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The Shading Effect of Poplar (*Populus Deltoides*) on Wheat Crop

Isha Katariya[1*], Lolita Pradhan[2], Nisha Tripathi[3]

[1]Ph.D. Scholar, [2]Assistant Professor, [3]Director*
[1,2] Amity School of Natural Resources & Sustainable Development, Amity University, Noida, Uttar Pradesh. India*
[3] Sanjeevani foundation for health education and environmental research action (SFHEERA), Delhi
Email ID: [1]ishakatariya96@gmail.com, [2]lpradhan@amity.edu, [3]nisha.sfheera@gmail.com*

**Corresponding author's E-mail: ishakatariya96@gmail.com*

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Abstract

This study was conducted in different villages of the district Saharanpur. The poplar tree (Populus deltoides) is used as the tree component and wheat crops are used as intercrops in an agrisilvicultural system. In this study, the different effects of poplar (Populus deltoides) on wheat crops were discussed. The parameters which are recorded were grain yield and biological yield. In the district Saharanpur, there are two patterns of tree growing with crops, block plantation and boundary plantation. It was observed that the yield with block plantation is less than boundary plantation. It was also recorded that 95% of farmers are doing boundary plantation in the district Saharanpur. In shaded areas, grain and straw yields were also drastically lowered by poplar border plantations. All villages saw a significant decline in grain yield due to the shading effect of poplar trees. It is observed that in the villages of district Saharanpur most of the farmers are practicing agroforestry with poplar (Populus deltoides). There are multiple effects of shading on agricultural crops. For this study, those farmers were surveyed who are growing poplar trees with different crops. Trees and crops both were analyzed for the survey.

Keywords: *Populus deltoides, boundary plantation, block plantation, shading effect*

1. Introduction

Studies show that farmers' primary reasons for adopting agroforestry systems based on poplar were to increase their incomes (more than 70%) and to have an emergency source of cash (nearly 20%) (Singh & Kumar, 2014). Land husbandry practices such as agroforestry are gaining importance as a way to diversify traditional agriculture (*Adoption of Poplar Based Agroforestry*, n.d.). The most significant impact on grain filling conditions, quality formation, and yield is observed after grain filling at the seedbearing stage in shading experiments at different growth stages of crops. Consequently, poor enrichment and poor quality were attributed to changes in soluble sugar, sucrose, starch, chalkiness, and yield after shading. Multiple agricultural and forest industries rely on agroforestry systems for raw materials (Chandana et al., 2018). In western Uttar Pradesh, where 70 percent of the land is under agriculture, poplar-based agroforestry is being practiced on a large scale. There are so many reasons that farmers choose poplar-based agroforestry- in comparison to other trees, poplar has a short rotation period, easy availability, poplars are leafless during winters, is economically beneficial, and it is compatible with different agricultural crops. Because of their rapid growth rate, numerous end-uses, easy establishment, and ability to adapt to a wide variety of soil types, poplar can be an important contributing tree to this goal. Wheat and paddy are the most common agricultural crops which can grow with poplar. The market value of poplar in different industries is also good, and according to farmers, it is more profitable than any other tree. Intercropped wheat yield is reported to be primarily affected by the age of the poplar trees (P. deltoides). Plantations under one year of age showed a 20.10% yield reduction, while those under four years of age displayed a 54 percent yield reduction. It is observed that the shade of the poplar tree reduces the grain yield. According to Huawei (2010), the effect of shading on grain yield is determined by the level of shading applied, as well as cultivar-specific influences. Although the combination of these two approaches has higher productivity on a system basis than pure cropping. There are several trees suitable for agriculture and agroforestry in northern India, but poplar (Populus deltoides) stands out. It was reported in 1996 that poplar borders are planted with

wheat (Triticum aestivum) to increase its value among farmers (Sharma et.al., 1996). Compared with many other crop rotations, poplar-based agroforestry is more economically feasible and profitable. This system appears to be risk-free based on sensitivity analysis. Due to high light capture caused by morphological modifications and a change in light fractions, low shading might not reduce or even increase wheat grain yield.

