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EXPLORING THE GROWTH BEHAVIOR AND ECONOMIC VALUE OF POPLAR TREES (*POPULUS DELTOIDES* BARTR. EX MARSHALL) GROWN UNDER FARM CONDITIONS

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ABSTRACT

Poplar (*Populus deltoides* W. Bartram ex Marshall) is an important agro-forestry tree in Pakistan due to its fast growing nature and high economical value. The objectives of this study were to determine the growth patterns and appropriate selling time of Poplar. Growth and price curves of the tree of different ages were worked out by collecting data about height and DBH (Diameter at Breast Height) of Poplar from different villages of Faisalabad district. About 1000 trees of 2 to 10 years age were selected for collection of the data during field survey. Data revealed that Poplar trees grew in height rapidly for the first 5 years as it achieved about 80% of its 10 years total height within initial 5 years. Similarly, DBH of the trees increased rapidly with more or less constant rate from 2 to 8 years, later on the increment was found very low and constant up to 10th year. Cambial surface area per tree increased rapidly (10.5m^2/year) during most of its life span excluding last 2 to 3 years. Prices of the trees did not increased in proportion to tree volume per year and it was found that tree should be harvested during early years (even before 8 year) for more income.

Key-words: Growth behavior, poplar trees,

INTRODUCTION

Pakistan is suffering from acute shortage of timber and firewood. The total wood demand is much higher than the present level of its domestic supply. It was reported that total wood demand in 2009 was 43.7 million m^3, out of which timber wood demand was 12 million m^3 and fuel-wood 32 million m^3. Sustainable provisions (annual growth rate) were only 14.4 million m^3. So there was a gap of 29.3 Mm^3 in wood demand and supply, which was frequently met by overexploiting the existing forests as well as import of wood and wood products (FAO, 2009). It has been predicted that gap would be severe in wood supply and demand by the year 2020. Currently about Rs. 77.78 billions are being spent to import wood and other wood products (PES, 2011).

Fire-wood, animal excreta (dung) and agricultural wastes are the main cooking and heating sources used by 90 percent of the rural and sixty percent of the urban community. Wood biomass contribution to our state energy requirement is about 32 percent (FAO, 2009). Only 10 percent of people’s firewood requirement is met by state forests and plantations. The 90 percent of our total firewood requirement is met by wood biomass that is being produced on our farmlands.

The above referred factors depict a very gloomy picture of our forest resources. For any agricultural country like Pakistan which mainly depends upon its agricultural products for its economic development, the only possible way to enhance the forest resource is to adopt agro-forestry practices on scientific lines. The success of agro-forestry is only possible by planting fast growing (exotic) species in suitable areas as well as on locations of Pakistan under wise management.

Research and developments have made it possible to use mature poplar wood for the purposes which were previously fulfilled from coniferous wood. The physical and chemical properties of Poplar are fairly comparable to Shisham, which is Pakistan’s most valuable hardwood, and can therefore be used for manufacture of various products. The tree is capable of growing under different climate conditions ranging from semi-arid plain areas up to hills. It grows better on well-drained fertile soils having neutral soil pH (Gupta *et al.*, 2005, Chauhan and Mangat, 2006) or near to neutral pH ranging from 5.5 to 7.5 (Jagdish and Kumar, 2000).

Pakistan spends millions of rupees annually in foreign exchange for the import of pulp and paper along with other wood and woody products. It has been estimated that presently Pakistan has to export 2.6 million tons of rice to import 16,862 tones of paper (FAO, 2010). So, in this connection it is necessary to develop our local paper and pulp industries through ample supply of raw material needed to these industries in the form of fast growing Poplar trees. Recently some attempts have been made by Adamjee Paper Mill Noshera (KPK) for producing the pulp from poplar wood. Packages Ltd., Lahore, is also willing to produce pulp from poplar wood at the rate of 100 tons of pulp per day if supply of raw material is ensured on sustainable basis.

