Indian J. of Agroforestry Vol. 18 No. 2 : 47-52 (2016)

Performance of climber type of medicinal plants in poplar based agroforestry system

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ABSTRACT: In order to evaluate the performance of medicinal climbers, in poplar based agroforestry system as an alternate crop in addition to traditional crops, a study was carried out. Three climber type medicinal plants *viz*., *Asparagus racemosus* (shatawari), *Mucuna puririta* (kwanch) and *Tinospora cordifolia* (giloe) were planted with poplar trees. Trees were planted at three spacing i.e. 5 × 4, 10 × 2, 18 × 2 × 2 m (paired row) and control and were thrice replicated. The medicinal climbers were planted near the poplar trees of two years age at 1 m distance from the tree trunks, in all the three spacing treatments with twenty trees in each replication. These were allowed/ aided to climb the trees, so that they do not require additional area for growing and replicated thrice in all the spacing's of poplar. The annual crop (kwanch) had a very poor germination and later establishment under the tree canopies, however the other perennial type of medicinal crops i.e. giloe and shatawari grew significantly better (in terms of growth parameters such as plant height, collar diameter and number of branch etc.), in close spacing of poplar i.e. 5 × 4 and 10 × 2 m as compared to the wider spacing of 18 × 2 × 2 m and control. Yield of both (shatawari and giloe) was also maximum in 5 × 4 m spacing (5.2 kg/plant in shatawari, 55 kg/ plant in giloe) and decreased significantly in wider spacing and control, however in kwanch seed yield per ha was highest in control (155.3 t/ha) and it decreased with decreasing spacing of poplar. Quality parameters such the total bitter content for giloe, saponin content for shatawari and L-dopa content was more in 5 × 4 m spacing of poplar and decreased significantly in wider spacing's and control.

Key words: Agroforestry, *Asparagus racemosus, Mucuna puririta, Populus deltoides* and *Tinospora cordifolia*.

Received on: 01.08.2016 Accepted on: 01.12.2016

1. INTRODUCTION

Shade loving perennial medicinal plants grow better under the shade of tree canopy and the shade proves significantly beneficial for the growth and yield of the crops underneath. As they provide ambient conditions similar to that available in the natural forests. A number of tropical medicinal and aromatic plants (MAPs) are well adapted to partial shading, moist soil, high relative humidity and mild temperatures (Vyas and Nein, 1999; Bimlendra and Madan, 2014), which suggests medicinal plants as a perfect crop to be intercropped with trees yielding timber and fuel wood, fruit trees etc. Some well known medicinal plants that have been successfully intercropped with fuel wood trees (e.g. *Acacia auriculiformis*, *Albizia lebbeck, Eucalyptus tereticornis, Gmelina arborea* and *Leucaeana leucocephala*) in India, include safed musli (*Chlorophytum borivilianum*), rauvolfia (*Rauvolfia serpentina*), turmeric (*Curcuma longa*), wild turmeric (*C. aromatica*), *Curculigo orchioides* and ginger (*Zingiber officinale*) (Chadhar and Sharma, 1996; Mishra and Pandey, 1998; Prajapati *et al*., 2003). Only four out of 6454 herbaceous medicinal plants tried in intercropping with two-year old poplar (*Populus deltoides*) spaced 5 m apart gave poor performance (Kumar and Gupta, 1991), indicating that most of the medicinal plants can be grown in agroforestry systems. The trees may benefit from the inputs and management given to the intercrops. Short stature and short cycle MAPs and culinary herbs are particularly suited for short-term intercropping during the juvenile phase of trees. Wherever markets are established, MAPs are remunerative alternative intercrops to the traditionally grown annual crops (Maheswari *et al*., 1985; Zou and Sanford, 1990). The duration, MAPs can be intercropped with a given tree species depends on the size and intensity of its canopy shade, tree spacing and management.

