



### Research Article

## SOIL PHYSICO CHEMICAL PROPERTIES, WHEAT GRAIN YIELD AND ECONOMICS OF *POPULUS DELTOIDES* BASED AGRO FORESTRY SYSTEM

Shahid Hafeez<sup>1</sup>, Khayyam Anjum\*<sup>1</sup>, Junaid Naseer<sup>2</sup>, Hafiz Masood Ahmad<sup>1</sup>, Talha Faridi<sup>1</sup>, Muhammad Ayyoub Tanvir<sup>1</sup>, Mehwish Kanwal<sup>3</sup>

<sup>1</sup>Department of Forestry and Range management, University of Agriculture, Faisalabad, Pakistan.

<sup>2</sup>Institute of Forest Sciences, The Islamia University of Bahawalpur, Bahawalpur. Pakistan

<sup>3</sup>Department of Botany, University of Agriculture, Faisalabad, Pakistan.

\*Corresponding author: [khayyamanjum.anjum63@gmail.com](mailto:khayyamanjum.anjum63@gmail.com)

### Abstract

The research was carried out to determine the effect of *Populus deltoides* trees on the soil physical and chemical properties and grain yield of wheat crop under the agro ecological conditions of Faisalabad (Punjab), Pakistan. Two fields were selected; one with wheat monoculture and the other had boundary trees of *Populus deltoides*. The average age of the *Populus* trees was 5 years. Number of trees was 40 per acre. The average height and diameter at breast height of trees was 12 meters and 42.43 cm respectively. The wheat crop was sown in October, 2020 in both fields and harvested in April, 2021. A quadrat of one meter square was used to collect the data. The quadrat was put at various distances (2-24 meter) from tree stems and the plants growing there were harvested. The grain yield (gm-2) per quadrat was determined with the help of an electric weighing balance. The soil samples were selected from both fields and various chemical and physical properties of soil were determined. The soil pH was 7.32 and 7.95 in wheat monoculture and *Populus*+wheat field respectively. Total nitrogen was 0.05 and 0.08% in both fields respectively as mentioned above. Organic matter was 0.64 and 0.81 in wheat monoculture and *Populus* based field respectively. The effect of *Populus* trees on grain yield of wheat was negative from 2m to 10 meter distance from trees. While from 12m to 24 m distance, wheat grain yield was more or less equal in both fields i.e. with and without trees. Net income was Rs. 67437.69 and Rs. 104781.03 per acre without and with trees, respectively. On the basis of this research, it is concluded that wheat + *Populus* is more suitable option for farmers. So farmers should adopt this system to generate more money while keeping the inputs same.

**Keywords:** Wheat, *Populus deltoides* trees, Soil, Grain yield, Net income.

(Received: 21, January 2023, Accepted: 8, April 2023) Cite as: Hafeez. S., Anjum. K., Naseer. J., Ahmad. H. M., Faridi. T., Tanvir. M. A., Kanwal. M., 2023 Soil physico chemical properties, wheat grain yield and economics of *populusdeltoides* based agro forestry system. Agric. Sci. J. 5(1): 37-44.

## 1. INTRODUCTION

Trees are extensively grown in combination with farm crops in almost all countries of the world. Pakistan is one of these countries where fast growing trees are commonly grown with conventional farm crops. The trees increase the organic matter present in the soil. On the other hand, trees, particularly fast growing trees compete with farm crops for water, nutrient and space. Farmers in Pakistan, being mostly illiterate/unaware, so grow such trees with their crops which do not make a suitable/beneficial combination. So, the yields of crops are reduced

significantly. Another reason may be that the farmers grow trees on a relatively long rotation. So, competition increases between the crops and trees which results in yield reduction. *Populus deltoides* is one of the fast growing trees popular among the farmers for planting on their farmlands. However, a very little research has been carried out in Pakistan about the suitability of this commercial tree for planting along with various farm crops. *Populusdeltoides* is mostly grown in combination with wheat in central Punjab, Pakistan. It is an exotic tree. In Pakistan, the information/data on poplar tree cultivation along with farm crops



especially wheat crop is scarcely available (Aulakh, 2005).

