

Assessment of Three Fast Growing Populus Deltoides Species in Various Soil Profiles Under Nursery Conditions

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Abstract

Populus plants are fast-growing plants that exhibit strong adaptability and a short rotation period. Poplar enhanced the carbon stock, which ultimately helps in combating climate change and sustaining livelihoods. Pakistan has a shortage of firewood and timber. Thus, hybrid fast-growing plants are the only way to balance wood demand and supply in the country. Therefore, the objective of the present study was to evaluate and compare the growth patterns and carbon stocks of three *Populus deltoides* varieties in three soil media under nursery conditions. To achieve the study goals, three fast-growing hybrid species of *Populus deltoides*, Italian *Populus* (euramerciana), clone A-Y48, and local *Populus* were used. Three healthy plants of mothers aged one to two years were selected from the field area of the Rangeland Research Institute (RRI), NARC. The cuttings were planted in 90 pots after being filled with three different media, and plant growth was recorded after seven days for the number of leaves, height, diameter, and number of irrigations applied to each pot. Three-month data were collected and analyzed by using an RCBD design. After the trial, all the plants were exhausted, and soil samples were taken from the pots and brought to the RRI laboratory for the estimation of total biomass and carbon stocks. It was concluded that Clone AY-48 achieved the highest height among all the *Populus deltoides* varieties and stored more carbon stock in comparison to Italian and local poplar varieties. Farmyard manure had a positive influence on the height of the different *Populus deltoides* varieties. Clone AY-48 and Italian poplar plants are more suitable for rapid growth.

HIGHLIGHTS

- Three fast-growing hybrid species of *Populus deltoides*, the Italian *Populus* (euramerciana), clone A-Y 48, and local *Populus* were selected for research.
- Three healthy mother plants one-year-old were selected and made soft cutting.
- Clone AY-48 achieved the highest height gained among others and had more carbon stock in comparison to Italian and Local poplar.
- Farmyard manure had a positive and significant influence on the height of different *Populus deltoides* AY-48.
- Clone AY-48 and Italian poplar are more suitable for fast growth.

INTRODUCTION

There is a severe lack of firewood and timber in Pakistan. The domestic supply of wood is currently far insufficient compared to the overall demand. According to reports, there was a total demand for wood in 2009 of 43.7 million m³, of which 12 million m³ was used for fuel and 32 million m³ was used for timber. Only 14.4 million m³ of sustainable provisions (annual growth rate) were available. As a result, there was a 29.3 m³ gap between the supply and demand for wood. This was frequently met by transporting wood and timber products as well as overusing the already existing wood (FAO, 2009). It is predicted that by the year 2020, there will likely be a significant gap between the supply and demand for wood (PES, 2011).

For a population of 170.5 million, the current calculated total annual wood consumption is 48.52 m³. With an increasing population, there will be an increase in wood use by 2015, 2020, and 2025, and the predicted wood utilization is predicted to reach 51.72, 55.64, and 59.44 million m³, respectively (Nazir et al., 2018). Major forest products such as firewood and timber are consumed at rates that significantly reduce Pakistan's wood supply and forestland. Due to the country's rising energy demand and growing population, people are consuming more of these two key products, and there are unlikely to be any replacements for wood shortly. To increase the contribution of biomass to renewable energy, the cultivation of fast-growing tree species has increased. In 2018, these plantations made up 2.5% of the world's total forest region (Cateau et al., 2018). Agroforestry systems based on poplars (*Populus deltoides*), which occupy 1.5 million ha, have gained widespread popularity throughout the world (Kutsokon et al., 2015). By planting poplar trees on marginal agricultural fields, the area is expected to multiply several times soon, meeting the fuel and timber requirements of developing nations (Kumar et al., 2023). While offering benefits for forests, it could minimize land use competition for biomass and food production (Pretzsch et al., 2017). The production of fast-growing tree biomass switches nonrenewable carbon resources and supports carbon absorption as well as other ecosystem amenities, including improving the value of soil and decreasing water erosion and improving biodiversity (Evangelou et al., 2012). Due to their numerous advantages, such as rapid growth, rapid harvesting, high productivity, and sustainable wood output, many fast-growing tree species have been planted in industrial plantations and community forestry (Adi et al., 2014).