Furthermore, the supply of electricity and telecommunication facilities in rural areas of Pakistan require a huge amount of posts and poles which mainly comes from poplar plantations. Thus huge consumption of poplar wood as industrial raw material, sports goods, posts, poles and as fuel motivates us to grow Poplar trees on commercial basis.

It has been reported that poplar growers are desperate due to lack of encouraging Govt. Polices and marketing facilities in the country. Furthermore, it has also been estimated that price of the trees do not rise in proportion to their volume as poplar wood is sold on weight basis (Dhillon *et al.*, 2001). Surprisingly, the prices per unit volume fall with increasing tree volume. Under these situations, traders are making too much profit when they buy "big/timber'' trees from growers at fire wood prices on one hand and by selling the stems as timber at much higher prices on the other hand. Hence the farmers can make much more money from these trees if they understand the market better.

In view of the above discussion, the objectives of this study were to investigate the present status of Poplar trees in respect of their growth behavior and price trends. This study will help to identify the farmer's problems pertaining to the market and will propose optimum harvesting rotation of Poplar (*Populus deltoids*). The present study has also been designed to know the growth and price curves for the trees of different ages in various villages of Faisalabad district and thus inculcate the determined role of *Populus deltoides* in the prosperity of the country and also of the farming community.

MATERIALS AND METHODS

Foremost efforts were made to collect all possible relevant information about Faisalabad district primarily from agro-foresters. Following steps have under taken as a measuring tool regarding information collection.

Study Area

Faisalabad district has an area of 5,856 sq km and a population of 35, 47,446 souls. Faisalabad stands in the rolling flat plains of northeast Punjab, between longitude 73°74 east, latitude 30°31.5 North, with an elevation of 184 m (604 ft) above sea level. The city proper covers an area of approximately 1,230 square kilometers (470 sq mi), while the district covers more than 16,000 square kilometers (6,200 sq mile). Faisalabad district has earned a name for agricultural productivity by virtue of nature's endowed rich soil as well as an efficient irrigation system. Faisalabad features an arid climate periodically experiencing extremes, with a summer maximum temperature 50 °C (122 °F) and a winter temperature of 2 °C (28 °F).

A simple random sampling technique was used for the selection of the respondents (Agro-foresters). A Performa was used to collect essential information by asking several simple questions with respondents. About 1000 poplar trees (*Populus deltoids*) were mensurated for data collection that were randomly selected from different villages of Faisalabad district. Data were collected for the different parameters like age, height, girth at the breast height (GBH) and price per tree.

Data were collected during spring 2012. For this purpose a suitable number of agro-foresters were contacted to determine the age and price of the standing trees. Desired data was recorded by selecting a number of trees of different ages from various villages of Faisalabad. The height of different trees was measured with Haga-Altimeter (Made in Germany), whereas, GBH by measuring tapes and DBH was calculated from the girth by using the following formula:

$$D.B.H = Girth / 3.14$$

The collected data for trees were arranged age wise and the arithmetic means of height, DBH & price/tree were calculated against different ages. Then data of average height and DBH were used to calculate the cambial area according to the following formula (Quraishi, 2005):

$$\text{Cambial surface area (m}^2\text{)} = [3.14 * \text{DBH (cm)} * \text{Height (m)}] / [2 * 100]$$

Formulation of Various Relationships

The whole analyzed data were arranged in different tables to make variables for various graphic and regression relations. By using the values from the tabulated data number of regressive and graphic relations were developed to know growth & price wise optimum rotational age for *Populus deltoids*.

RESULTS AND DISCUSSION

Tree stands are usually measured by dimensions (e.g., height and DBH). Height is a useful measure for comparing the growth potential of trees on different soil types (Hibbs *et al*., 2000). Data related to age-tree height growth trend of farm grown *Populus deltoids* in Faisalabad district is explained in Fig.1.