Although, in India, research has been carried out on *Populus*-wheat cultivation in combination with one another. However, this research may not be equally applicable under the agro climatic conditions of Pakistan. So there is a need to conduct scientific research on *Populus*-wheat interaction under the climatic conditions of Punjab, Pakistan. Faisalabad is located in Punjab and Poplar –Wheat combination is a Popular combination among the farmers of Faisalabad (Punjab), Pakistan. Poplar is a fast growing tree and gives handsome income within a few years after planting. So, farmers like this tree to grow on their farmlands. Keeping in view these facts, the present research was carried out to know the actual impact of *Populus* trees on soil characteristics and grain yield of wheat crop.

It seems appropriate to have a review of the available literature regarding *Populus*-wheat interactions.

In many Indian states, *Populus* trees are grown with wheat, sugarcane, tomatoes and maize etc. A rotation of 6-8 years of *Populus* trees is followed for better economic returns (Sharma *et al.*, 2001).

A study was carried out to evaluate the effect of *Populus* trees on the yield of wheat crop. A reduction of 15.3% was noted in the yield of wheat crop cultivated with *Populus* trees (Sing *et al.*, 1993).

Two experiments were carried out. In 1st experiment, *Populus*, *Eucalyptus*, *Leucaenaleucocephala* and *Meliaazedrach* were grown with wheat crop. Grain yield was 25.6 quintals per hectare in case of *Populus*-wheat agro forestry system. It was 18.7 quintals in case of *Eucalyptus*-wheat combination. In second experiment, effect of *Populus* on wheat yield was evaluated. The grain yield was between 17.28 to 28.83 quintals per hectare under different tree densities. Low density produced more grains as compared to high density of trees per hectare (Sarvade *et al.*, 2014).

*Populus* trees were grown with wheat at 1-5 years age. At one year age of *Populus* trees, the wheat yield was 43.35 quintals per hectare. On the other hand, the wheat yield growing with 5 years old trees reduced to 25 quintals per hectare. The wheat yield reduced because of more shade of large sized trees and more root competition of trees with crop. Weight of 1000 grains was 47.50 g when age of trees was 1 year. The grain weight reduced to 37.15 g at 5 years age of trees (Chuhan *et al.*, 2012).

Performance of various wheat varieties was evaluated when grown with *Populus* trees. The yield of wheat was between 41.3 to 45.3 quintals per hectare at various tree densities (Bisht *et al.*, 2017).

Poplar trees were grown on various densities along with wheat. Wheat yield reduced as number of trees increased. Yield decreased from 27.9% to 59.2% at various densities of *Populus deltoides* (Sirohi *et al.*, 2016).

Review about effect of trees on various soil parameters is given below as it is also an important component of this research.

The soil characteristics under *Populus*-Sugarcane and *Populus*-wheat-sorghum tree crop combinations were investigated. The amount of organic carbon in the soil was 4.50 g per kilogram in case of *Populus*-wheat-sorghum system. While the amount of organic carbon in case of *Populus*-sugarcane system was 6.21 g per kilogram of soil (Singh and Sharma, 2007).

Soil characteristics under *Populus*-wheat intercropping systems were investigated. The percentage of organic carbon was 1.21 and 0.76% at 0-15 and 15-30 cm depth respectively in wheat monoculture. While organic carbon content was 1.44 and 1.55 in case of *Populus*-wheat intercropping at the same two depths of soil as indicated earlier. The amount of available nitrogen was 155 kg per hectare in case of wheat monoculture. On the other hand, it was 197.78 kg per hectare, in case of *Populus*-wheat agro forestry system. The amount of

phosphorus was 21.88 and 27.07 kg per hectare under wheat monoculture and *Populus*-wheat combination respectively. The amount of potash in both systems (monoculture and tree-crop combination) was 175.09 and 228.11 kg per hectare respectively (Uthappa *et al.*, 2015).