In Pakistan, the exotic poplar (*Populus deltoides*) tree was first introduced in the late 1950s (Sheikh 1988). A significant tree species called *Populus deltoides* is extensively applied for afforestation worldwide (Borges et al., 2016). Poplar has gained widespread acceptability among Pakistani farmers over the past 20 years, particularly in Punjab, because of its quick growth rate, crop compatibility, and strong marketing demand. The local population uses the branches, leaves, and, occasionally, the roots of the tree as fuelwood, while the country's plywood manufacturers use the tree's wood. The rapid growth pattern and wide range of adaptability of these trees across the country give them a tremendous amount of potential to store carbon and sequester CO₂ (Arora et al., 2014). Due to its many applications, market potential, and rapid rate of growth, it has become quite popular as a commercial timber tree. The majority of poplar trees used in industry are grown on farms, and only a very minor amount (approximately 0.029 million m³) comes from state-run irrigated plantations in Punjab (PES, 2011). The poplar-based agroforestry land use strategy has not only considerably increased the number of trees outside of natural forests but also shown potential for socioeconomic growth, ecological restoration, and agricultural diversification (Pretzsch et al., 2017). The creation of poplar woodlots, the growth of wood-based industries, the creation of jobs, and the collection of tax income for the government have had multiplier effects on the economies of rural areas (Dhiman et al., 2012). *Populus* has long been regarded as a major contender for bioenergy. The genus has a significant history of study on tree improvement, and vegetative propagation is rather simple. This permits the establishment of clonal *Populus* plantations suited for particular traits (Kline and Coleman, 2010). *Populus* species can maintain growth

and turgor under minor to modest stress by reducing osmotic pressure through osmotic modification, the energetic gathering of solutes during stress, and other methods (Tschaplinski. Et al.,2019)

MATERIALS AND METHODS

Experimental Site

The pot experiment was conducted at the greenhouse of the Rangeland Research Institute, National Agricultural Research Centre (NARC) Islamabad, Pakistan, in 2023. The site is located at 33°43'N and 73°04'E at an altitude of 540 m above sea level on the Potohar Plateau in the northeastern region of the country. The experimental site has a humid subtropical climate with a mean annual rainfall of 790 mm.

Experimental treatments

This experiment was conducted in pots. Three different soil composites for pots were prepared as per the general recommendation of balanced fertile soil. The selected tree species for this study were three varieties of *Populus deltoides*: local poplar, Italian poplar and clone AY48. Twenty-seven plants of each species were transplanted into different soil compositions, which were divided into three sets. Thus, a total of 81 plants were transplanted in this study. The objective of this study was to assess the growth and biomass of three fast-growing hybrid species of *Populus deltoides* under various soil profiles to overcome the imbalance of wood demand and supply in the country due to their short rotation and fast-growing nature. To achieve the study objectives, three fast-growing hybrid species of *Populus deltoides*, Italian *Populus* (euramerciana), clone A-Y48, and local *Populus* were used. Three healthy plants of mothers aged one to two years were selected from the field area of the Rangeland Research Institute (RRI), NARC. Thirty cuttings were taken from each healthy maternal plant. The average length of the cuttings was 8–9 inches. These cuttings were put into bags to maintain their moisture content and transported to the nursery site for further planting into the pots. The cuttings were planted in 90 pots and arranged into the nursery bed. These pots were filled with three different media. The three media used were compost, vermicompost, and farmyard manure (FYM). These media were taken at three different ratios (30–70, 40–60, and 50–50). All the soil media were examined for pH, EC, bulk density, and N, P, and K. These cuttings were horizontally planted into the pots at 80–85°C.

Data collection

The growth data were recorded daily until they emerged. Then, plant growth was recorded after seven days for no leaves, height, diameter, or no irrigation frequency in each pot under the nursery conditions. Three-month data were collected from the pothouses. All the data were recorded on an analysis sheet and used in the RCBD design. At the end of the experiment, entire plants were examined, and soil samples were taken from the pots and subsequently transported to the laboratory of the RRI. The total biomass and total carbon stock were estimated. A factor of 0.50 was multiplied by the biomass to obtain the total carbon stock. These results were evaluated with statistical tools to determine the results and to support our objective.

