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ASSESSMENT OF PHENOTYPIC VARIABILITY AND NUTRIENT COMPOSITION OF *POPULUS DELTOIDES* CLONES IN PRAYAGRAJ, INDIA

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ABSTRACT

A field experiment was conducted during April-June of 2022 at the central nursery of the ICFRE-Eco-rehabilitation Centre (formerly, FRCER), Prayagraj. Phenotypic and nutrient analysis among the various clones of Populus deltoids were conducted. The total number of 17 clones of *Populus deltoides* were undertaken in study *viz.* AM 41, FS 57, L-30-82, AM-58, AM 59, FS 16, FS 32, L 89, G 48, FS 47, VHF12, FS 175, AM 44, AM 32, L-200-84, AM 12 and FS 31. Different phenotypic characteristics viz., plant height, number of branches, collar diameter of Poplar clones was observed at 30, 60 and 90 DAT. The data of phenotypic characteristics showed that the clone L-200-84, outperformed other clones in terms of plant height (cm), clone FS 31 was found maximum in number of branches (15.39), collar diameter (15.59 mm). Out of the 17 clones, 10 clones with better phenotypic performance were selected and their leaves were analysed for various nutrients. The assessment of data revealed that the highest nutrient content in terms of dry matter accumulation, crude protein content, ether extract, crude fibre and ash content were also highest in FS 31 (55.76 g, 11.87%, 4.68, 42.56% and 8.13 % respectively). Concurrently, the results demonstrated notable differences among the clones and underscored the significant role of soil properties in influencing clone performance. This study provides crucial insights for selecting optimal clones and optimizing soil conditions to improve productivity in agroforestry systems.

Keywords: *Populus deltoides*, phenotypic variability, nutrient composition, growth performance and nutrient uptake.

Introduction

Populus deltoides is a fast-growing tree with short rotation intervals and high harvest rates are widely recognized as a rapidly expanding trend globally (Sardón, 2012; Dhillon and Sandhu, 2020). The high market demand for its products is evident from the presence of almost 1,200 diverse industrial units in regions such as Punjab, Haryana, Delhi, Uttarakhand and Uttar Pradesh (Chauhan *et al*., 2012). Farmers favour this tree due to its rapid growth rate, ease of harvest, beneficial interactions with crops, high yield, lucrative returns and upfront marketing (Tomar *et al.,* 2024). The deciduous characteristic and upright, unblemished trunk also allow for the growth of many seasonal and yearly crops. Poplar, a versatile tree species, is highly desired by global businesses for its use in paper/pulp, plywood and matchwood production (Pandey *et al.,* 2020).

The enormous range of clone x environment interaction and stability of Populus in research is influenced by the diversity of the and the composition and magnitude of the clonal populations (Pliura *et al.,* 2007). "Poplar has specific photoperiodic and temperature requirements, limiting its plantation zone in India to areas north of 28°N latitude. It has shown growth potential in Uttar Pradesh (terai region), Uttarakhand, Punjab, Haryana and Himachal Pradesh and has now successfully established in the eastern parts of Uttar Pradesh." Poplar species and their hybrids are at the forefront of short-rotation forestry because of their rapid initial growth rates, broad distribution, substantial genetic variety, ease of

hybridization and high biomass output (Guo & Zhang, 2010). *Populus deltoides* is essential in riparian environments, serving as a habitat and food source for several animal species. According to by Temel and Pehluvan, (2015), The nutritional composition of leaves from shrubs and trees varies according to the season, phenological phase and species. Shrub and tree species provide livestock with food resources that have high nutritional, energy, vitamin and mineral contents. This is because these species retain their quality for a longer time compared to herbaceous species. (Gupta *et al.,* 2016). Earlier studies have shown that the foliage of poplar trees has significant nutritional content and may be used as feed for animals.

Incorporating the cultivation of desirable trees for livestock feed should be included as a component of a farm practice to withstand drought conditions. During a drought, the only vegetation that remains green on dry farms is usually limited to trees, especially poplar. Certain farmers are using this resource as a feed source for livestock, but other farmers are disregarding this fodder supply on their farms. Poplars can be adopted for fodder to fulfil a function in soil conservation and enhancement of water quality. Strategically positioning more trees on the property will enhance its diversification. Poplar trees have remarkable resilience and show a favourable response to pruning. They may serve as reliable sources of stock feed, since older trees can survive pollarding. Hence, this research was carried out to evaluate the growth performance of different poplar clones and the nutrient status of poplar leaves to identify the most suitable poplar clone for the region.