In a *Populus*-mustard agro forestry model, the amount of soil nitrogen was found to be 175.2 kg per hectare. While it was 167 kg per hectare under mustard monoculture. Similarly, the amount of phosphorus was 15.3 kg per hectare in agro forestry system and 14.5 kg per hectare in mustard monoculture. Furthermore, the amount of available potash was 131.8 and 158.3 kg per hectare in case of mustard and *Populus*-mustard agro forestry system (Ghimire and Bana, 2015).

Almost all the above mentioned research outcomes are from India. In Pakistan, a little literature is available about interactions of Poplar-wheat agro forestry systems. So, many aspects of *Populus*-wheat dynamics are still to be investigated. Keeping in view all above information/facts, the present study was designed with the objectives given below:

#### **Objectives of study:**

- (1) To evaluate the effect of *Populus deltoides*-wheat intercropping on soil characteristics.
- (2) To evaluate the effect of *Populus deltoides* trees on grain yield of wheat crop.
- (3) To find out the system among wheat monoculture and *Populus*-wheat systems which is more profitable.

## **2. MATERIALS AND METHODS.**

### **2.1. Soil collection and analysis**

Two fields were selected for present study. In one field, there were no trees. In the other field, 40 trees were growing at the boundary in linear style. Soil samples were taken from both fields at 0-15 and 15-30 cm depth. Various soil parameters viz. Ec, pH, organic matter, nitrogen, phosphorous, potash and saturation percentage were determined by using standard analytical techniques as described by (Qazi, 2020).

The brief description is given below. Nitrogen was determined by Kjeldal method using alkaline potassium permanganate. Phosphorous was checked/determined using Olsen's method. Potassium was determined by flame photometer and organic matter by Walkley and black method.

### **2.2. Selection of trees and measuring grain yield**

On an average, trees were 5 years old with straight stems. Their height was twelve meters with diameter of 42.43 cm. Wheat was sown in October 2020 and harvested in April 2021. From 2 to 24 meter distance from the stem of each tree, one meter square quadrat was put at each 2 meter interval/distance. The plants in each quadrat were harvested and grain yield was recorded by using an electronic weighing balance.

### **2.3. Economics of Wheat and Wheat + *Populus* trees:**

For calculating economics of wheat and (wheat + *Populus* trees), following assumptions were made. These assumptions were based on the research findings of (Chavanet *et al.*, 2022).

1. The trees affected the wheat crop only in the age of 3 to 5 years.
2. Loss in the yield of wheat crop due to trees was 9.735 maunds acre<sup>-1</sup> (actual calculation). So, loss in three years (from 3 to 5 years of age of trees) was 29.205 maunds acre<sup>-1</sup>.
3. Rice was the kharif crop. It also had to bear same loss as in wheat crop (9.735 maunds acre<sup>-1</sup>).
4. Rice had same yield/production and same price as wheat.
5. Total loss in both crops (wheat + rice) was 9.735 x 2 = 19.47 maunds acre<sup>-1</sup> per year. So, total loss in three years was 19.47 x 3 = 58.41 maunds acre<sup>-1</sup>.

## **3. RESULTS**

### **3.1. Soil parameters**

The percentage of sand, silt and clay was 45.53%, 28.45% and 26.03% respectively in the soil of wheat monoculture field at 0-15 cm depth. While the same was 44.98%,