Poplar based agroforestry systems have been

conveniently adopted by the farmers of India because of the several added advantages associated with the tree. Poplar tree is known to cause a negligible effect on the intercrops during the first three years of growth. A significant (40-45%) decrease in the yield of traditional crops is observed after 3year of planting. Shade loving and perennial medicinal crops can be a very viable and profitable option for inclusion in these systems after 3 years of tree growth (Bimlendra and Madan, 2016). The present work was carried out to find out best suited, perennial, shade-tolerant and rhizomatic medicinal climber type plants which, can be grown on a long-term basis in poplar based agroforestry.

2. MATERIALS AND METHODS

The poplar trees were planted in 2007 in three spacing's i.e. 5 × 4 m, 10 × 2 m and 18 × 2 × 2 m (paired rows) in the farm area of Department of Forestry, Haryana Agricultural University, Hisar, Haryana. The geographical location of Hisar is 29° 10' N latitude and 75° 46' E longitude with an elevation of 215.2 m above the mean sea level.

Three of the climber type of medicinal crops giloe (*Tinospora cordifloia*), shatawari (*Asparagus racemosus*) and kwanch (*Mucuna puririta*) were raised in nursery area of the department and transplanted near the poplar trees of two years age at 1 m distance from the tree trunks, in all the three spacing treatments with twenty trees in each replication. These were allowed/ aided to climb the trees, so that they do not require additional area for growing and replicated thrice in all the spacing's of poplar. The sole crops of all medicinal plants and poplar were maintained as controls and were planted in completely randomized block design with three replications each.

The recommended cultural practices for all the medicinal crops and poplar were followed; data was collected for growth parameters annually for all crops and poplar tree and yield, quality parameters at the time of maturity (i.e. for annual plant kwanch, after five months of planting and for rest of the perennial crops, after 36 months of planting).

The planting material of all the medicinal crops was procured from the section of medicinal and aromatic plants of Department of Plant Breeding, CCS Haryana Agricultural University, Hisar. Data were collected for growth parameters (plant height, collar diameter, leaf number, number of branches etc.) for giloe and shatawari annually, except kwanch (after five months at maturity) and poplar trees (tree height and dbh). Yield and quality parameters were taken at the time of maturity (after 36 months of planting), except kwanch.

Quality analysis of medicinal plants was conducted at Quality Analysis Laboratory of Medicinal and Aromatic Plants, MAP Section, Department of Genetics & Plant Breeding and Department of Chemistry & Physics, CCS Haryana Agricultural University, Hisar. Saponin content in shatawar tubers was estimated by following the method of Birk *et al.,* (1963) with some modifications by Madan *et al.,* (2008). Bitter principles (%) in giloe were estimated by following the method of Srivastava *et al*., (1959) with some modifications and La-Dopa content was estimated by method given by Parikh *et al*., (1989).

The light interception was measured with Lux meter during the month of October, November at three times (10 AM, 1 PM and 4 PM), weekly during crop growth years, under all the poplar spacing treatments.

The data were statistically analyzed to examine the significant variations of results due to different spacing of poplar (Panse and Sukhatme, 1985). Economics of various treatments was worked out taking into account the current costs of inputs and produce.

3. RESULTS AND DISCUSSION

The results of this experiment were quite encouraging in terms of desired outcome in the form of yield from individual medicinal plants grown in three tier arrangement of the novel silvo-agri-medicinal system.

Growth characters of climbers with poplar at different spacing

***T. cordifolia* (giloe):** Plant height and collar diameter in case of giloe, was significantly heigher in 5 × 4 m spacing and it decreased with increasing spacing and control. Plant height of giloe in closest spacing was 32.5% more than that of control, while in case of shatawari it was 21.7% more in 5 × 4 m as compared control (Table 2).

***A. racemosus* (shatawari):** In 5 × 4m spacing, other

growth characters of shatawari i.e. branch no. (28), tuber length (38 cm), no. of tubers/plant, leaf no. and branch no. were significantly higher as compared to control and the wider spacings. Islam *et al*., (2013) also reported similar results. Similarly the economic yield of tuber crops such as kalihari, kali musli, safed musli when grown as intercrops was significantly higher than sole crops (Solanki *et al*., 2013). This might be due to the shade effect in the closer spacings of poplar tree, which is beneficial for growth and tuber yield of the plant (Table 1 and 2).