Data revealed that average height achieved by the tree in 10 years of age was 12m. Out of which about 80% (10 m) tree height was gained by the tree within first five years of age as shown in the Fig. 1. Height increment achieved by the tree up to fifth year was significantly higher than the height gained in later years as the remaining height (2 of 12m) was gained by the tree from 6-10 years of age which was only 20% of the total height.

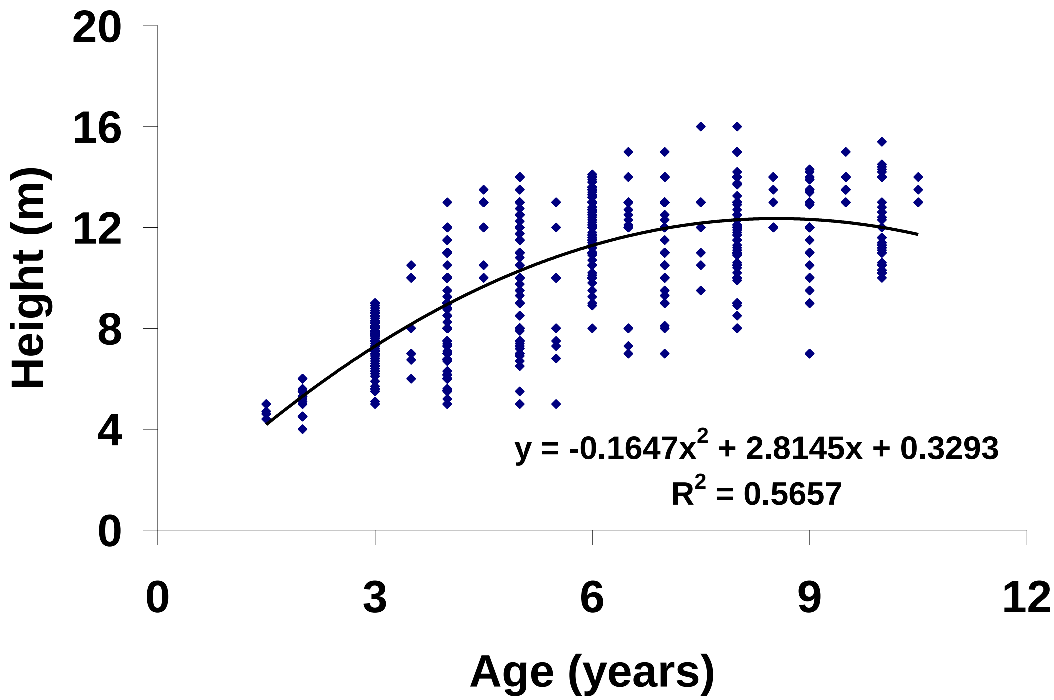

Fig.1: Age-Height Relationship for *Populus deltoides* in District Faisalabad.

Relatively lower proportion of height increment was noted after 6th year of age suggesting slow growth rate of the tree during later years of its life span (6th-10th years). However, the resulted mean height-growth increment for whole of the period from 2-10 year of age was 2m per year. According to Netzer *et al.*, (2002) and Tanvir and Siddiqui (2010), poplar tree typically grew in height from 0.76 m to 2.13 m per year. They also noted that several clones averaged in height at the rate of 1.52 to 2 m per year for 10 years growth. Our results are in agreement with the findings of Netzer *et al.*, (2002) and Trincado *et al*., (2007).

The changes in height from 2-10 years age can be best described by the regression model respecting height growth value from age-height curve (Fig.1). The regression co-efficient (R^2=0.5657) of the predicted model shows that one could fix the target to have certain height of the tree during 2-10 year of age of *Populus deltoides* using this regression equation. The graph also indicates that the tree grew in height rapidly during its initial formative stages up the five years and for the next 5 years the height growth slowed down. Similar results were reported by Zhang (1997) and Tanvir *et al.* (2003).