Characteristics of Populus deltoides

Poplar (Populus deltoides) is commonly known as, eastern cottonwood. Poplar is a huge, quickly-growing deciduous tree with a broad, open-rounded shaped habit that normally grows 50–80' tall. On separate male and female trees, tiny male and female flowers emerge in separate catkins (dioecious). Early spring (March–April) is when flowers bloom before the foliage appears. Reddish, but not ostentatious, are the male blooms. When mature, the female blooms are followed by dehiscent capsules that burst open to release a profusion of densely tufted seeds. As they move through the air and along the ground and generally gather near gutters, curbs, roadsides, and fences, seeds with silky white hairs resemble cotton. Up to 5" long, triangular, acuminate, coarsely serrated, glossy, dark green leaves. In the fall, leaves become yellow. Crates, plywood, and pulp are the only economic uses for wood because it is fragile and readily warped. Agroforestry with poplars may provide endless raw materials. The average amount of wood generated per hectare per year is 20 m3, and with the right crop combinations, the profitability has increased significantly, encouraging farmers to embrace it(S. K. Chauhan et al., n.d.-a).

Problems with Populus deltoides

The main problem with this tree is diseases like dieback, cankers, powdery mildew, rust, and leaf spots.

Uses of Populus deltoides

It is typically believed that ornamental use is wrong. Trees are an especially bad choice for cities since they are untidy, have fragile wood, and their roots can buckle sidewalks and harm sewer lines. It might grow well in rural locations where other great trees might struggle, especially in low spots or along streams. There are a few all-male varieties for sale.

2. Materials And Methods

Study Area

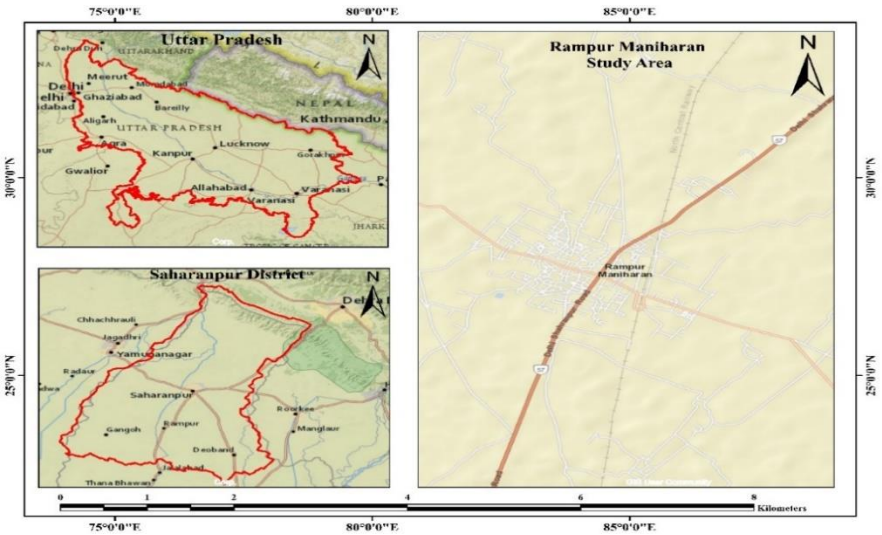

Fig. 1. Location map of the study area

This present study was conducted in 10 different villages of the district Saharanpur. It covers a geographical area of 3,589 km2 and is situated between 29°34′ and 30°23′N and 77°05′ and 77°58′E. With an elevation of 284 meters above sea level, it is the highest point in the city. Between the holy rivers of the Ganges and the Yamuna, the Saharanpur district forms the most northern part of Doab land. Saharanpur District is surrounded by Shivalik hills in the north and northeast and the Yamuna River forms the boundary in the west, which separates it from the Karnal and Yamunanagar districts of Haryana. The geographical area of the district is 3860 sq. km. Saharanpur has a tropical climate because of the proximity of the Himalayan region across this northern district. It is a sub-humid region, especially in the upper Ganga plain area. Saharanpur records an average temperature of about 23.3°C during the year. June is the hottest month, and January is the coldest. Humidity is more in the western area compared to the eastern region of Saharanpur. Agriculture plays an important role in the economy

of the district. Roughly 70% of the land is under agricultural use. The important food crops of the region are wheat, rice, jowar, maize, and bajra. Sugarcane, oilseeds, cotton, and jute are the main commercial crops.