**Table:1: Physical and chemical properties of soil as influenced by wheat crop and *Populus deltoides* +wheat crop**

Properties	Units	Wheat crop		<i>Populusdeltoides</i> + wheat crop	
		Depth (0-15cm)	Depth (15-30cm)	Depth (0-15cm)	Depth (15-30cm)
Sand	%	45.53	47.32	44.98	46.65
Silt	%	28.45	26.30	28.03	26.33
Clay	%	26.03	26.40	26.99	27.02
Saturation percentage	%	28	30.02	30	35.07
EC	dS m <sup>-1</sup>	1.84	1.74	1.53	1.55
Ph	-	7.32	7.54	7.03	7.28
Total nitrogen	%	0.05	0.04	0.08	0.07
Phosphorus	mg kg <sup>-1</sup> soil	5.90	6.20	8.90	6.89
Extractable Potassium	mg kg <sup>-1</sup> soil	121	106	156	126
Organic matter	%	0.64	0.49	0.91	0.77

28.03% and 26.99% in the soil of *Populus*-wheat field respectively at the same depth. EC was 1.84 and 1.74 dSm<sup>-1</sup> in wheat monoculture field and 1.53 and 1.55 dSm<sup>-1</sup> in *Populus* + wheat field at 0-15cm and 15-30 cm soil depths respectively. pH was 7.32 and 7.03 in wheat monoculture and *Populus*-wheat field at 0-15 cm soil depth respectively. Nitrogen was 0.05% and 0.04% in wheat monoculture soil and 0.08% and 0.07% in *Populus*-wheat field at depths of 0-15 and 15-30 cm respectively. The amount of phosphorous was 5.90 and 6.20 mg kg<sup>-1</sup> of soil in wheat monoculture where as it was 8.90 and 6.89 mg kg<sup>-1</sup> of soil in *Populus*-wheat field at same two depths. The amount of extractable potassium was 121 and 106 mg kg<sup>-1</sup> of soil in wheat monoculture while it was 156 and 126 mg kg<sup>-1</sup> of soil in *Populus*-wheat field at 0-15 and 15-30 cm of soil depth. The amount of organic matter was 0.64 and 0.49% in wheat monoculture and it was 0.91 and 0.77% in

*Populus*-wheat field at same two depths, respectively.

### 3.2. Grain yield of wheat

Wheat grain yield at 2m distance from the trees was 32.01 (gm<sup>-2</sup>) followed by 86.64 (gm<sup>-2</sup>) at 4m distance (table-2). At 10m distance it was 274.63 (gm<sup>-2</sup>) and at 12m distance, it was 341.76 (gm<sup>-2</sup>). On the other hand, grain yield at 2m distance from boundary (without trees) was 376.66 (gm<sup>-2</sup>) followed by 375.95 (gm<sup>-2</sup>) at 4m distance. The grain yield was 367.02 (gm<sup>-2</sup>) at 10 m distance and it was 372.06 (gm<sup>-2</sup>) at 12 m distance. It is evident that grain yield was minimum at a distance of 2m from trees and it increased gradually with increasing distance. It increased with increasing distance because shade and root competition decreased with increasing distance.

The grain yield at a distance of 14 meters from trees (table-4) was 364.42 (gm<sup>-2</sup>) and at 16 m distance, it was 362.51 (gm<sup>-2</sup>). The

grain yield at 24m distance was 371.68 (gm<sup>-2</sup>). The difference in grain yield was statically insignificant from 14 to 24 meters from trees. (Table-5). The grain yield (without trees) was 368.33(gm<sup>-2</sup>) to 371.57 (gm<sup>-2</sup>) from 14 to 24m distance

*Populus*-wheat agro forestry system (Table-6). The support price of wheat was Rs. 1800 per mond (Anonymous, 2023). So, the income from wheat was Rs. 67437.69 acre<sup>-1</sup> in monoculture. While the income from wheat crop was Rs.49919.03

**Table: -2: Wheat grain yield (gm<sup>-2</sup>) under wheat monoculture and *Populus* based agro forestry system at various distances (2 to 12 meters) from trees**

Distance from trees (meter)	Wheat yield under monoculture system (gm <sup>-2</sup> )	Wheat yield in <i>Populus</i> based agro forestry system (gm <sup>-2</sup> )
2	376.66	32.01
4	375.95	86.64
6	371.29	145.76
8	368.11	220.36
10	367.02	274.63
12	372.06	341.76

from boundary, which is also statistically non-significant.