It is obvious from the tree height difference indicated by the curves that during initial 5 years that the growth was governed more by moisture availability rather than temperature regime. It seemed that during initial 5 years sufficient moisture was equally available to the tree. The monthly mean temperature and rainfall (Fig. 2 and Fig. 3) supported to understand the reason why the plants were so active to produce high biomass during early years of their establishment as the height growth increment was significantly higher in initial 5 years of its life span. The plants were restricted to produce much of its biomass during spring and summer months because of its deciduous nature (Rasul *et al.*, 2009). Data (Fig. 2 and Fig. 2) shows that environmental conditions were highly favorable during spring and summer months because of sufficient moisture availability accompanied by high temperature (Quraishi, 2005).

In later years (above 5 year age) moisture availability per unit biomass was significantly reduced because of low rainfall interception as well as larger tree size. So the growth was reduced during later years. It is clear from the figure that per year contribution of height to the tree volume for the first 5 years was more. After this height contribution to volume production was low but constant.

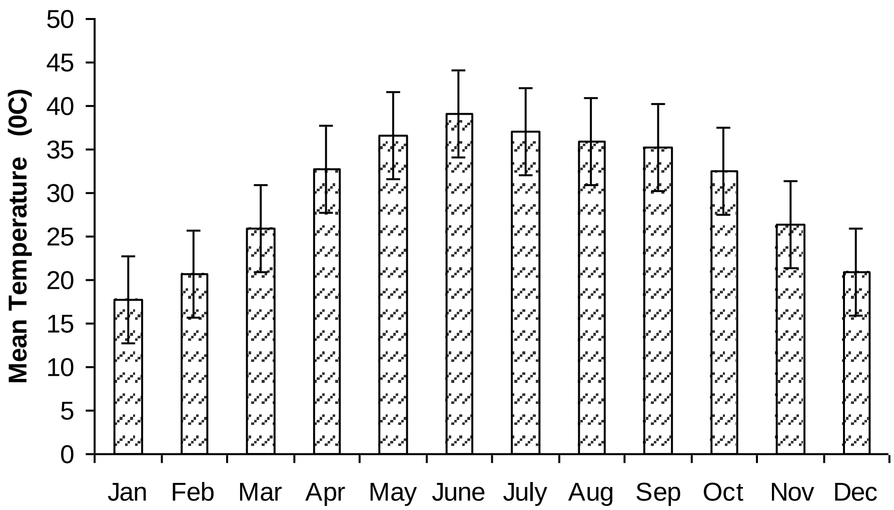

Fig. 2 Monthly based Mean temperature (°C) of Faisalabad district from 2000-2010.

Data related to age-tree DBH (Diameter at Breast Height) growth trend of farm grown *Populus deltoides* in Faisalabad district is explained in Fig. 2. The derived curve based on data of DBH of the tree collected from various villages of district Faisalabad indicates that DBH of the tree increased rapidly and with somewhat constant rate up to the age of 8 years.

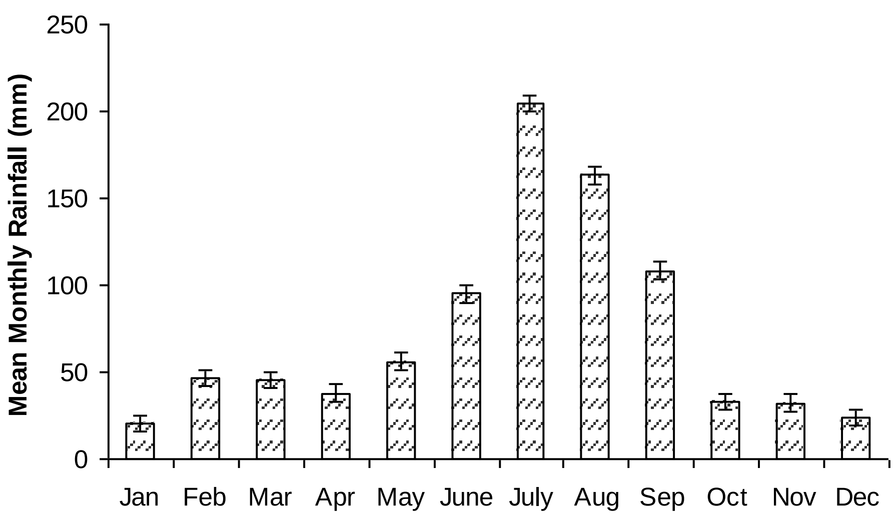

Fig. 3. Monthly based Mean Rainfall (mm) of Faisalabad district from 2000-2010 (Chaudhry, 2010)

