*Indian J. of Agroforestry Vol. 17 No. 2 : 70-75 (2015)*

# Cultivation of a high value crop – sweet corn (*Zea mays* Linn.) in poplar based agroforestry

**R.C. Dhiman and J.N. Gandhi**

*Wimco limited, R & D Center, Bagwala, Rudrapur, U.S.Nagar- 263 153. Uttarakhand, India*

*Corresponding author's E mail: Gandhi.jn@wimco.in*

**ABSTRACT:** The results of four field trials on growing sweet corn (*Zea mays* Linn.) under poplar plantations (clone WSL 39) of five different ages are presented. The age of poplar plantations was 2, 14, 26, 38 and 50 months when sweet corn was sown and 6, 18, 30, 42 and 54 months respectively when it was harvested. The intercrop was sown during April and harvested during August of 2006, 2007, 2008 and 2009.The results of sweet corn yield grown under poplar trees were also compared with that grown in open conditions. Results revealed that the age of poplar trees had significant influence on yield of sweet corn cobs and fodder. Tree height and diameter increment in 14 months old plantations was significantly higher than the other aged plantations. The economical analysis of growing sweet corn under poplar plantations indicated positive cash flow to the growers till the stage of 2 years age of trees and decreased thereafter.

***Key words***: Cash crops, commercial agroforestry, economics, fodder and Punjab

Received on: 28/10/2014 Accepted on: 19/07/2015

## 1. INTRODUCTION

Poplar (*Populus deltoides* Marsh) is extensively grown tree in commercial agroforestry in parts of North India. The tree is grown as a cash crop along with a very large number of agricultural crops for the greater period of its retention on the farm land. Poplar based agroforestry helps the growers to sustain crop production from intercrops whereas the sale of poplar trees provides cumulative tax-free agriculture income. Growing of cereals, cash crops, forage, etc. provide food and sale of these crops supplement income of the growers. Poplar trees get growth inputs from the normal agronomical operations and inputs like, irrigation, weeding, hoeing and fertilizers applied to intercrops during their cultivation under trees.

Maize (*Zea mays* L.) is one of the important cereal crop grown in poplar based agroforestry in many locations especially in some parts of Hoshiarpur and Jallundar districts of Punjab (Dhiman, 2012a). In India, it is grown for grain production, fodder and for sale of cobs for fresh roasting/baking. Different maize varieties are grown for seed, baby corn and sweet corn. Sweet corn is used in soup, fast food and for fresh eating on roasting, baking and boiling. Some information on effect of poplar trees on the production and yields of intercrops in poplar based agroforestry is available (Jain and Singh, 1999; Chauhan, 2000; Dhanda and Kaur, 2000; Moushin and Ram, 2002; Dhiman and Gandhi, 2011; Dhiman, 2012a). This study was conducted to assess the impact of tree age on productivity of sweet corn which is a high value crop and has a potential to provide additional income to the growers.

## 2. MATERIALS AND METHODS

The study was conducted at R and D Centre of Wimco Limited (Wimco Seedlings Division) situated at $28^0$N latitude, $78^0$E longitude and at an altitude of 200 above mean sea level. The centre is located in the Tarai belt, Kichha Tehsil of District Udham Singh Nagar, Uttarakhand. Annual rainfall and relative humidity of the locality varies from 1,500 mm to 1,800 mm and from 66 to 97 per cent respectively. This locality experiences humid sub tropical climate with hot dry summers and cool winters. Frost occurs towards the end of December and continues till the end of January. The soil of experimental site is clay loam. Block plantations of poplar clone WSL 39 were established at 5 X 5m spacing for consecutive five years w.e.f. 2004 to 2008 on the same field to create a series of age gradation for detailed study of intercrops grown there with. This series of poplar plantations was used to study the performance of sweet corn and its results are presented here.