acre<sup>-1</sup>.in *Populus*-wheat agro forestry system. Price of one standing tree was

**Table: -3: ANOVA table for wheat grain yield (gm-2) under monoculture and populus based agro forestry system at various distances (2 to 12 meters) from trees**

Source of variation	DF	SS	MS	F-value	P-value	Significance
Distance	1	529312	529312	1621.3	<2e-16	***
Treatment	1	366529	366529	1122.7	<2e-16	***
distance: treatment	1	282466	282466	865.2	<2e-16	***

Rs.4000 and total income from trees was

**Table: -4: Wheat grain yield (gm<sup>-2</sup>) under wheat monoculture and *populus* based agro forestry system at various distances (14 to 24 meters) from trees**

Source of variation	DF	SS	MS	F-value	P-value	significance
Distance	1	7.8	7.8	0.093	0.7679	NS
Treatment	1	0.8	0.8	0.009	0.9268	NS
Distance X treatment	1	516.9	516.9	6.194	0.0376	*
Residuals	8	667.5	83.4			

**Table: -5: ANOVA table for wheat grain yield (gm-2) under monoculture and populus based agro forestry system at various distances (14 to 24 meters) from trees**

Source of variation	DF	SS	MS	F-value	P-value	significance
Distance	1	7.8	7.8	0.093	0.7679	NS
Treatment	1	0.8	0.8	0.009	0.9268	NS
Distance X treatment	1	516.9	516.9	6.194	0.0376	*
Residuals	8	667.5	83.4			

\*only interaction is significant

### 3.3. Economics of wheat monoculture and *Populus*-wheat agro forestry system

Grain yield of wheat was found to be 37.465 monds acre<sup>-1</sup> in wheat monoculture while it was 27.73 monds acre<sup>-1</sup> in

160,000 acre<sup>-1</sup>. The price of trees was inquired/asked from the farmer. The trees reduced the wheat yield at a rate of 9.735 monds per acre. The loss in rice crop was same (as assumed) as in case of wheat. So, total loss per year was 19.47 monds acre<sup>-1</sup>

<sup>1</sup>and total loss in three years was 58.41 monds acre<sup>-1</sup> amounting to Rs. 105138. Thus, net income from *Populus*-wheat agro forestry system was Rs.104781.03 acre<sup>-1</sup> while it was only Rs. 67437.69 acre<sup>-1</sup> in wheat monoculture. Thus the net income from *Poplar* based system was Rs.37343.34 acre<sup>-1</sup> more than wheat monoculture.

under wheat-*Populus* agro forestry system, nitrogen was more (0.73%) as compared to sole wheat monoculture (0.34%). Similarly amount of phosphorous and potassium was also higher (7.72 and 4.35 mg kg<sup>-1</sup> of soil) in *Populus*-wheat agro forestry system as compared to wheat monoculture (4.53 and 2.12 mg kg<sup>-1</sup> of soil) at soil depths of 0-15- and 15-30 cm respectively.

**Table: -6. Yield and economics of wheat monoculture and (*Populus* + wheat) system**

	Wheat	Populus + wheat
	Crop yield (monds/acre)	
	37.465	27.73
Price per mond (Rs.)	1800	
Income from crop (Rs. Acre-1)	67437.69	49919.03
Income from one tree (Rs.)	-	4000
Total No. of trees acre-1		40
Income from all (40) trees (Rs. Acre-1)	-	160,000
Total income (Rs. Acre-1) (crop + trees)	67437.69	209919.03
Decrease/Loss in yield of wheat crop and rice crop collectively (monds/acre) in one year	9.735 x 2 = 19.47 monds per acre	
Decrease/Loss in yield of wheat crop and rice crop collectively (monds/acre) in three years	19.47 x 3 = 58.41	
Loss in monetary value (Rs.)	58.41 x 1800 = 105138	
Net income (Rs.)	67437.69	104781.03