During two consecutive years, 2021 and 2022, the study was conducted for wheat crops and block and boundary plantation of Populus deltiodes. This observation is based on wheat that was sown in November 2021 and harvested in April 2022. Generally, the age of poplar trees is 4 to 6 years. This particular study was done on poplar trees that were sown in 2017 at 1x1 m spacing. It was observed that in the shaded area the agricultural crops were not growing properly and the grain size is comparatively small. While in unshaded are the crops are healthy.

This study was conducted in the district Saharanpur where a large number of farmers adopted agroforestry at present. There is a huge popularity for poplar among farmers, and wheat (Triticum aestivum) is one of the most important rabi crops (Sharma and Dadhwal, 1996). It was found by (Jain and Singh, 2000) that poplar-based agroforestry yields a higher return on investment than other crop rotation strategies. Poplar is beneficial for farmers but at the same time, it is also harmful to crops in some ways. Intercropped wheat grain yield is influenced by the age of poplar (P. deltoides) trees (Yadav et al., 2018). In Punjab, a 1-year-old poplar plantation reduced grain yield by 20.10%, while a 4-year-old poplar plantation reduced grain yield by 54%(Sharma et al., 2016).

The effects of shading on grain yield have been documented in numerous studies (Gill et al., 2009; Mu et al., 2010). According to Huawei (2010), the effect of shading on grain yield is dependent on the shading degree and cultivar. As morphological modifications and changes in light fractions result in high-efficiency light capture, low shading may not reduce wheat grain yield or even increase it.

Data analysis

After completing the primary data collection through interviews with farmers the data were tabulated and analyzed. Benefit-cost analysis and tabular analysis were mostly used to examine the study's data. The formulas of benefit-cost analysis:

- Net return=$\frac{\sum Bt}{(1+i)t} - \frac{\sum Ct}{(1+i)t}$ Eq (1)

Where ∑Bt = total occurred benefits for a period of t years,

∑Ct=total occurred cost for a period of t years

i= discount rate, t=time period

- Annual average return= =$\frac{\sum Bt}{(1+i)t} - \frac{\sum Ct}{(1+i)t}$/T Eq (2)

Where, ∑Bt = total occurred benefits for a period of t years,

∑Ct=total occurred cost for a period of t years

i= discount rate, t=time period, T= year of crop rotation

- Benefit-cost ratio= $\frac{\frac{\sum Bt}{(1+i)t}}{\frac{Ct}{(1+i)t}}$ Eq (3)

Where, ∑Bt = total occurred benefits for a period of t years,

∑Ct=total occurred cost for a period of t years

i= discount rate, t=time period.

Intercropping of Poplars and Wheat

It is possible to generate higher returns per unit area by planting trees and crops. Due to the leafless nature of the poplar trees during winter, intercropping is complicated, but winter crops have been successful in poplar-based systems. There are reports that mixed woodland systems produce more than monocultures, especially when trees gain access to resources that crops would otherwise lack(S. K. Chauhan et al., n.d.-b). Because poplar is deciduous, it is more suited for winter crops since it doesn't block sunlight and it is under storey crops that won't be shaded. In contrast to poplar trees, under-storey wheat crops are almost fully developed, and enter the reproductive stage as soon as their foliage develops.

Effects of Shading

Grain Yield

Due to the shade of trees on wheat crops, there are many effects on wheat crops the major effect is the size of the wheat grain (Table1. and fig.1.). The size of the wheat grain is smaller in shaded areas in comparison to the grain size in unshaded areas. The crop growth rate is consistently decreased by shading in roughly a direct proportion to the size of the canopy(Alam et al., 2012). When the size of the grain is small, the overall weight of wheat grains is less and farmers face a loss in their additional income. The crop takes more time to get ripe than the normal ripe time.

The maximum reduction was found in the year 2021 in Rampur Maniharan dehat. The reduction is about 25%. The minimum reduction was found in 2016 and that is only 10%.