Four experiments were laid out in a Randomized Block Design with four replications under poplar plantations

of different ages. Seed of sweet corn (Variety Sugar 75) @ 20 kg $ha^{-1}$ was sown at a spacing of 80 X 15 cm in 4-5 cm deep furrows made with the help of hand-hoe under poplar plantations and also under open conditions during the year 2006 to 2009. Fertilizers @ 120 kg N $ha^{-1}$, 60 kg P $ha^{-1}$ and 40 kg K $ha^{-1}$ were applied through urea, granular single super phosphate and murate of potash, respectively. Herbicide-Pendamethalene 30% EC @ 1 litre $ha^{-1}$ was applied within 36 hours of seed sowing to control weeds.

Sweet corn seed was sown during the month of April each year under poplar plantations which were established during different years as per details given in Table 1. For example, sweet corn was sown in April when the trees completed 2, 14, 26, 38, 50 and 62 months age and experiment was terminated when trees were of 6, 18, 30, 42, 54 and 66 months age, respectively. Sweet corn was also grown in open conditions each year for comparison of yield and its attributes with that grown under poplar plantations.

Height and girth of trees were recorded on the start and termination of the experiments and the data on crop yield and yield attributes were recorded at the time of harvesting the intercrop. The data obtained during the course of this study were analyzed, standard error of means (S. Em.±) computed and the critical difference (C.D.) at 0.05 probability level were calculated for comparing the treatment means.

## 3. RESULTS AND DISCUSSION

### Tree Growth

Tree growth between the start and completion of the experiment during the year 2006, 2007, 2008 and 2009 are presented in Table 2 and Table 3, respectively. A perusal of results presented in the Table indicates significant differences in mean values for height, girth

Table 1. Age of poplar plantations on start and termination of experiments

| Year of plantation | Age of plantations (months) during the years of growing sweet corn | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2006 | | 2007 | | 2008 | | 2009 | |
| | On start | On termination | On start | On termination | On start | On termination | On start | On termination |
| 2008 | | | | | 2 | 6 | 14 | 18 |
| 2007 | | | 2 | 6 | 14 | 18 | 26 | 30 |
| 2006 | 2 | 6 | 14 | 18 | 26 | 30 | 38 | 42 |
| 2005 | 14 | 18 | 26 | 30 | 38 | 42 | 50 | 54 |
| 2004 | 26 | 30 | 38 | 42 | 50 | 54 | 62 | 66 |

Table 2. Tree height (m) and girth at breast height (cm) at the start of experiment

| Age of trees (months) | Year of plantation | | | | | | | | Weighted average | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2006 | | 2007 | | 2008 | | 2009 | | | |
| | Height | GBH | Height | GBH | Height | GBH | Height | GBH | Height | GBH |
| 2 | 4.0 | 6.2 | 4.3 | 7.2 | 2.0 | 2.4 | | | 3.4 | 5.2 |
| 14 | 8.4 | 21.9 | 6.9 | 20.1 | 5.4 | 12.3 | 4.2 | 8.5 | 6.2 | 15.7 |
| 26 | 12.2 | 33.9 | 13.3 | 38.4 | 10.1 | 31.5 | 9.4 | 29.2 | 11.2 | 33.2 |
| 38 | | | 14.9 | 42.7 | 15.9 | 48.0 | 13.8 | 45.6 | 14.9 | 45.4 |
| 50 | | | | | 17.4 | 57.9 | 18.8 | 59.0 | 18.1 | 58.4 |
| 62 | | | | | | | 19.2 | 64.4 | 19.2 | 64.4 |
| Mean | 8.2 | 20.7 | 9.8 | 27.1 | 10.2 | 30.4 | 13.1 | 41.3 | 12.2 | 37.1 |

Table 3. Tree height (m) and girth at breast height (cm) at the harvesting of maize

| Age of trees (months) | Year of plantation | | | | | | | | Weighted average | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2006 | | 2007 | | 2008 | | 2009 | | | |
| | Height | GBH | Height | GBH | Height | GBH | Height | GBH | Height | GBH |
| 6 | 5.4 | 11.6 | 6.7 | 16.2 | 3.5 | 6.9 | | | 5.2 | 11.6 |
| 18 | 11.2 | 32.2 | 10.4 | 32.6 | 9.0 | 25.5 | 9.0 | 25.3 | 9.9 | 28.9 |
| 30 | 14.0 | 39.1 | 16.2 | 45.4 | 13.0 | 41.7 | 12.2 | 43.0 | 13.8 | 42.3 |
| 42 | | | 17.6 | 52.1 | 17.8 | 54.9 | 16.0 | 57.2 | 17.1 | 54.7 |
| 54 | | | | | 18.7 | 60.9 | 20.3 | 66.6 | 19.5 | 63.7 |
| 66 | | | | | | | 20.4 | 68.4 | 20.4 | 68.4 |
| Mean | 10.2 | 27.6 | 12.8 | 36.6 | 12.7 | 38.0 | 15.7 | 52.1 | 14.3 | 49.9 |