However the increment was very low and constant for the next two (8^{th}-10^{th}) years. Data revealed that a stem total big share of (98%) i.e. 24.88cm out of (26.4cm) diameter in 10 years had been achieved within first 8 years of age with maximum per year increment per year. Data also explained that the volume of the tree is determined more by the DBH, rather than height so, maximum biomass increment was achieved up to 8 years (Fig.1, 4. 5.), and this part can be explained well by the regression modal presented. The value of regression co-efficient (R^2 =0.63) for the predicted model showed that one could fix the target to have certain value of DBH of *Populus deltoides* for either year of age using the regression equation of the predicted model. The results are similar to the findings reported by the Netzer *et al*. (2002) and Tanvir and Siddiqui (2010) who noticed that the DBH of farm grown *P. deltoides* was 18-23 cm in 10 years, but different from the findings reported by Riemenschneider *et al.* (2001) due to less the competition for light on farmlands that pulled the trees more upward rather in width (diameter).

The data of monthly mean temperature (Fig. 2) and rainfall (Fig. 3) supported as well to understand the reason why the plant was so active to produce biomass as the DBH growth increment was significantly higher in initial 8 years of its life span.

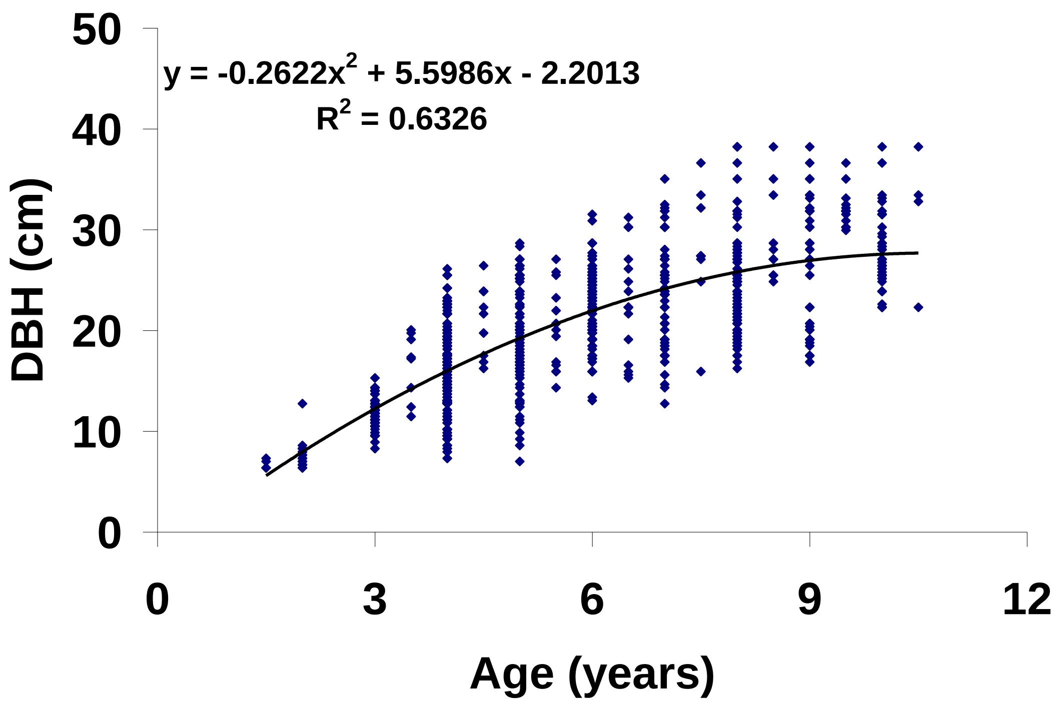

Fig. 4. Age-DBH Relationship for *Populus deltoides* District Faisalabad.