Material and Methods

The study was conducted at the ICFRE- Eco-Rehabilitation Centre in Prayagraj, Uttar Pradesh, India, in February, 2022. Poplar experiment was established in the year February 2018 at Prayagraj, Uttar Pradesh. The longitude (25.54°N) and latitude (81.89°E) of plantation site. The experiment was laid out in randomized block design with 17 treatments and three replications. The experimental location lies in agro-climatic zone V, which is known for its humid subtropical climate including hot summers, mild winters and moderate monsoons. The soil has excellent drainage, is composed of alluvium and has a low level of fertility. The study included the cultivation of three-year-old *Populus deltoides* clones in February 2022, with a planting layout of 60 × 60 cm. Analytical tests were conducted on soil samples collected from depths of 0-15 cm and 15-30 cm to determine levels of organic carbon, accessible nitrogen, phosphorus, potassium, pH and electrical conductivity. The field experiment was carried out between April and June 2022, when 17 clones were chosen at random for in-depth analysis. Data was collected at 30-day intervals, specifically measuring plant height, branch count and collar diameter. *Details of Poplar Clones*-Total number of 17 clones of *Populus deltoides* were studied *viz.* AM 41, FS 57, L-30-82, AM-58, AM 59, FS 16, FS 32, L 89, G 48, FS 47, VHF12, FS 175, AM 44, AM 32, L-200-84, AM 12 and FS 31. Out of 17 clones of *Populus deltoides* 10 superior clones were selected on the basis of best performing clones for Proximate nutrient content analysis includes dry matter, ash, crude fat, crude protein, ether which are essential in determining the quality of the fodder.

Table 1: Chemical analysis of soil of the experimental field.

Particulars		Value		Method employed
		0-15 cm	15-30 cm	
Chemical properties				
a)	Organic carbon (%)	0.24	0.14	Rapid titration method (Piper, 1966)
b)	Available nitrogen (kg ha^{-1})	152.90	119.7	Modified Alkaline Permanganate Method (Subbiah and Asija, 1956)
c)	Available phosphorus (kg ha^{-1})	24.35	49.15	0.5*M* $NaOH_3$ extractable (Olsen *et al.,* 1954)
d)	Available potassium (kg ha^{-1})	87.50	65.60	1*N* Neutral Ammonium Acetate Method (Jackson,1973)
e)	Soil pH (1:2.5 soil and water suspension)	8.20	8.30	Glass electrode digital PH meter (Jackson, 1973)
f)	EC (dS m^{-1} at 25℃)	0.145	0.123	Electrical conductivity meter (Jackson, 1973)

Result and Discussion

The study on the growth performance of different *Populus deltoides* clones under the nursery conditions in Prayagraj was assessed for various phenotypic traits at the interval of 30, 60 and 90 days. The plant height of the clones significantly grew as the time length increased, as shown in Table 2 and illustrated in Fig. 1. Throughout each period, the clone with the greatest height was F-31, while the clone with the minimum height was FS 47. The F-31achieved a maximum height of 152.1 cm after 90 days. Nevertheless, even after 90 days, FS 47 remained the shortest, measuring 44.40 cm. In a similar study, Ghasemi *et al.* (2009) found that the maximum height increases in 10 days occurred from June 20 to June 30, with a 19-cm increase in height, while the lowest increases were observed at the end of September and October. According to Sagwal (1991), clone 'G-3' reached its highest height (3.02 m in one year), followed by 'A (74) 1016' (3.00 m). Data pertaining to number of branches indicated in Table 2 and illustrated in Fig. 1 showed significant growth in few clones of Populus deltoids. Each clone experienced growth in terms of number of branches at successive observation intervals. FS 31 had the highest number of branches throughout the intervals of observation with 7.1 (at 30 DAT), 11.13 (at 60 DAT) and 15.39 (at 90 DAT), while many clones, such as, AM 41, FS 57, L-30-82, AM-58, AM 59, FS 16, FS 47, VHF 12, FS 175 and AM 12 persistently retained zero number of branches. Similar finding was found in Saini *et al.* (2002).

Table 2: Growth performance of *Populus deltoides*.

Clones	Plant height			No. of branches			Collar diameter		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
AM 41	62.20	65.70	71.70	0.00	0.00	0.00	6.43	6.76	7.13
FS 57	69.10	71.25	73.65	0.00	0.00	0.00	9.39	9.45	9.53
L-30-82	88.00	90.85	93.50	0.00	0.00	0.00	8.89	8.64	8.25
AM-58	55.40	58.20	61.10	0.00	0.00	0.00	5.68	5.77	5.89
AM 59	68.50	70.60	72.70	0.00	0.00	0.00	6.34	6.26	6.32
FS 16	98.90	102.50	106.20	0.00	0.00	0.00	8.66	8.75	8.86
FS 32	125.00	128.90	132.80	3.70	4.10	4.70	10.67	10.74	10.81
L 89	111.50	115.60	118.00	3.60	4.00	4.30	10.44	10.58	10.75
G 48	123.30	127.20	130.40	3.90	4.30	4.80	10.57	10.74	10.80
FS 47	37.60	41.40	44.40	0.00	0.00	0.00	3.75	3.85	3.92
VHF12	44.80	48.20	51.30	0.00	0.00	0.00	4.13	4.05	4.26
FS 175	45.80	48.60	52.10	0.00	0.00	0.00	5.32	5.45	5.48
AM 44	66.50	70.50	73.80	1.90	1.90	2.10	6.85	7.09	4.15
AM 32	87.80	90.10	93.70	0.67	1.00	1.30	7.87	7.84	8.40
L-200-84	134.00	140.30	146.60	1.10	1.40	1.70	11.62	11.70	11.83
AM 12	83.80	86.70	93.40	0.00	0.00	0.20	8.13	7.98	8.21
FS 31	124.10	143.50	152.10	7.10	11.13	15.39	12.61	15.40	15.59
SEm±	3.88	4.66	4.82	0.07	0.11	0.03	0.42	0.41	0.41
CD (P=0.05)	11.53	13.86	14.32	0.21	0.32	0.08	1.26	1.21	1.21