and increment of poplar trees of different ages between sowing and harvesting of sweet corn.

Results revealed that trees grew and increased in size with age. Trees were able to grew to 20.4 m in height and 68.4 cm in girth at breast height (GBH) at the end of 66 months age. Tree size both in height and girth is a function of age and site conditions and therefore, the trees of old ages are taller in height and thicker in girth. Trees at the age of 18 months attained maximum height and girth increment, whereas, 66 months old trees attained minimum height and girth increment growth. Poplar is a fast grown tree and its growth curve between Current Annual Increment (CAI) and Mean Annual Increment (MAI) culminates at a very young age of 2-3 years (Dhiman, 2012b). Poplar takes some time immediately after planting to establish its lateral feeding root system and puts up maximum height and diameter growth during second and third year, and starts declining thereafter (WSD, 2009). The experimental period for cultivation of sweet corn between April and August is also the main growing period for poplar trees and therefore they grew maximum during this period in all ages of plantations.

**Crop yield**

The data on cob and fodder yield of sweet corn grown under poplar plantations of different ages during the years 2006, 2007, 2008 and 2009 are presented in Table 5. Results revealed that crop grown under open conditions had produced maximum cob and fodder yield, whereas, crop grown under older plantations produced less cob and fodder yield. The productivity of sweet corn was affected with increasing shade of old trees. The magnitude of reduction in crop yield decreased with the increase in tree age. The mean values for cob and fodder yield were significantly higher under open conditions when compared with yield obtained under 6, 18 and 30 months old trees during the year 2006. Similarly, mean values of cob yield were significantly higher under open conditions, followed by that in 6 and 18 months old trees when compared with yield obtained from maize under 30 and 42 months old plantations. The productivity of intercrops under agroforestry is affected due to competition for light, water and nutrients between trees and crops. The competition for resource sharing gradually increases with the expansion of canopy and root system of trees. This trend of reduction in cob and

Table 4. Increment in tree height (m) and GBH (cm) for different years experiments

| Age of trees (months) | Year of plantation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2006 | | 2007 | | 2008 | | 2009 | | Weighted average | |
| | Height | GBH | Height | GBH | Height | GBH | Height | GBH | Height | GBH |
| 6 | 1.4 | 5.4 | 2.4 | 9.0 | 1.5 | 4.5 | | | 1.8 | 6.3 |
| 18 | 2.8 | 10.3 | 3.5 | 12.5 | 3.6 | 13.2 | 4.8 | 16.8 | 3.7 | 13.2 |
| 30 | 1.8 | 5.2 | 2.9 | 7.0 | 2.9 | 10.2 | 2.8 | 13.8 | 2.6 | 9.0 |
| 42 | | | 2.7 | 9.4 | 1.9 | 6.9 | 2.2 | 11.6 | 2.3 | 9.3 |
| 54 | | | | | 1.3 | 3.0 | 1.5 | 7.6 | 1.4 | 5.3 |
| 66 | | | | | | | 1.2 | 4.0 | 1.2 | 4.0 |
| Mean | 2.0 | 7.0 | 2.9 | 9.5 | 2.2 | 7.6 | 2.5 | 10.8 | 2.2 | 7.8 |
| SE diff. | 0.13 | 0.52 | 0.24 | 0.49 | 0.30 | 0.54 | 0.31 | 0.82 | | |
| CD 0.05 | 0.38 | 2.51 | 17.6 | 3.14 | 18.7 | 3.03 | 20.4 | 4.31 | | |

