.87	239.49	228.92	201.43	70.36	66.81	71.53	69.57	3.55	4.55	4.03	4.04
5503	148.02	218.95	239.68	202.21	76.00	76.45	77.84	76.76	3.11	4.26	3.91	3.76
1007	166.82	234.58	266.47	222.62	72.85	71.04	70.24	71.38	3.50	4.81	3.61	3.97
L-200/86	171.96	345.24	289.05	268.75	73.21	73.39	63.32	69.97	3.86	4.71	3.81	4.13
PL-3	320.45	289.73	329.34	313.17	75.32	75.09	75.09	75.17	3.52	4.21	3.72	3.82
PL-6	233.47	339.07	287.60	286.72	76.15	76.91	75.63	76.23	3.61	4.22	3.55	3.79
PL-7	171.51	318.74	301.03	263.76	76.85	79.55	80.15	78.85	3.57	4.38	3.72	3.89
Mean	295.97	279.57	255.07		73.59	73.40	72.96		3.43	4.50	3.59	

Table 5. Variation in apical angle, basal diameter and stem volume of poplar clones

Name of Clones	Apical angle (^{0})				Basal diameter (mm)				Stem volume (m^3)			
	DhaulaKuan	Ludhiana	Nauni	Mean	DhualaKuan	Ludhiana	Nauni	Mean	DhualaKuan	Ludhiana	Nauni	Mean
L-30 / 06	38.51	71.15	61.89	57.18	30.07	31.10	25.26	28.81	0.0030	0.0034	0.0019	0.0028
L-62/ 84	39.79	76.27	68.77	61.61	21.64	31.45	21.14	24.75	0.0012	0.0038	0.0012	0.0021
G-48	37.76	61.80	68.24	55.93	24.06	27.27	25.34	25.56	0.0015	0.0025	0.0018	0.0019
L-61/05	53.89	69.44	56.13	59.82	18.22	30.07	24.18	24.15	0.0007	0.0033	0.0018	0.0019
S_7C_{15}	57.13	71.87	73.28	67.43	26.31	33.32	23.24	27.62	0.0021	0.0043	0.0017	0.0027
S_7C_8	50.00	88.69	59.04	65.91	25.18	31.04	20.16	25.46	0.0018	0.0036	0.0009	0.0021
WSL-22	47.93	67.79	53.23	56.32	30.39	30.78	24.15	28.44	0.0031	0.0036	0.0019	0.0029
WSL-39	51.13	76.37	65.41	64.31	17.11	28.58	18.50	21.40	0.0006	0.0028	0.0008	0.0014
6503	46.11	74.95	61.61	60.89	27.24	32.86	25.27	28.46	0.0023	0.0039	0.0020	0.0027
5503	57.19	84.44	63.95	68.52	24.70	30.26	24.38	26.44	0.0015	0.0032	0.0018	0.0022
1007	32.48	70.19	59.40	54.02	24.07	33.16	24.30	27.18	0.0016	0.0042	0.0017	0.0025
L-200/86	47.71	66.68	60.28	58.22	31.72	32.94	29.33	31.33	0.0035	0.0040	0.0027	0.0034
PL-3	33.32	73.75	65.00	57.36	25.37	28.08	25.80	26.42	0.0018	0.0027	0.0020	0.0021
PL-6	40.60	79.15	65.64	61.80	27.80	28.37	22.98	26.39	0.0022	0.0027	0.0015	0.0021
PL-7	38.39	79.19	61.49	59.69	26.74	31.11	23.57	27.14	0.0022	0.0033	0.0017	0.0024
Mean	44.80	74.11	62.89		25.37	30.69	23.84		0.0019	0.0034	0.0017	

4. CONCLUSION

The influence of the different site environment shows positive and significant variation in 15 clones of poplar (*Populus deltoides*). The clones react specifically at different site for quantitative characters. There is significant variations at all three sites, amongst these Ludhiana recorded higher values in quantitative trait's whereas Nauni had lower values in all traits. Dhaula Kuan site had comparatively average variation among all clones.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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