Table 1. Available radiation under three different spacings of poplar in terms of PAR

Tree spacing (m)	Time 10 am	Time 1 pm	Time 4 pm	Mean	Incident radiation (%)
5x4	2400	38200	2000	14200	31.8
10x2	2650	47300	3200	17716	39.7
18x2x2	4400	47800	3100	18433	41.3
Control	42000	64600	27100	44566	-

(Control is without trees)

Table 2. Effect of poplar spacing's on growth of giloe, Shatawari and kwanch

Growth, yield parameters and yield	Poplar spacing (m)				C.D. at 5%
	5 × 4	10 × 2	18 × 2 × 2	Control	
			Giloe		
Plant ht. (cm)	36.6	21.5	11.8	11.9	9.6
Collar dia. (mm)	20	17	15	12	2.8
			Shatawari		
Plant ht. (cm)	4.6	3.8	2.7	2.0	0.7
Collar dia. (mm)	1.2	0.8	0.7	0.6	0.03
Branch No.	28	22	23	18	5.4
Tuber length (cm)	38	35	35	24	4.2
No. of tubers/plant	28	29	20	18	6.2
			Kwanch		
Plant ht. (m)	7.4	6.5	5.9	4.5	1.2
Collar dia. (mm)	24	22	20	20	NS
Leaf No.	46	44	36	33	3.2
Branch No.	5	4	3	3	1.0

***M. puririta* (kwanch):** In case of closer spacing of poplar seems to have adversely affected the height and collar diameter growth. The growth in height and collar diameter was maximum (7.4 m, 24 mm, respectively) in control and minimum (4.5 m, 20 mm, respectively) in 5 × 4m spacing. Plant height was significantly affected with the increased shade in closer spacings of poplar, while decrease in collar diameter growth was not statistically significant (Table 2). However leaf number and branch number were significantly more in closer spacings, maximum being in 5 × 4m (46, 5 respectively).

Yield and quality of giloe, shatawari and kwanch

***T. cordifolia* (giloe):** Growth in terms of plant height and girth, fresh and dry yield and quality in terms of total bitter content % has been found to be significantly more in the closer spacings i.e. 5 × 4 m and 10 × 2 m of poplar as compared to the wider spacing (18 × 2 × 2m) and control.

Dry yield of giloe increased to more than double to that of control in closest spacing of 5 × 4 m and the yield increased significantly as compared to control with the decreasing spacings of poplar (14.7 t/ha in 5 × 4 m,12.2 t/ha in 10 × 2 m,10.2 t/ha in 18 × 2 × 2m and 7 t/ha in control), confirming the shade preferring nature of the plant. There are several previous reports, showing positive effect on yield of medicinal crops, when grown with trees. The herbage yield of coleus aloe and lemon grass increased, when planted under Teak (Pujar, 2007).

Quality of giloe in terms of the total bitter content was analyzed on maturity and it has been found to significantly increase (0.65, 0.63, 0.59 and 0.57% in 5 × 4 m, 10 × 2 m, 18 × 2 × 2 m and control, respectively) with decreasing space between poplar rows. This indicates the shade enduring nature of the plant (Table 1 and 3). The prospects of growing indigenous MAPs such as "japana" (*Eupatorium triplinerve*), worry wine (*Stachytarpheta jamaicensis*), inflammation bush (*Verbersina alata*) and lemongrass (*Cymbopogon citratus*) in association with the medicinal trees noni (*Morinda citrifolia*) and moringa have been explored. These local herbs are commonly used as bush teas and very popular in the Caribbean. Medicinal plants and herbs in intercropping produced similar yields and better quality to those in sole cropping (Palada and Williams, 2000).