Table 1 Study design and details of manure treatment at different ratios and replicates in this study

Study Design for three different plant varieties one			
Plant varieties	Ratio₁ 30:70	Ratio₂ 40:60	Ratio₃ 50:50
	Replications	Replications	Replications
V₁	r ₁ r ₂ r ₃	r ₁ r ₂ r ₃	r ₁ r ₂ r ₃
V₂	r ₁ r ₂ r ₃	r ₁ r ₂ r ₃	r ₁ r ₂ r ₃
V₃	r ₁ r ₂ r ₃	r ₁ r ₂ r ₃	r ₁ r ₂ r ₃

Statistical analysis

The data collected on various parameters were subjected to statistical analysis via analysis of variance (ANOVA) under a completely randomized design. Means were compared by using the least significant difference (LSD) test.

Results and discussion

This chapter describes the results of the study in detail. The data collected from the field were analyzed and are presented in the form of tables. The main aim of the study was to examine the growth, height, and above- and belowground biomass of three different varieties (local poplar, Italian poplar, and clone ay48) of *Populus deltoides*. The impacts of various soil manures (compost, vermicompost, farmyard manure) and their ratios (r₁, 30:70; r₂, 40:60; and r₃, 50:50) on *Populus deltoides* varieties and the physiochemical health of the soil were also studied. The analysis and interpretations of the findings are discussed.

4.1 Growth parameters

4.1.1 Plant Height

The application of manures at different ratios significantly affected plant height. The data presented in Table 4.1 show the results obtained after one complete growing season. There was a significant ($P \leq 0.05$) difference in plant height among the soil manures. The maximum mean height was obtained at the FYM farm (33.16 cm), followed by the VC farm (28.75 cm), whereas the minimum mean height was obtained at the compost farm (26.23 cm). The influence of soil manure on the height of the different *Populus deltoides* varieties is shown in Table 4.2. There was a significant ($P \leq 0.05$) difference in the height of all the *Populus deltoides* varieties. The maximum mean height was recorded for AY48 (35.56 cm), followed by Italian (33.30 cm), whereas the minimum mean height was recorded for local poplar (19.28 cm). The effect of the manure ratio on the height of the different *Populus deltoides* varieties is shown in Table 4.3. The plant height in R₁ was significantly ($P \leq 0.05$) different from that in R₂ and R₃. R₃. The maximum mean height was obtained in R₁ (31.85 cm), whereas the minimum mean height was

obtained in R₂ (28.07 cm) and R₃ (28.22 cm). Among the interactions between soil manure, plant variety, and soil ratio, the significant maximum mean in the entire bar series was followed by later scripts for smaller means. Digits carrying the same scripts **were considered to be significantly different ($P \leq 0.05$)**. Kumar et al. (Kumar et al., 2023) studied different plant varieties in the FYM and canal silt and recorded the highest plant height in the FYM. The results of this experiment are in agreement with those of the present study.

Another scholar experimented on ten cuttings of poplar clones for various parameters and observed a greater DBH and height in the poplar clone AY48 than in other clones, which matches the findings of the present study by Yeo Jin-gi et al. (2007).

Table 4.1
Effect of different manures on plant height (cm).

Manures	Soil: Manure Ratios			Mean
	R ₁	R ₂	R ₃	
Compost	34.23a	19.06c	25.40b	26.23C
FYM	34.63a	33.14a	31.72a	33.16A
VC	26.69b	32.01a	27.54b	28.75B
Mean	31.85A	28.07B	28.22B	

At the 0.05 probability level, means denoted by different letters vary significantly.

LSD Value (0.05) for Manures = 1.9274

LSD value (0.05) for manures × ratio = 3.3383

Table 4.2
Effect of different manures on the plant height (cm) of different *Populus deltoides* varieties

Manures	Plant Varieties			Mean
	AY48	Italian	Local	
Compost	28.79d	25.96de	23.94e	26.23C
FYM	40.92a	41.35a	17.22f	33.16A
VC	36.97b	32.59c	16.68f	28.75B
Mean	35.56A	33.30B	19.28C	

At the 0.05 probability level, means denoted by different letters vary significantly.

LSD value (0.05) for varieties = 1.9277

LSD value (0.05) for Manures × Variants = 3.3388

Table 4.3
Effect of different soil ratios on the plant height (cm)
of different *Populus deltoides* varieties

Manures	Soil: Manure Ratios			Mean
	R ₁	R ₂	R ₃	
AY48	39.51a	36.41a	30.76b	35.56A
Italian	31.46b	32.17b	36.27a	33.30B
Local	24.58c	15.62d	17.64d	19.28C
Mean	31.85A	28.07B	28.22B	

At the 0.05 probability level, means denoted by different letters vary significantly.