DAT=Days after transplantation*

The collar diameter measurements shown in Table 2 and illustrated in Fig. 1 & 2 exhibited significant variation across the clones. Throughout each observation period, a noticeable augmentation in the collar diameter was seen. Throughout all periods of observation, FS 31 exhibited a maximum collar diameter of 12.61, 15.40 and 15.59 at 30, 60 and 90 days after transplanting (DAT) respectively. However, the FS 47 clone consistently exhibited the smallest collar diameter at 30 days after treatment (DAT) with a measurement of 3.75, at 60 DAT with a measurement of 3.85 and at 90 DAT with a measurement of 3.92. Ghasemi *et al.* (2009) found that the time from the end of June to early July had the highest mean height growth of 3.5 mm and was also the optimum period for diameter growth in *P. deltoides* 63/8, with a mean increase of 3 mm. Ghasemi *et al.,* (2009) found that the optimal time for diameter development in *P. deltoides* was from the end of June to early July, with a mean height increase of 3.5 mm. They also observed a diameter growth of 3 mm in *P. deltoides* 63/8 during this period.

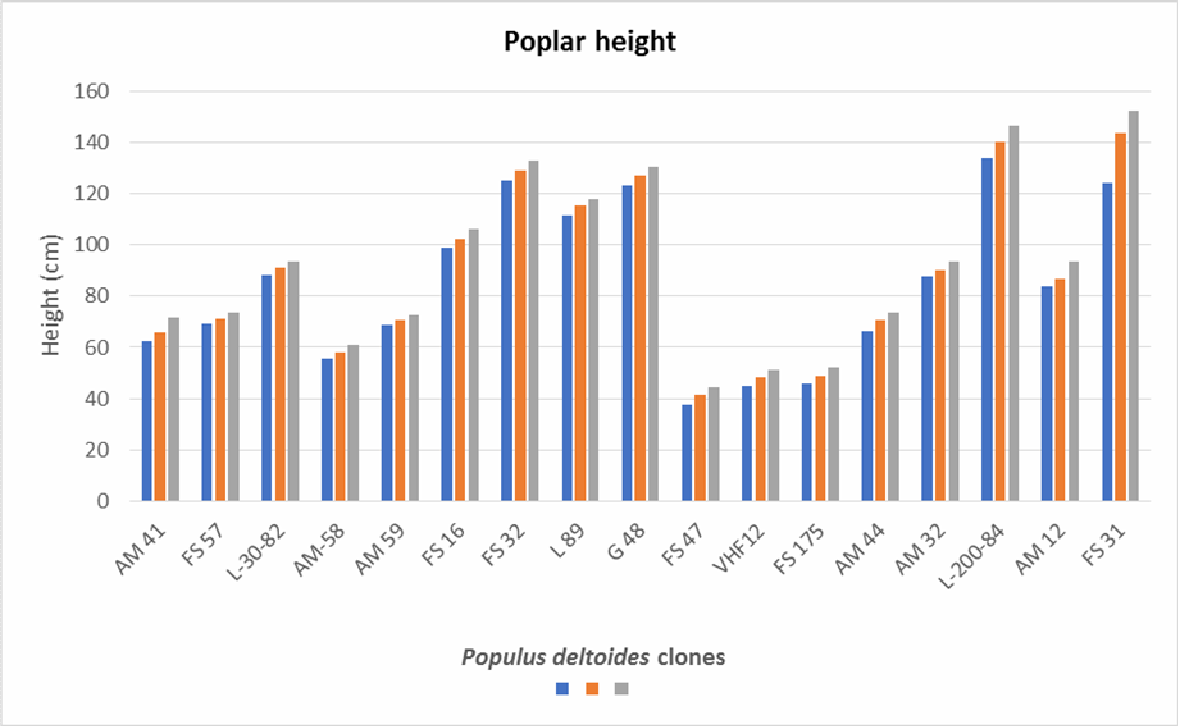

Fig. 1 : Height of *Populus deltoides* after 30th, 60th and 90th days

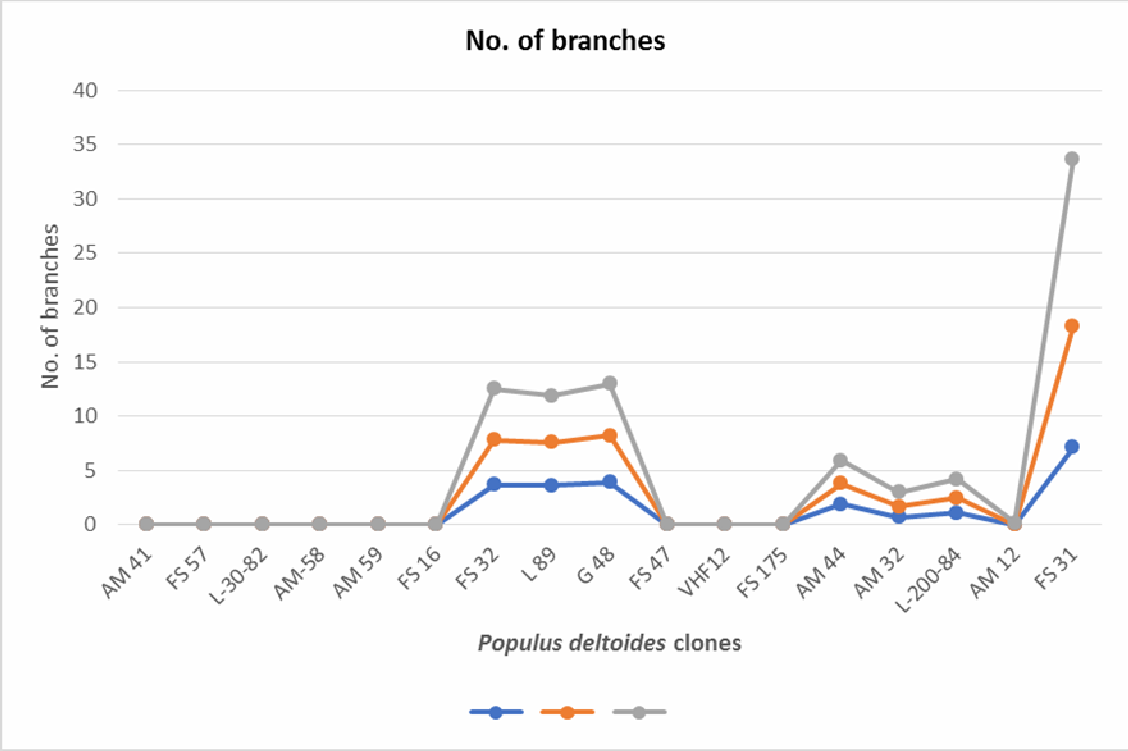

Fig. 2 : No. of branches of *Populus deltoides* after 30th, 60th and 90th days

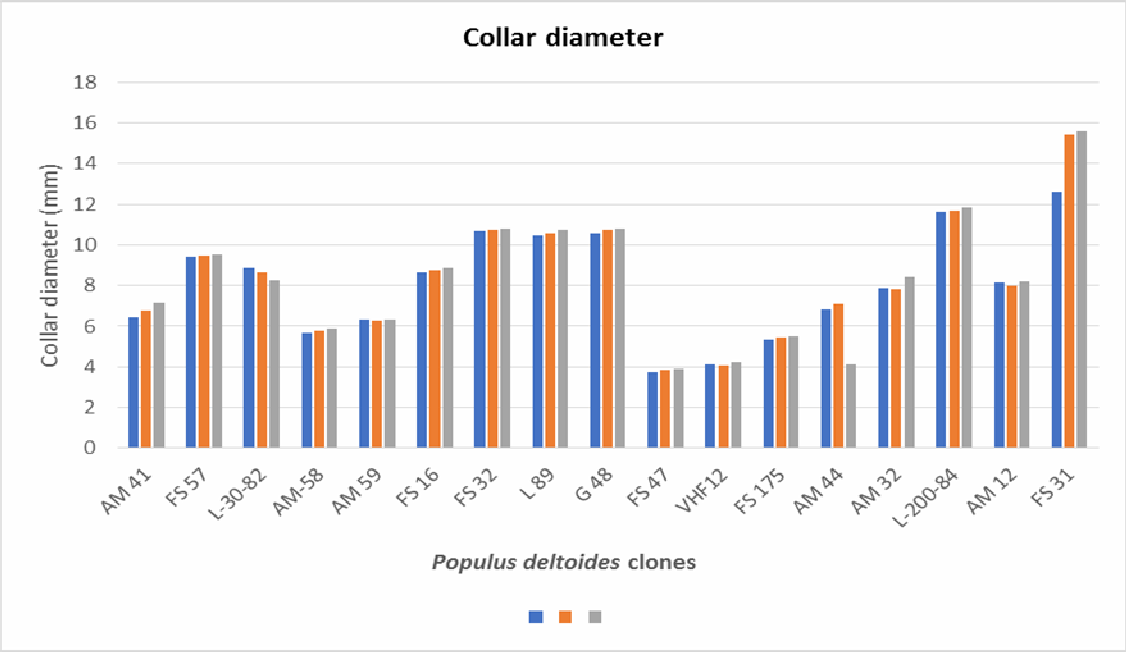

Fig. 3 : Collar diameter of *Populus deltoides* after 30th, 60th and 90th days

Nutritional composition of Poplar leaves

The nutritional composition of livestock feed is influenced by many critical factors, such as the quantity of nutrients that can be easily digested and the quantity of energy that can be readily accessed. The evaluation of quality of leaves comprises the analysis of proximate parameters in several green poplar clones. The results of this analysis is presented Table 3 and illustrated in Figures 2 and 3.