Table 5. Fresh Yield (t/ha) of sweet corn cobs and fodder under different aged poplar trees

| Age of trees (months) | Year of plantation | | | | | | | | Weighted average | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2006 | | 2007 | | 2008 | | 2009 | | | |
| | Cobs | Fodder | Cobs | Fodder | Cobs | Fodder | Cob | Fodder | Cobs | Fodder |
| 6 | 25.00 | 9.62 | 20.70 | 16.35 | 15.48 | 15.15 | | | 20.39 | 13.71 |
| 18 | 12.25 | 2.02 | 18.17 | 15.70 | 14.79 | 13.17 | 7.19 | 9.24 | 13.10 | 10.03 |
| 30 | 9.12 | 0.475 | 10.72 | 5.00 | 13.90 | 10.25 | 6.65 | 9.14 | 10.09 | 6.22 |
| 42 | | | 9.17 | 0.67 | 9.62 | 9.37 | 6.51 | 6.64 | 8.43 | 5.56 |
| 54 | | | | | 9.28 | 7.50 | 5.27 | 6.57 | 7.27 | 7.03 |
| 66 | | | | | | | 4.30 | 5.10 | 4.30 | 5.10 |
| Open field | 33.95 | 17.05 | 25.22 | 18.60 | 17.72 | 15.85 | 8.60 | 10.04 | 21.37 | 17.167 |
| Mean | 20.08 | 7.29 | 16.80 | 11.26 | 13.46 | 11.88 | 6.42 | 7.79 | 10.09 | 9.71 |
| SE diff. | 2.863 | 1.556 | 2.745 | 1.823 | 1.238 | 1.432 | NS | NS | | |
| CD0.05 | 6.24 | 3.39 | 5.849 | 3.886 | 2.639 | 3.008 | | | | |

fodder yield was also observed in other years, though in some cases the differences in the mean values were non-significant. Dhiman and Gandhi (2007) while growing *Tagetes minuta* under 3 to 7 years old poplar plantations reported less yield of intercrop under older plantations compared to that under young plantations.

Crop yield recorded during the year 2009 under all plantations and open conditions were affected due to heavy rains that year. Non significant differences were noticed in cob and fodder yield of sweet corn grown under different aged poplar trees as well as under open field conditions that year. The crop grown under open conditions recorded maximum mean values for cob and fodder yield, whereas crop under 66 months old tree canopy recorded minimum mean values.

Compared to open conditions the over all yield was reduced by 4.58%, 38.69%, 52.78%, 60.55%, 65.98% and 79.87% for cobs and 20.13%, 41.57%, 63.76%, 67.61%, 59.04% and 70.29% for fodder under 6, 18, 30, 42, 54 and 66 months old trees, respectively. The findings of the study are in line with those conducted for other crops (Saroj and Dadhwal, 1997: Vyas and Nein, 1999: Chauhan *et al.*, 2010) who reported the adverse effect of tree age and size on yield of intercrops. Poplar being a fast grown tree quickly expands crown and canopy on field planting. Reduced incident of photosynthetic photon flux density (PPFD) under tree canopy is critical for growth and development of intercrops under tree canopies (De Castro 2000). Studies with some agri-crops grown under varying light intensities created through shade nets have demonstrated that 33% shade is the critical limit for growing those intercrops (Alam *et al.,* 2010, 2014). Dhiman (2009) reported the crown cover of poplar trees of 1, 2, 3, 4, 5 and over 6 year old trees as 21.24%, 32.22%, 52.84%, 78.56%, 95.08%, and 100% respectively. Sweet corn was grown as a summer crop in the present studies when poplar trees are not leafless. As a result, poplar casts heavy shade on intercrops and is one of the major reasons for reduced sweet corn yield in the present studies.