LSD value (0.05) for the ratio = 1.9148

LSD value (0.05) for varieties × ratios = 3.3166

4.1.2 Total Biomass

All the biomass of the plant, i.e., aboveground and belowground biomass, was included. The effects of soil manures and ratios are presented in Table 4.4. There was a significant ($P \leq 0.05$) difference in the total biomass of the plants among the soil manures. The maximum mean was recorded in the FYM treatment (14.51 g), followed by the compost treatment (13.25 g), whereas the minimum mean was recorded in the VC treatment (12.03 g). The effect of soil manure on the total biomass of the different *Populus deltoides* varieties is shown in Table 4.5. There was a significant ($P \leq 0.05$) difference in the height of all the *Populus deltoides* varieties. The maximum mean was recorded for AY48 (15.64 g), followed by Italian (13.05), whereas the minimum mean was recorded for local poplar (11.06). The influence of manure ratio on the total biomass of different *Populus deltoides* varieties is shown in Table 4.6. The total biomass of the plants in R₁ was significantly ($P \leq 0.05$) different from that in R₂ and R₃. The maximum mean was recorded in R₁ (14.12 g), whereas the minimum mean was recorded in R₂ (13.03 g) and R₃ (12.64 g). Among the interactions between soil manure, plant variety, and soil ratio, the significant maximum mean in the entire bar series was followed by later scripts for smaller means. Digits carrying the same scripts were considered to be significantly different ($P \leq 0.05$). In addition, Mandal et al. (2009) analyzed soybean production and biomass yield in response to NPK fertilizer and organic manure and recorded significant differences in total biomass in the FYM + NPK treatment compared to the NPK + control. This result is in agreement with the current study

On the other hand, a scholar studied the responses of ten poplar clones and one willow clone and reported that Clone Ay-48 produced the greatest biomass and annual total biomass in comparison to the other clones (Yeo Jin-gi et al., 2007), which is in agreement with the findings of the present study.

Table 4.4
Effect of different manures ratios on total biomass (g).

Manures	Soil: Manure Ratios			Mean
	R ₁	R ₂	R ₃	
Compost	18.14a	10.05d	11.57c	13.25B
FYM	14.6b	14.61b	14.30b	14.51A
VC	9.60d	14.43b	12.06c	12.03C
Mean	14.12A	13.03B	12.64B	

At the 0.05 probability level, means denoted by different letters vary significantly.

LSD Value (0.05) for Manures = 0.6086

LSD Value (0.05) for Manures × Ratios = 1.0541

Table 4.5
Effect of different manures on the total biomass (g) of different *Populus deltoides* varieties

Manures	Plant varieties			Mean
	AY48	Italian	Local	
Compost	11.16c	10.89c	17.62b	13.22B
FYM	19.81a	15.87b	7.85d	14.51A
VC	15.97b	12.40c	7.72d	12.03C
Mean	15.64A	13.05B	11.06C	

At the 0.05 probability level, means denoted by different letters vary significantly.

LSD value (0.05) for varieties = 1.0220

LSD value (0.05) for Manures × Variants = 1.7701

Table 4.6
Effect of different soil and manure ratios on the total biomass (g) of different *Populus deltoides* varieties

Manures	Soil: Manure Ratios			Mean
	R ₁	R ₂	R ₃	
AY48	14.42cd	18.52a	13.99de	15.64A
Italian	11.21f	12.62ef	15.42bc	13.08B
Local	16.73b	7.95 g	8.51 g	11.06C
Mean	14.12A	13.03B	12.64B	

At the 0.05 probability level, means denoted by different letters vary significantly.