The same phenomenon is explained in the Fig. 4 by horizontal (slightly negative) curve of DBH in later (8-10) years. This curve also suggested that harvesting of the tree should be done with the rotation of 8 years for maximum woody biomass the annual growth increment (DBH) was constantly increasing from 2 to 8 years. Then it becomes stable showing very low or negligible further increment. Thus environmental factors affected the growth rate positively in the study area. The regressive relationship with graphic representation of age-DBH of farm grown *Populus deltoides* is the best explanation for time to time the change in DBH from 2 to 8 years based on data of in different villages of Faisalabad district.

Fig. 5 depicts increment in cambial surface area of *Populus deltoides* and it was observed that cambial surface area of *Populus deltoides* increased at more or less constant rate of 10.5 m^2/year during most of the life span excluding last 2 to 3 years. This peculiar pattern of growth indicated decreasing vigor of the tree during later years.

As clear from the Fig. 5, the trend of no addition in cambial surface area of *Populus deltoides* after 7th year of its life span explains well, why trees grew very rapidly during early years of their life. Perhaps, the tree vitality For last 3-4 years became very low; hence the trees were not so active and vigorous for speedy growth. These results are in agreement with the findings of (Sharma and Zhang, 2004) who also found the decrease in tree vitality in the later years in *Populus deltoides*.

Fig. 6 shows the changes in prices per tree for given volume in *Populus deltoides*. The price per tree for a given age increased through the years of its life span. Slope of the graph indicated that prices per tree increased linearly with increase in tree size up to 10th year of age. These changes may be explained by the following regression equation. The price trend of *Populus deltoides* indicated by Fig. 6 showed that the prices did not rise in proportion to height and diameter increment which was opposite to what one expects from classical forestry practice.