***A. racemosus* (shatawari):** Plant height and collar diameter was significantly high in all the tree spacings as compared to control (0.8 cm in 5 × 4, 10 × 2 m, 0.7, 0.6 cm in 18 × 2 × 2 and control) and the growth increased with decrease in spacings (4.6 m in 5 × 4, 3.8 m in 10 × 2 m, 2.7 m in 18 × 2 × 2 and 2 m in control). Number of leaves, no. of tubers per plant was showed similar results, fresh weight of tuberous roots of asparagus was highest in 5 × 4 m poplar spacing (2.4 t/ha, 1.8 t/ha, respectively), which was just double to that of control.

The dry yield of shatawari tubers ranged from 1.2 - 1.8 t/ha in different tree spacing's. It was significantly more (1.8 t/ha) in the closer spacings i.e. 5 × 4 m and 10 × 2 m of poplar as compared to the wider spacing 18 × 2 × 2m (1.5 t/ha) and control (1.2 t/ha). The saponin content percent however was highest (4.5%) in 5 × 4 m followed by 10 × 2 m spacing of poplar (4.3%).

However, the increase in fresh yield in fourth year was three times more, dry yield was about eleven times more as compared to yield of 3rd year. This drastic increase during 4th year was due to the fact that this plant adds much more biomass in the underground rhizome portion, in later growth years. The drastic increase in the dry yield during 4th year is also attributed to the low moisture content. Rahman (2004) harvested bumper yield of ginger from partial shade conditions. Jayachandra *et al*., (1998) reported in Kerala, India that coconut + ginger system under rainfed conditions gave better yield (11-27%) higher than the open field.

In Karnataka and Kerala states, India, areca nut palm is commonly intercropped with ginger, turmeric, black pepper (*Piper nigrum*) and cardamom (Korikanthimath and Hegde, 1994). Some of these intercrops may cause small reduction in areca nut yields but the combined returns from both the components are greater than s to control. Hence the increase in saponin content can be attributed to lesser availability of light in closer spacing (Table 3), indicating the shade loving nature of the crop and it's suitably for growing with poplar.

***M. puririta* (kwanch):** The seed yield in case of kwanch decreased significantly with decrease in poplar spacings (155.3 t/ha in control, 136.8 t/ha in 18 × 2 × 2 m, 133.5 t/ha in 10 × 2m and 120 t/ha in 5 × 4 m spacing),

Table 3. Effect of poplar spacings on yield and quality of kwanch, giloe and shatawari

Tree spacing (m)	Kwanch		Giloe		Shatawari	
	Seed yield (t/ha)	Quality L-dopa Content (%)	Dry yield (t/ha)	Quality Total Bitter Content (%)	Dry yield (t/ha)	Saponin Content (%)
Control	155.3	3.76	7.00	0.57	1.2	4.20
5 × 4	120.0	3.96	14.76	0.65	1.8	4.59
10 × 2	133.5	3.84	12.26	0.63	1.8	4.33
18 × 2 × 2	136.8	3.80	10.26	0.59	1.5	4.26
C.D. (5%)	12.4	NS	3.5	0.14	0.54	NS

showing the negative effect of shade on yield of the plant, which is true for many of the medicinal crops and has been reported by many workers. The trend of quality in terms of L-dopa content (%) was however different, it increased in closer spacings significantly (Table 1 and 3).

***P. deltoides* (poplar):** Height and diameter growth of poplar tree was significantly affected in case of giloe, in all the spacings of poplar as compared to sole poplar plantation. This is because of the very tight and strong binding of the plant on the poplar stem and a large spread of the climber on the tree crown, hindering growth thereby. However, the growth of poplar, in terms of tree height and tree diameter was not significantly influenced by other two medicinal climbers i.e. shatawari and kwanch, as these climbers do not have tight association with the stem as well as these do not spread and reach the crown (Table 4).