LSD value (0.05) for varieties = 0.8198

LSD value (0.05) for varieties × ratios = 1.4199

4.1.3 Aboveground Biomass

The effects of different soil manures and ratios on the aboveground biomass of plants, i.e., shoots and leaves, are shown in Table 4.7. No significant ($P \leq 0.05$) difference was detected in the aboveground biomass of the plants among the soil manures. The maximum mean was recorded in the FYM treatment (3.31 g), followed by the compost treatment (3.04 g), whereas the minimum mean was recorded in the VC treatment (2.97). The influence of soil manure on the aboveground biomass of the different *Populus deltoides* varieties is shown in Table 4.8. AY48 and Italian were significantly ($P \leq 0.05$) different from local poplar. The maximum mean was obtained in Italy (3.31 g), followed by AY48 (3.26 g), whereas the minimum mean was in local poplar (2.79 g). The effect of the manure ratio on the aboveground biomass of the different *Populus deltoides* varieties is shown in Table 4.9. The aboveground biomass of the plants in R₁ was significantly different from that in R₂ and R₃. The maximum mean was recorded in R₁ (3.26 g), followed by R₂ (3.21 g), whereas the minimum mean was recorded in R₃ (2.85 g). Among the interactions between soil manure, plant variety, and soil ratio, the significant maximum mean in the entire bar series was followed by later scripts for smaller means. Digits carrying the same scripts were considered to be significantly different ($P \leq 0.05$). Sarma and Gogoi (2015) studied the effects of different soil organic amendments on the germination of okra (*Abelmoschus esculentus* L.) and recorded high aboveground biomass in vermicompost and recommended FYM and VC compared to biochar. This result is in agreement with the current study. Sher et al. (2000) conducted a comparison between *Populus deltoides* and *Tamarix ramosissima* and measured the growth responses of each species in terms of height and aboveground biomass; the authors concluded that *Populus deltoides* density (height, aboveground biomass) was more important than the *Tamarix* density for determining growth response, which is in agreement with the findings of the present study.

Table 4.7
Effect of different manures on shoot biomass (g).

Manures	Soil: Manure Ratios			Mean
	R ₁	R ₂	R ₃	
Compost	3.49a	3.05abc	2.59c	3.04A
FYM	3.35ab	3.43a	3.14abc	3.31A
VC	2.95abc	3.15abc	2.81bc	2.97A
Mean	3.26A	3.21A	2.85B	

At the 0.05 probability level, means denoted by different letters vary significantly.

LSD Value (0.05) for Manures = 0.3517

LSD value (0.05) for manures × ratios = 0.6091

Table 4.8
Effect of different manures on the shoot biomass (g) of different *Populus deltoides* varieties

Manures	Plant varieties			Mean
	AY48	Italian	Local	
Compost	2.61bc	2.87bc	3.64a	3.04A
FYM	3.87a	3.62a	2.44c	3.31A
VC	3.31ab	3.30ab	2.30c	2.97A
Mean	3.26A	3.27A	2.79B	

At the 0.05 probability level, means denoted by different letters vary significantly.

LSD value (0.05) for varieties = 0.4146

LSD value (0.05) for Manures × varieties = 0.7180

Table 4.9
Effect of different soil and manure ratios on the shoot biomass (g) of different *Populus deltoides* varieties

Manures	Soil: Manure Ratios			Mean
	R ₁	R ₂	R ₃	
AY48	3.40ab	3.55a	2.85bcd	3.26A
Italian	3.27abc	3.38ab	3.15abcd	3.27A
Local	3.12abcd	2.71cd	2.55d	2.79B
Mean	3.26A	3.21AB	2.85B	

At the 0.05 probability level, means denoted by different letters vary significantly.

LSD value (0.05) for varieties = 0.3704

LSD value (0.05) for varieties × ratios = 0.5415

4.1.4 Belowground Biomass

The influence of different soil manures and ratios on the belowground biomass of plants is shown in Table 4.5. There was a significant ($P \leq 0.05$) difference in the belowground biomass of plants among the soil manures. The maximum mean was recorded for compost (3.35 g), followed by FYM (3.03 g), whereas the minimum mean was recorded for VC (2.64 g). The effects of soil manure on the belowground biomass of the different *Populus deltoides* varieties are shown in Table 4.9. AY48 and Italian were significantly ($P \leq 0.05$) different from local poplar. No significant difference is present between AY48 and Italy. The maximum mean was obtained in AY48 (3.48 g), followed by Italian (3.20 g), whereas the minimum mean was in local poplar (2.35). The effect of the manure ratio on the belowground biomass of the different *Populus deltoides* varieties is shown in Table 4.13. The belowground biomass of the different varieties in R₁ was significantly ($P \leq 0.05$) different from that in R₂ and R₃. The maximum mean was recorded in R₁ (3.46 g), followed by R₃ (2.81), whereas the minimum mean was recorded in R₂ (2.756 g). Among the interactions between soil manure, plant variety, and soil ratio, the significant maximum mean in the entire bar series was followed by later scripts for smaller means. Digits carrying the same scripts were considered to be significantly different ($P \leq 0.05$). Reeve et al. (2010) conducted a study on wheat plants treated with fertilizers and compost + fertilizers. The study revealed that the belowground biomass was greater in response to fertilizer alone than in combination with 1% compost. This result is in agreement with the current study. Arora et al. (2014) studied the growth and carbon stocks of *Populus deltoides* plants of different ages and reported that belowground biomass significantly increased with age (1–11 years), which is in agreement with the findings of the present study.