Table 3: Dry matter accumulation (g), Crude protein (%) and Ether extract (%) in leaves of *Populus deltoides* after 30th, 60th and 90th days

Clones	Dry matter accumulation (g)			Crude protein (%)			Ether extract (%)		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
AM 41	36.23	42.02	50.81	7.18	7.23	11.54	3.03	3.40	4.11
FS 57	36.33	43.58	51.10	7.28	7.60	11.56	3.10	3.49	4.15
L-30-82	37.10	45.57	52.59	7.46	7.67	11.57	3.12	3.54	4.19
AM-58	38.38	46.24	52.93	7.61	7.77	11.61	3.15	3.61	4.20
AM 59	38.73	47.68	53.10	7.64	7.86	11.63	3.23	3.65	4.22
FS 16	39.18	47.74	53.74	7.67	8.47	11.65	3.24	3.66	4.23
FS 32	39.69	48.23	54.03	7.79	8.62	11.67	3.29	3.67	4.25
L 89	40.40	48.69	54.29	7.82	8.98	11.68	3.41	3.71	4.41
G 48	40.59	49.21	54.44	8.33	9.31	11.74	3.44	3.76	4.46
FS 47	40.65	49.30	55.76	8.39	9.45	11.87	3.46	3.82	4.68
VHF12	0.59	0.67	0.87	0.12	0.11	0.20	0.05	0.05	0.04
FS 175	1.76	2.00	2.59	0.37	0.33	0.59	0.14	0.16	0.12
AM 44	2.64	2.49	2.83	2.79	2.29	2.93	2.59	2.49	1.67
AM 32	36.23	42.02	50.81	7.18	7.23	11.54	3.03	3.40	4.11
L-200-84	36.33	43.58	51.10	7.28	7.60	11.56	3.10	3.49	4.15
AM 12	37.10	45.57	52.59	7.46	7.67	11.57	3.12	3.54	4.19
FS 31	38.38	46.24	52.93	7.61	7.77	11.61	3.15	3.61	4.20
SEm±	38.73	47.68	53.10	7.64	7.86	11.63	3.23	3.65	4.22
CD (P=0.05)	39.18	47.74	53.74	7.67	8.47	11.65	3.24	3.66	4.23

Table 4: Crude fibre and Ash content in leaves of *Populus deltoides* after 30th, 60th and 90th days

Clones	Crude fibre (%)			Ash content (%)		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
AM 32	36.20	39.19	42.07	5.21	5.96	6.71
AM 12	36.24	39.36	42.09	5.34	6.02	6.90
FS 16	36.31	39.48	42.12	5.44	6.05	7.06
L-30-82	37.02	39.62	42.13	5.48	6.13	7.21
FS 57	37.04	39.91	42.15	5.52	6.14	7.27
L 89	37.33	40.86	42.18	5.61	6.27	7.34
G 48	38.24	40.94	42.19	5.66	6.34	7.44
FS 32	38.29	41.01	42.22	5.67	6.49	7.56
L-200-84	38.46	41.02	42.24	5.70	6.58	7.97
FS 31	38.81	41.44	42.56	5.75	6.62	8.13
SEm±	0.51	0.65	0.67	0.07	0.09	0.10
CD (P=0.05)	1.51	1.92	1.99	0.21	0.26	0.29

DAT*=Days after transplantation

The collected data suggested dry matter accumulation indicating the biomass produced by each clone. Observations for dry matter accumulation at 30, 60 and 90 DAT revealed that FS 31 had significantly higher dry matter accumulation at 40.65 g, 49.30 g and 55.76g respectively. The lowest accumulation of dry matter was observed in AM 32. Crude protein content is an indicator of nutritional value. The data pertaining to crude protein is depicted in Table 2. Analysis of crude protein was carried out during the interval of 30, 60 and 90 DAT. FS 21 possessing significantly the highest percentage of crude protein was noticed during all the intervals of observation. The minimum value of crude protein was observed in the clone AM 32 with 7.18% at 30 DAT, 7.23% at 60 DAT and 11.54% at 90 DAT. Ether extract content indicating fat content, shown in Table 3 revealed that FS 31 had the highest ether extract &content while the clone AM 32 had a significantly lower amount of ether extract during all intervals i.e., 30, 60 and 90 DAT. The data revealed crude fibre content which is an indicator of dietary fiber. FS 31 was observed to be significantly superior than all the other clones in terms of crude fiber at 30 DAT (38.81 %), 60 DAT (49.30 %) and 90 DAT (55.76 %). While AM 32 showed the lowest content of crude fibre at 30, 60 and 90 DAT (36.20, 39.19 and 42.07 % respectively). Ash content, indicating mineral content, found maximum in FS 31, while minimum in AM 32 at each interval of observation. These results are in agreement with Shavo (1997), Subba (1998), Näsi and Pohjonen (1981), Sinha *et al.,* 1989 and Azim *et al.,* 2002).