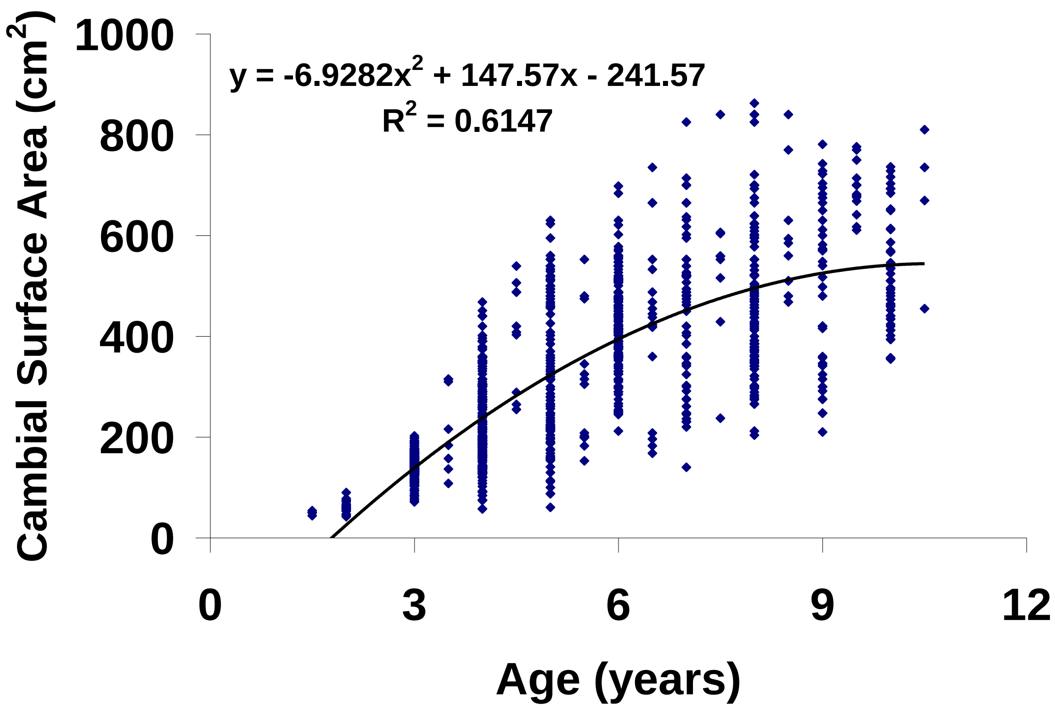

Fig. 5. Age-cambial surface area Relationship for *Populus deltoides* in Faisalabad.

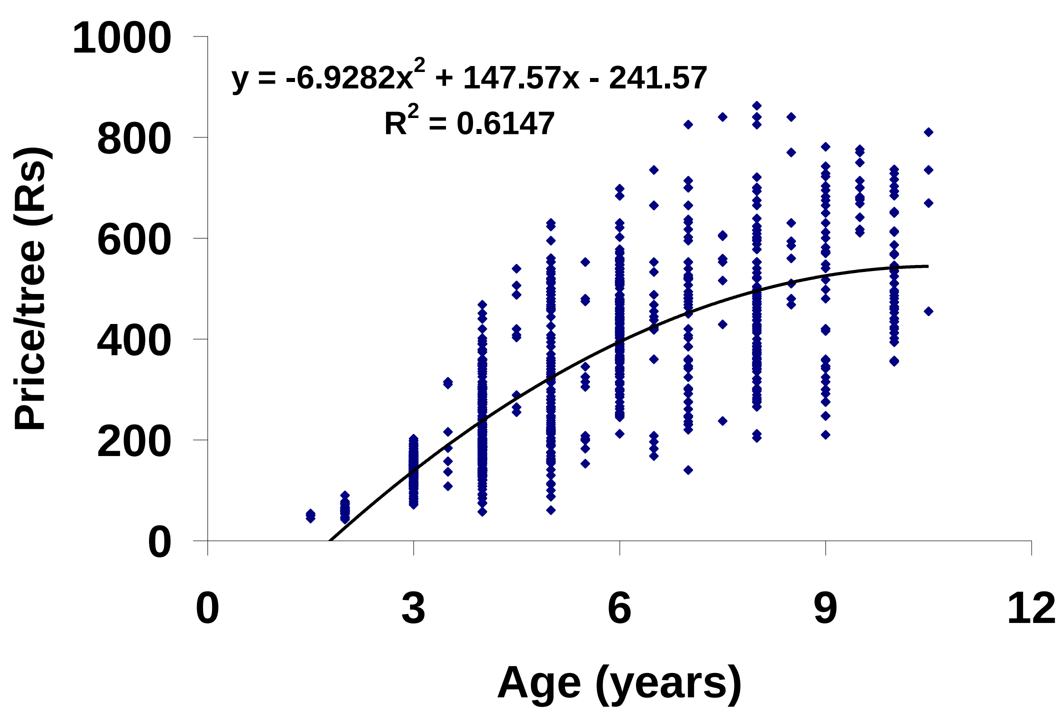

Fig. 6: Age-price Relationship for *Populus deltoides* in Faisalabad.

Conclusions

All available data of *Populus deltoides* has strongly suggested that *Populus* should be grown on very short rotation because it ensures early maximum income and minimum harm to crop. Gradual and rapid decrease in tree vitality causes the slow growth rate in later years. So less increment will be obtained in late rotation. Pakistan is very lucky having excellent and unique price trend for *Populus deltoides* in Faisalabad under farm conditions. The favorable situation of more income for the tree crop in early years is presenting a good chance to our farmer for enjoying more and more benefits by planting of *Populus deltoides*. The trend may be changed if new set up of industry is developed or by the replacement of *Populus* wood with other commodity in its uses. So it is needed to revise the same study survey after 5 years because of rapid change in market.

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