**Cost of Cultivation**

Component wise cost of cultivation of sweet corn under poplar trees of different ages during different years of study was recorded separately and is summarized in Table 6. The increase in production cost in the later years was mainly due to increase in labour cost which was influenced by the plucking cost of sweet corn cobs. The cost of cultivation consists of expenditure incurred on soil preparation, seed, fertilizer, chemical and labour. The total operational cost includes cost of agronomical practices and collection of cobs. The cost was different for different years and under different plantations due to seasonal and annual variation in labour efficiency and labour rates. The cost of cultivation varied from year to year during the course of investigation

Economics of growing sweet corn under different aged poplar plantation and that grown under open field conditions during the year 2006, 2007, 2008 and 2009 are tabulated in Table 7. The net returns from sweet corn grown under poplar plantations varied from year to year, maximum of which was obtained from the crop grown under open field conditions followed by that grown under 6 months old trees. Lower net returns under higher aged plantation indicated the lower crop productivity due to high shade intensity. The net returns from sweet corn crop decreased with the increase in age of plantation.

Table 6. Item wise cost of cultivation of sweet corn in different years

| Sl. No. | Description | Cost/ha (₹) | | | | |
|---|---|---|---|---|---|---|
| | | 2006 | 2007 | 2008 | 2009 | Weighted Average |
| 1 | Cost of seed | 1200 | 1500 | 1800 | 2500 | 1750 |
| 2 | Field preparation | 2850 | 3150 | 3450 | 3325 | 3194 |
| 3 | Labour cost-sowing and preparation of bunds | 425 | 575 | 625 | 775 | 600 |
| 4 | Labour cost-application of fertilizer and chemicals | 315 | 375 | 425 | 625 | 435 |
| 5 | Labour cost-irrigation | 725 | 775 | 825 | 925 | 812 |
| 6 | Labour cost-hoeing/weeding | 5000 | 5500 | 6000 | 6500 | 5750 |
| 7 | Cost of Fertilizers and Chemicals | 2875 | 3175 | 3245 | 3275 | 3142 |
| 8 | Harvesting of Fodder | 1575 | 1675 | 1750 | 2250 | 1812 |
| | Total Expenses/ha (Rs.) | 14965 | 16725 | 18120 | 20175 | 17496 |

Table 7. Economics of sweet corn cultivation under different aged poplar trees

| Age of trees months | During the year 2006 | | During the year 2007 | | During the year 2008 | | During the year 2009 | | Weighted Average | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total Return | Net Profit | Total Return | Net Profit | Total Return | Net Profit | Total Return | Net Profit | Total Return | Net Profit |
| 6 | 25490 | 5715 | 47085 | 14010 | 43355 | 9755 | | | 38643 | 9827 |
| 18 | 7102 | (8872) | 44701 | 12276 | 41254 | 8214 | 48954 | 13539 | 35503 | 6289 |
| 30 | 3220 | (11980) | 15716 | (6009) | 37825 | 5805 | 46159 | 11664 | 25730 | (130) |
| 42 | | | 4451 | (12954) | 26864 | (876) | 41444 | 8229 | 24253 | (1867) |
| 54 | | | | | 25450 | (1950) | 33860 | 3165 | 29655 | (607) |
| 66 | | | | | | | 26265 | (2070) | 26265 | (2070) |
| Open | 42587 | 19097 | 54066 | 18741 | 48845 | 13005 | 55174 | 17779 | 50168 | 17155 |

Economics and returns from tree and crop culture in agroforestry depend on numerous factors of which the existing market conditions play a significant role. Some reports are now available on the returns from poplar based agroforestry (Chaudhary and Chaudhary 2012, Dhiman and Gandhi, 2007; Chauhan, 2003a, 2003b and others), many of which are locality, intercrop and input specific. The present study provided returns from sweet corn as intercrop grown under poplar in isolation from other crops grown in other seasons and years in the same experiment.

The net weighted average for losses on cultivation of sweet corn under 66, 54, 42 and 30 months old plantations were ‘ 2070, 607, 1867 and 130 per ha, respectively. These are nominal losses and well compensated from the sale of trees on their maturity. Many growers maintain their poplar plantations without intercrops during summers and apply additional inputs on ploughing, irrigation and fertilizers etc. Growers who do not grow summer crops, plough fields after wheat harvest, apply one bag of single super phosphate and one bag of murate of potash per acre to supplement nutrients for poplar in absence of intercrops. The cost on these inputs is much higher than some losses on account of taking sweet corn in summers under poplars as indicated in the present study.