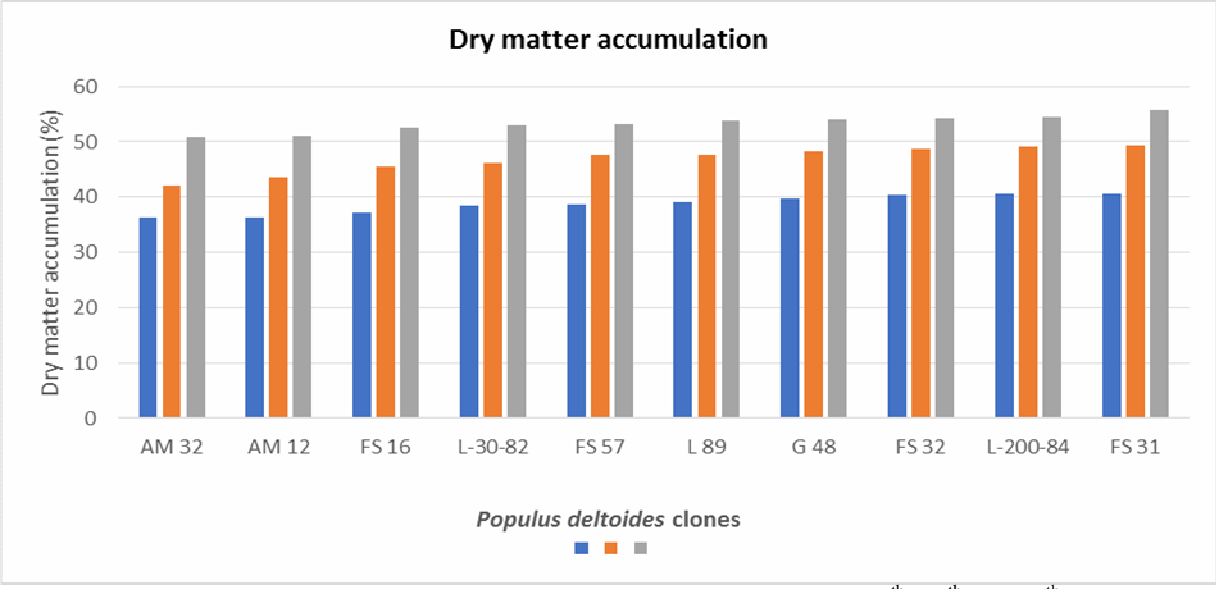

Fig. 4 : Dry matter accumulation in *Populus deltoides* leaves after 30th, 60th and 90th days

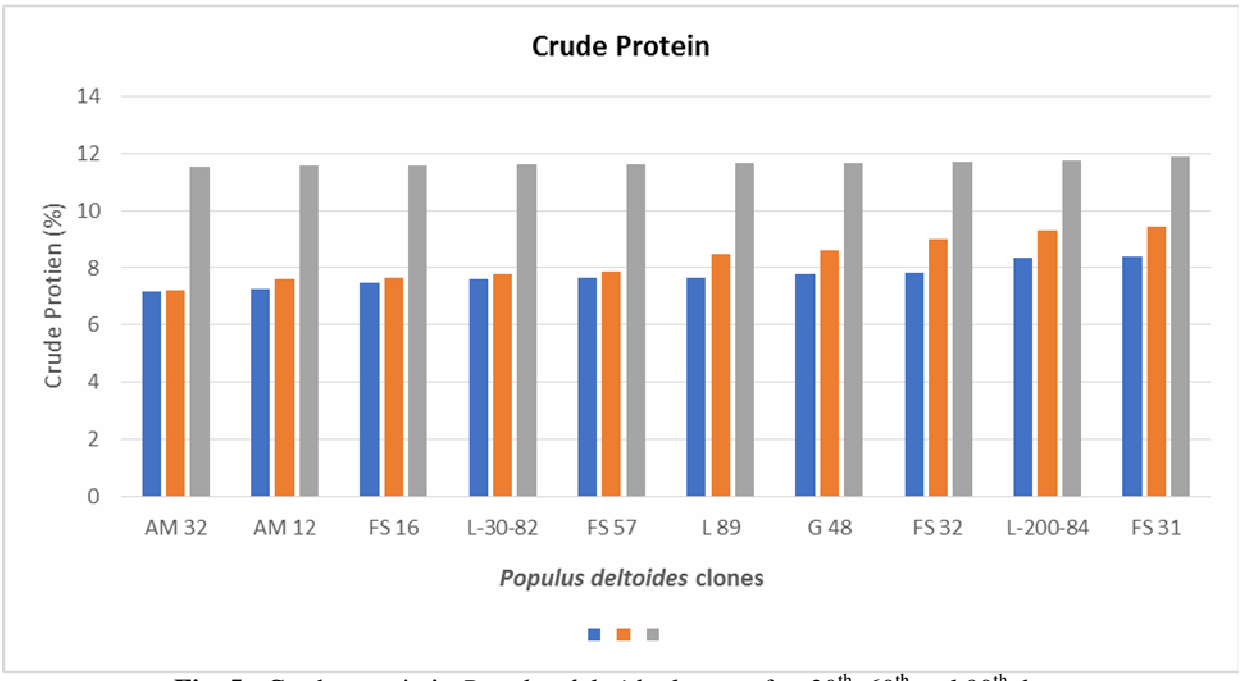

Fig. 5 : Crude protein in *Populus deltoides* leaves after 30th, 60th and 90th days