#### 4. DISCUSSION

The amount of nitrogen, phosphorous and potassium is more in the field having trees along with wheat crop. It is a fact that trees increase the fertility of soil by adding organic matter in the form of leaves, flowers, fruits and branches etc. So, soil under agro forestry systems is usually more fertile as compared to soil under sole crop (Dori *et al.*, 2022). The present study has similar results to that of (Kanwal *et al.*, 2022) who stated that organic matter in sole wheat field was 0.53% while in *Populus* field, it was 0.97%. Total nitrogen was 0.03% and 0.09% in sole wheat and agro forestry system respectively. These results are also in line with the findings of (Fahad, 2022) who described that in soil

The wheat grain yield from 2m to 12m distance from trees was significantly different. However, in case of wheat monoculture, the grain yield was more or less same (significantly not different) at various distances from field boundary (without trees). These results are in line with the findings of Singh *et al.* (1993) and Hakeem *et al.* (2020) who described that grain yield of wheat was significantly less in *Populus*-wheat intercropping as compared to wheat monoculture. The results of present study are also confirmed by (Sarvade *et al.*, 2014) who reported that grain yield of wheat was more in monoculture (28.83 quintals ha<sup>-1</sup>) as compared to *Populus*-wheat intercropping (17.28 quintals ha<sup>-1</sup>).

The grain yield was significantly reduced up to the distance of 12 meters from trees. After 12 meters, grain yield was almost same. Our findings are also confirmed by (Chuhan *et al.*, 2012) who described that grain yield of wheat was 45.35 quintals ha<sup>-1</sup> at 1 year age of *Populus* trees while it was 25 quintals ha<sup>-1</sup> when trees were 5 years old. It is clear that no trees or very small trees (one year of age) do not decrease the grain yield of wheat crop significantly. However large trees obviously decrease the grain yield significantly. These results are also confirmed by the findings of (Sarvade *et al.*, 2014). He reported that wheat yield decreased as the number of trees per hectare increased. Although, the parameter is different in both studies. But it is proved that trees reduce grain yield especially when their number per unit area is more and/or they are large in size.

The net income from sole wheat crop was Rs. 67437.69 while it was Rs. 104781.03 from *Populus*-wheat agro forestry field. These results are verified/confirmed by the findings of (Singh and Kaur, 2020) who found that income from sole wheat crop was Rs. 77467 while it was Rs.112345 under *Poplar*-wheat agro forestry system. The results of current study coincide with the findings of (Chavan *et al.*, 2022) who described that income from sole wheat crop was Rs. 78954 and it was Rs. 134567 under poplar based agro forestry system.

## 5. CONCLUSION

Trees significantly decreased the yield of wheat crop as compared to wheat monoculture. However, the cultivation of wheat both in monoculture and with *Populus* trees was financially acceptable/suitable but in tree based system, it was more (by Rs.37343.34 acre<sup>-1</sup>). Moreover, the effect of trees on various soil physical and chemical properties was prominently better in case of *Populus* based agro forestry system as compared to wheat monoculture. So, farmers are advised to adopt *Populus*-wheat agro

forestry system rather than wheat monoculture to get better economic returns and improve soil fertility.

## 6. ACKNOWLEDGEMENT

The researcher is highly thankful to all his colleagues who encouraged him to carry out this research work.