Table 4.10
Effect of different manures on the root biomass (g).

Manures	Soil: Manure Ratios			Mean
	R ₁	R ₂	R ₃	
Compost	4.79a	2.22	3.04bc	3.35A
FYM	3.10b	3.15b	2.84bcd	3.03B
VC	2.49de	2.89bcd	2.55cde	2.64C
Mean	3.46A	2.76B	2.81B	3.01

At the 0.05 probability level, means denoted by different letters vary significantly.

LSD Value (0.05) for Manures = 0.3083

LSD value (0.05) for manures × ratios = 0.5340

Table 4.11
Effect of different manures on the root biomass (g) of different *Populus deltoides* varieties

Manures	Plant varieties			Mean
	AY48	Italian	Local	
Compost	2.99b	3.22b	3.83a	3.35A
FYM	4.21a	3.30b	1.59c	3.03B
VC	3.23b	3.07	1.63c	2.64C
Mean	3.48A	3.20A	2.35B	

At the 0.05 probability level, means denoted by different letters vary significantly.

LSD value (0.05) for varieties = 0.3069

LSD value (0.05) for Manures × Variants = 0.5316

Table 4.12
Effect of different soil and manure ratios on the root biomass (g) of different *Populus deltoides* species

Manures	Soil: Manure Ratios			Mean
	R ₁	R ₂	R ₃	
AY48	3.33abc	3.97a	3.13bc	3.48A
Italian	3.07bc	2.77c	3.75ab	3.20A
Local	3.98a	1.52d	1.55d	2.35B
Mean	3.46A	2.76B	2.81B	

At the 0.05 probability level, means denoted by different letters vary significantly.

LSD value (0.05) for varieties = 0.4107

LSD value (0.05) for varieties × ratios = 0.7113

4.2 SOIL ANALYSIS

Table 4.13 indicates that the soil in all the manures was alkaline. The highest pH was observed in the FYM (8.75), followed by that in the compost (8.23), and the lowest pH was observed in the VC (7.72%).

As shown in Table 4.13, the maximum EC was obtained from VC 690.22, followed by FYM 622.1, and the minimum EC was obtained from compost 600.33. Total N was significantly ($P \leq 0.05$) greater in the FYM than in the VC and compost, and total P was significantly ($P \leq 0.05$) greater in both the VC and FYM than in the compost. P was significantly greatest in FYM 719.22, followed by VC 689.11, and the total p was minimal in compost 618.3. (Table 4.13). One scholar studied the effects of different organic manures (compost, VC, FYM) and micronutrients (NPK) on the yield of cotton, and the results were in agreement with those of the present study (Channagouda et al., 2015).

Table 4.13
Chemical properties of the soil compost, vermicompost, and farmyard manure

Soil property	Compost	VC	FYM
pH	8.23a	7.72b	8.75b
EC (ms/m)	600.33c	790.22a	685.1b
N	0.814c	0.94b	1.32a
P (mg/kg)	1.37c	2.18a	2.35a
K (ppm)	618.3c	689.11b	719.22a

At the 0.05 probability level, means denoted by different letters vary significantly.

LSD value (0.05) for compost = 1.6421

LSD value (0.05) for VC = 3.2261

LSD value (0.05) for FYM = 3.7445

Conclusions

The summarized results of the present research revealed that the response to farmyard manure had a positive and significant influence on the height of different *Populus deltoides* varieties. Clone AY-48 and Italian poplar plants are suitable species for rapid growth and short rotation and can improve the livelihood of former plants by growing these hybrid poplars on farmlands and in agroforestry. Clone AY-48 can also grow for carbon sequestration, which can help in combating climate change because it stores more carbon than Italian poplar plants, and local poplar plants are not suitable for planting due to their slow growth.

Declarations

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