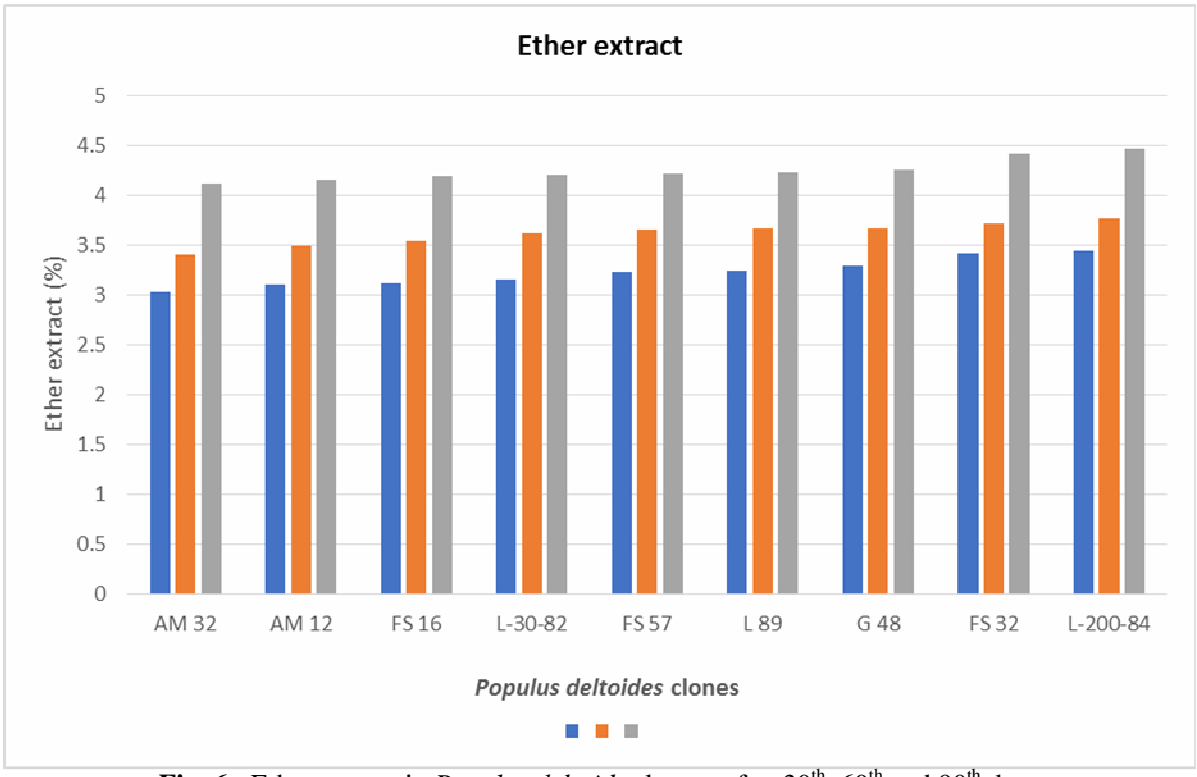

Fig. 6 : Ether extract in *Populus deltoides* leaves after 30th, 60th and 90th days