## 7. REFERENCES

- Anonymous.2023.<http://www.amis.pk/Agristatistics/SupportPrice/wheat/wheat.htm>  
1. Browsed on 14-03-2023.
- Aulakh. 2005. Performance of poplar (*populus deltoides*) and its effect on wheat yield under agro forestry system in irrigated agro-ecosystem, India. *Cas. J. Env. Sci.* 10(1):53-60.
- Bisht, N., V. K. Sah, K. satyawali and S. Tiwar. 2017. Comparison of wheat yield and soil properties under open and Poplar based agro forestry system. *J. App. Nat. Sci.* 9(3):1540-1543.
- Chauhan, S. K., M. S. Brar and R. Sharma.2012. Performance of Poplar (*Populus deltoides*) and its effect on wheat yield under agro forestry system in irrigated agro-ecosystem, India. *Caspian, J. Env. Sci.* 10(1):53-60.
- Chavan, S. B., R. S. Dhillon and C. Sirohi.2022. Enhancing farm income through boundary plantation of poplar (*Populusdeltoides*): an economic analysis. *Sustain.* 14(3):1-17.
- Dori, T., Z. Asefaw and T. Kippie. 2022. Soil characteristics under dominant agroforestry systems along toposequence of Gedeo, Southeastern Ethiopia. *Environmental and Sustainability indicators.* 15(1): 369-377.
- Fahad, S., S. B. Chavan and A. R. Chichagare. 2022. Agro forestry

- systems for soil health improvement and maintenance. *Sust.* 14(22): 223-245.
- Ghimire, T. B. and O. P. S. Bana. 2015. Soil physic-bio-chemical properties under poplar + Indian mustard intercropping system. *J. Nepal. Agric. Res. Coun.* 1:14-20.
- Hakeem, S., Ali, Z., Saddique, M,A,B., Rehman. M.H.U. 2020. Line × tester analysis and estimating combining abilities for the physiological and yield traits inbred. *Agric. Sci. J.* 2(2): 19-29.
- Kanwal, M. S., A.K. Yadava and S.C.R. Vaishvakarma.2022. Crop productivity and soil properties under agroforestrysystem in kosi watershed of kumaun Himalaya. *Ind. J. Eco.* 49(1): 21-30.
- Qazi, A. 2020. Soil and water analysis manual. Soil fertility research institute, Lahore, Pakistan. Pp.11-20.
- Sarvade, S., H. S. Mishra, R. Kaushal, S. Chaturvedi, S. Tewari and T. A. Jadhav. 2014. Performamance of wheat (*Triticum aestivum*) crop under different spacing of trees and fertility levels. *Afr. J. Agric. Res.* 9(9): 866-873.
- Sharma, N. K., J. S. Sarma and H. P. Singh. 2001. Influence of boundary plantation of poplar (*Populus deltoides* M.) on soil–water use and water use efficiency of wheat. *Agri. Wat. Mgtt.* 51(3): 173-185.
- Sikander, K. Tanveer, Imtiaz Hussain , M. Sohail , N.S. Kissana and S.G. Abbas. 2003. Effects of Different Planting Methods on Yield and Yield Components of Wheat. . *As. J. Pl. Sci.* 2: 811-813.
- Singh A., R.S.Dhanda and P.K.Ralhan. 1993. Performance of wheat varieties under poplar (*Populusdeltoides*Bartr.) plantations in Punjab (India). *Agroforestry Systems.* 22(1): 83-86.
- Singh, B. and K. N. Sharma. 2007. Tree growth and nutrient status of soil in a Poplar (*Populusdeltoides*) based agroforestry system in Punjab, India. *Agrofor. Syst.* 70(1): 125-134.
- Singh, . and M. Kaur.2020. An Economic analysis of poplar cultivation in Punjab, India. *Econ. Aff.* 65(4): 535-542.
- Sirohi, C., K. S. Bangarwa, R. S. Dhillon and K. K. Bhardwaj. 2016. Performance of different wheat varieties under Poplar (*Populusdeltoides*) based agro forestry system. *Ind. J. Eco.* 43(2):752-755.
- Uthappa, A. R., O. P. S. Bana, M. Kumar and M. Kanwal. 2015. Soil physico-bio-chemical properties as influenced by varying tree densities in Poplar (*Populusdeltoides*) based agro forestry system. *Ind. J. Agrofores.* 17(11):81-90.