It is established from the present study that sweet corn can be economical viable crop under poplar plantations till the second year of tree growth and a substitute for sugarcane for first and second year of poplar plantations where the later crop is not grown. Sweet corn as a summer crop could be an option for integration with poplar when farmers have no choice for crop selection for poplar based agroforestry during summer season in some locations.

## REFERENCES


Alam, B., Chaturvedi, M., Singh, A.K., Newaj, R. and Dhyani, S.K. 2014. Microclimatic modification through agroforestry in the context of climate change: An eco-physiological appraisal. *Indian Journal of Agroforestry*, 16(1): 1-8.

Alam, B., Singh, R., Newaj, R. and Ram, M. 2010. Shade induced changes on the photochemical efficiency of green gram (*Vigna radiate* L.,). *Range Management and Agro forestry*, (B):194-196.

Chaudhary, N.P. and Chaudhary, G. 2012. Poplar culture on farmland: Farmer’s experience from Uttar Pradesh. *ENVIS Forestry Bulletin*, 12(1): 68-74.

Chauhan, V.K. 2000. Evaluation of wheat and maize varieties under poplar based agroforestry system in Paonta Valley. Ph. D. Thesis, Division of Extension Education, FRI (Deemed University), Dehradun.

Chauhan, H.S. 2003a. Growing medicinal and aromatic crops under well developed poplar and eucalypt plantations. In: National Symposium on Agroforestry in 21st Century, Ludhiana, February, 11-14, 2003, Abstracts. Ludhiana, P.A.U. p. 9.

Chauhan, H.S. 2003b. Performance of poplar (*Populus deltoides*) based agroforestry system using aromatic crops. *Indian Journal of Agroforestry,* 2: 17-21.

Chauhan, Sanjeev K., Sharma, S.C., Chauhan, R., Gupta, Naveen and Ritu. 2010. Accounting poplar and wheat productivity for carbon sequestration in agri-silvicultural system. *Ind. For.*, 136(9): 1174-1182.

De Castro, F. 2000. Light spectral composition in a tropical forest: measurements and model. *Tree Physiol.*, 20:49-56.

Dhanda, R. S. and Kaur, I. 2000. Production of poplar (*P. deltoids* Batr.) in agri-silviculture system in Punjab. *Indian J. Agroforestry* 2:93-97.

Dhiman, R.C. 2009. Carbon footprint of planted poplar in India. *ENVIS Forestry Bulletinl*, 9(2): 70-81.

Dhiman, R.C. 2012a. Diagnosis of intercrops for poplar based agroforestry. *Indian Forester*, 138(7):600-609.

Dhiman, R.C. 2012b. Status of poplar culture in India. *ENVIS Forestry Bulletin*, 12(1):15-32.

Dhiman R.C. and Gandhi, J.N. 2007. Growing of medicinal and aromatic plants in agroforestry: WIMCO’s experience. *ENVIS Forestry Bulletin*, 7(2): 34-45.

Dhiman, R.C. and Gandhi, J.N. 2011. Agro-economical analysis of cultivating medicinal aromatic plan-*Ammi majus* Linn. In poplar based agroforestry. *Indian J. Agro forestry*, 13(2): 59-64.

Jain, S.K. and Singh, P. 1999. Performance of intercrops in agroforestry system: The case study of poplar (*Populus deltoides*) in Uttar Pradesh (India). *Indian Forester*, 125(2): 195-205.

Moushin, F. and Ram, B. 2002. Sixty month study on litter production, changes in soil chemical properties and productivity under poplar (*Populus deltoides*) intercropped with wheat. *Indian J. of Agroforestry*, 4(2): 81-88.

Saroj, P.L. and Dadhwal, K.S. 1997. Present status and future scope of mango based Agroforestry in India. *India J. Soil Cons.*, 25(2): 118-127.

Vyas, S. and Nein, S. 1999. Effect of Shade on the growth of *Cassia unguisitifolia*. *Indian Forester*, 125: 407-410.

WSD. 2009. Annual Research Report, Wimco Seedlings Division (Wimco Ltd.), Rudrapur, U.K.