Table 1. wheat crop production in shaded and unshaded areas

Year	Shaded	Unshaded	Percentage difference
2016	18 quintals	20 quintals	10%
2017	19 quintals	21 quintals	10.5%
2018	19 quintals	22 quintals	15.7%
2019	17 quintals	20 quintals	17.6%
2020	18 quintals	22 quintals	22.2%
2021	16 quintals	20 quintals	25%

Source: primary data collection

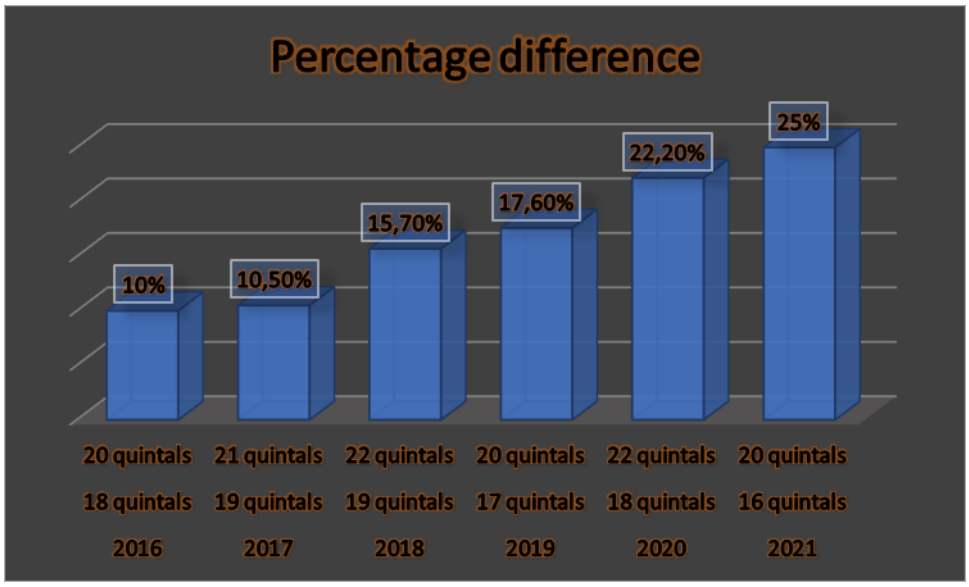

Fig.2. Percentage difference of wheat in the shaded and unshaded area

Straw Yield

The effect of shading is also noticed in straw yield. Boundary poplar plantations reduced straw yield in shaded areas as well. The price of straw is calculated according to its weight and quality. Under the shading area the straw gets thin that's why the weight and quality are reduced and the market value also gets decreased.

3. Results and Discussion

To observe the effect of shading on wheat crops, a variety of parameters were recorded. According to the farmers, the shade of trees affects the crops in different ways. The immediate post-crop sowing leaf shedding impacts seedling germination and development initiatives, which is compounded later with a reduced yield (S. Chauhan et al., 2012). It was noticed that when the spacing of trees is less than 0.9m, the crops get more effect under the shadow but when the gap between the trees is 0.9m or more than 0.9m, the shade of trees is not that harmful to the crops. It was noticed by the local farmer that the shade of poplar trees affects the crops in so many ways.

Irrigation

Irrigation problems increase after growing poplar on land. Poplar plantations lack essential information about irrigation management practices, therefore limiting irrigation and technology innovation. As a result of dry soils and drought stress, microorganisms are less likely to be able to access soluble

resources. Drought stress and high transpiration rates cause the plant to lose turgor due to dry soil and water loss.

Pest Control/Fertilizers

Since their introduction in India, most exotic poplar trees, especially Populus deltoides, have been injured by multiple insects (Ahmad & Faisal, n.d.). Due to insect or pest problem poplar affect the growth of the wheat crop. The pests infect the tree leaf, and when the leaf falls on the ground it affects the main crop.

Effects of Weak Light

Plant growth is affected by weak light in many different ways (Table 2.), according to different studies. The quality of light affects the reduction of crop biomass. Light is one of the main factors for the growth of the wheat crop. Light is a major component that limits the growth and development of intercropped crops in tree-based intercropping systems (Qiao et al., 2019).