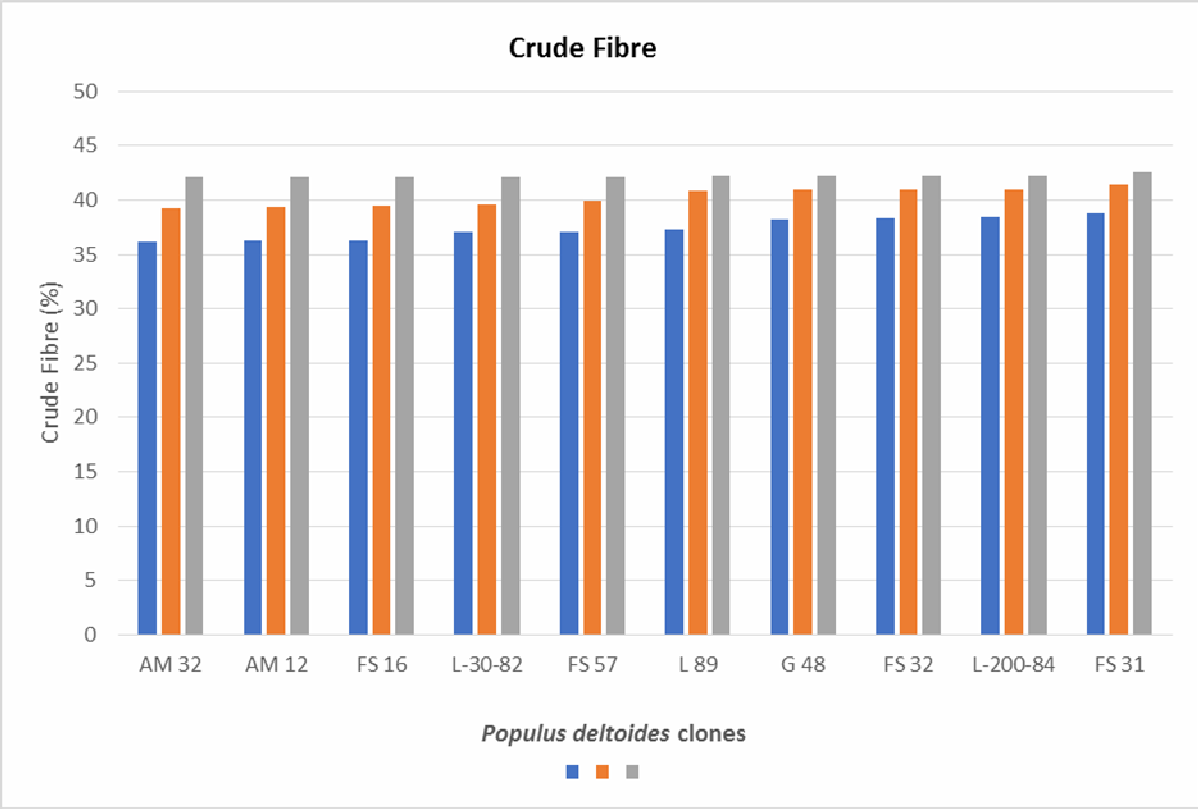

Fig. 7 : Crude Fibre in *Populus deltoides* leaves after 30th, 60th and 90th days

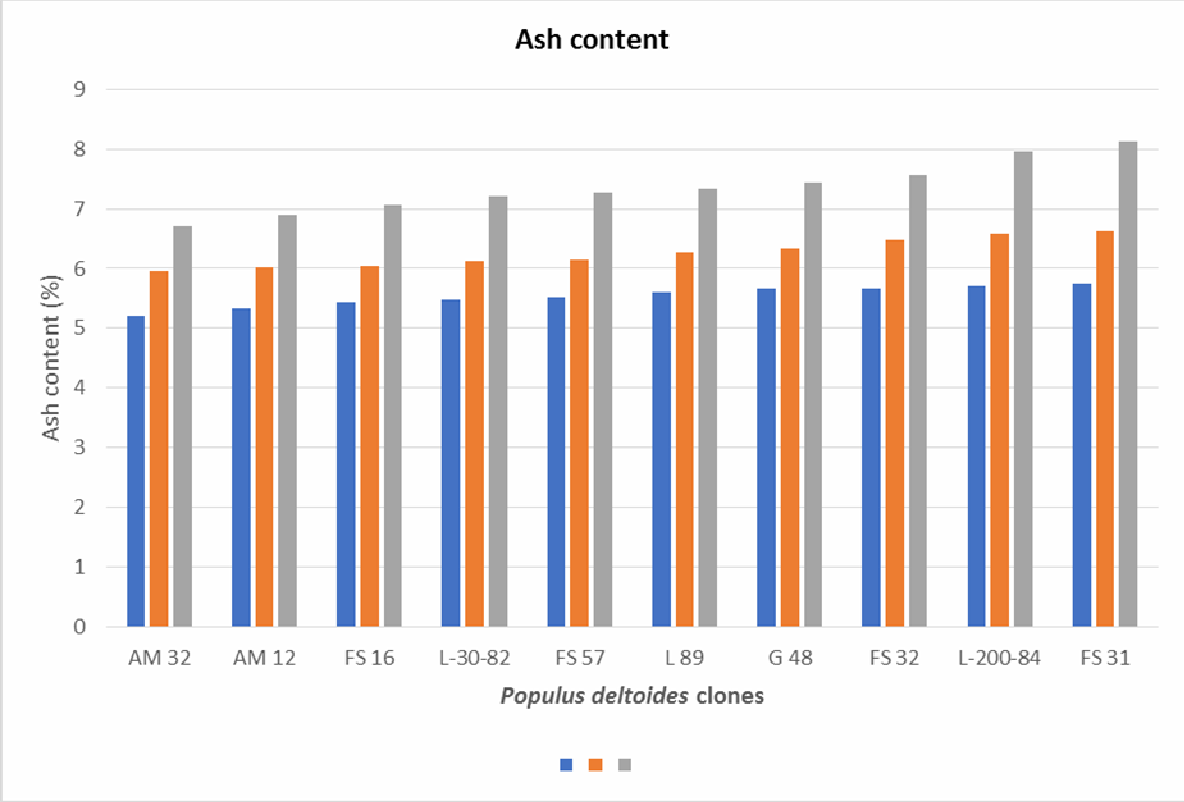

Fig. 6 : Ash content in *Populus deltoides* leaves after 30th, 60th and 90th days

Conclusion

The study on the growth performance of *Populus deltoides* clones at Prayagraj reveals significant variations in growth metrics among different clones. Clones such as L-200-84 and FS 31 demonstrated superior in terms of growth, making them highly suitable for cultivation in the observed nursery conditions. The leaf nutrient assessment will help to improve the quality of feed animals the availability of appropriate planting material for Poplar will be a benefit to local farmers, as it will help to strengthen their economic status through agroforestry and improve the feed of livestock. The careful selection of high-performing clones is crucial for achieving optimum development and suitability of *Populus deltoides* in the Prayagraj region. new opportunity to expand the use of this species in agroforestry. Overall, FS 31 consistently outperformed other clones across most parameters at all the time intervals, indicating its superior adaptability, growth performance and nutritional value when supplemented with concentrate feed at 50% level in total mixed rations helped to achieve moderate intake and normal digestibility under the given conditions.

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