Table 2. The different effects of shading on the wheat crop are listed below:

Effects	In shaded area	In un shaded area
Seed size	Small	Normal
Seed color	Dark brown	Light brown
Harvesting period	Take more time to harvest	Less time
Quantity	Reduce quantity	Normal quantity
Quality	Not good quality	Good quality
Height of tillers	Less	More

Soil pH

According to (Sirohi & Bangarwa, 2017) As poplar age increased, the soil's pH fell in all spacings. The extent of the soil pH drop was larger in the wheat plots with trees incorporated into them. Too high of a soil pH can be detrimental to the health and growth of plants. The amount of nutrients and other substances that are soluble in soil water and hence available to plants depends on the pH of the soil.

Why Poplar is a good choice for Agroforestry?

Poplar is also grown in agroforestry systems as a fast-growing windbreak and/or as an additional source of income in addition to being planted in wood plantations for wood production. Poplar-based agroforestry has additional advantages over paddy-wheat rotation. In contrast to the regular practise of rice-wheat rotation, we have discovered that poplar plants result in an improvement in soil health. The crop yields harvested following the poplar's harvest have been much greater than those harvested on plots without poplars (S. K. Chauhan et al., n.d.-a). A large amount of leaf litter, twigs, and roots from trees accumulated on the soil surface under trees, stimulating soil microflora (Beule et al., 2020).

Table 3. Cost-benefit analysis of poplar-based AF in district Saharanpur

Particulars	Amount (Rs.) Per annum
Input cost of trees	6467
Input cost of crop	66780
Total input cost	73247
Return from trees	60000
Return from crops	150000
Total return	210000
Net return	136753
Annual average return	19536
Benefit-cost ratio	2.86

There are harmful effects of poplar shading on crops but still farmers are using poplar with agricultural crops, the reasons are as follows:

- The leaf litter it produces contributes to the fertility of the soil
- Wheat, oats, sorghum, maize, and many others can be intercropped among common crops

- Poplar wood can be sold at the end of the rotation to compensate for yield loss in the inter-crops.

Results of other relatable research papers: There are other research papers on this topic that were published in different years. The results of those papers are listed below in table no. 3:

Table 3. results of other relatable research papers:

Findings	Title of the paper	Author	Year of publication
The overall performance of crops with admire to growth and yield in open conditions become higher than that underneath poplar plantations and the values of all the parameters reduced with growth in the age of poplar plantations.	Performance of poplar (Populus deltoides bartr.) and its effect on wheat yield under agroforestry system in irrigated agro-ecosystem, India	Sanjeev Chauhan, Mandeep Singh Brar, Rajni Sharma	2012
biological yield (grain + straw) was reduced substantially in shaded regions by way of border plantations of poplar.	Impact of Shading on Wheat Crop in Poplar Based Agroforestry Practice of Northern Plain of Uttar Pradesh, India	Divya Yadav, Harikesh Singh	2018
we located that tree color intensity was usually the predominant limitting factor for crop productivity in agroforestry gadget	Impact of fruit-tree shade intensity on the growth, yield, and quality of intercropped wheat	Xu Qiao, Lihan Sai, Xingwu Chen, Lihua Xue, Junjie Lei	2019

4. Conclusion

During the survey in villages of district Saharanpur, it was observed that there are many different effects of poplar tree (Populus deltoides) shade on wheat crops. The main reason for these effects is weak light on the crop. The wheat crop doesn't get enough sunlight under the shadow of poplar trees so the growth of the crop gets affected. It was also noticed that if the spacing between trees was more than 0.9 m, the shade of trees does not do that much harm to the wheat crop. Due to the shading effect, grain quality decreases day by day, and the market value of tree wood also gets decreases. Plant height, number of grains, and weight were among the yield-contributing parameters that decreased, which led to a decrease in the gross biological yield. It was concluded that yield reduction was not only because of tree shading but also due to the reduction of land area for agricultural crops.

Conflict of interest

There is no conflict of interest.

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