Economic analysis of medicinal plants tested in poplar based system

The economics of cultivation of all the medicinal plants tried i.e. *T. cordifolia*, *A. racemosus* and *M. puririta* sole and in combination with poplar tree at three different spacing treatments has been analyzed to ascertain the most profitable combination feasible for North-Western parts of India, where poplar tree is being grown on a large scale on farmlands as agroforestry tree. Table 4 indicates that total cost of cultivation was highest in

Table 4. Effect of medicinal crops on growth (height and dbh) of poplar trees

Growth parameters of Poplar		Poplar spacing (m)		
		5 × 4	10 × 2	18 × 2 × 2
Height (m)	Poplar+ giloe	11.5	11.2	12.9
	Poplar	13.8	14.5	13.5
	Poplar+ shatawari	13.4	12.9	13.2
	Poplar	13.8	14.5	13.5
	Poplar+ kwanch	13.6	13.2	12.9
	Poplar	13.8	14.5	13.5
C.D. at 5%		1.7	2.5	1.6
Diameter (dbh) (cm)	Poplar+ giloe	35.8	38.0	36.5
	Poplar	46.4	44.5	45.6
	Poplar+ shatawari	43.8	43.2	45.4
	Poplar	46.4	44.5	45.6
	Poplar+ kwanch	44.2	44.9	45.8
	Poplar	46.4	44.5	45.6
C.D. at 5%		4.7	3.1	2.9

Table 5. Economics analysis of the climber type of medicinal crops under poplar based agroforestry system

Medicinal crops	Tree spacing (m)	Gross Income (Rs.)	Cost of cultivation (Rs.)	Net total Income (Rs.)	Net annual Income (Rs.)	Benefit/ Cost Ratio (BCR)
Tinospora cordifolia	5 × 4	81000	20000	59000	20000	2.9
	10 × 2	72000	20000	52000	17333	2.6
	18 × 2 × 2	66000	20000	46000	15333	2.3
	Control	60000	20000	40000	13333	2.0
Asparagus racemosus	5 × 4	460500	120000	340500	113500	2.8
	10 × 2	460500	120000	340500	113500	2.8
	18 × 2 × 2	423750	120000	303750	101250	2.5
	Control	346500	120000	226500	75500	1.8
Mucuna puririta (annual)	5 × 4	36000	12000	72000	24000	1.8
	10 × 2	39990	12000	83970	27990	2.3
	18 × 2 × 2	41040	12000	87120	29040	2.4
	Control	46590	12000	103770	34590	2.8

shatawari (Rs. 120000/ha), followed by giloe (Rs. 20000/ ha).

The net income generated in all of the silvo-medicinal plant systems tried was markedly better as compared to control (Yadava, 2009). It was best in close poplar tree spacing i.e. in 5 × 4 m, followed by 10 × 2 m and 18 × 2 × 2 m in all the cases (Table 5). Cultivation of shatawari was found to be the most profitable (Rs.113500/ha/year), in spite of the high cultivation cost (Rs.120000/ha), followed by giloe (Rs. 20000/ha /year). The results are supported by several reports such as Solanki *et al.,* (2013) reported that economic yield (q/ ha) was higher for tuber crops like kalihari, kali musli and safed musli, when grown as intercrops as compared to sole crops. Similar were the findings of Bari and Rahim (2012), Nayak *et al.*, (2014). The highest benefit cost ratio (BCR) of 2.9 was recorded in giloe planted in 5 × 4 m spacing of poplar and shatawari (2.8) planted in 5 × 4, 10 × 2 m poplar spacing. The lowest BCR of 1.8 was observed in sole cropping of shatawari. Hence shatawari and giloe are the climber type of crops, which can be advantageously grown in closer spacings of poplar. However in kwanch the value of benefit cost ratio were just the opposite i.e. highest (2.8) in control and lowest (1.8) in closest spacing, thus confirming that this crop is not suitable to grow in the shade of trees.

4. CONCLUSION

Two of the three climber type of medicinal crops, proved to be beneficial on the basis of this study i.e. shatawari and giloe, being perennials, can be recommended to the farmers, for inclusion in to the poplar based agroforestry systems, where otherwise after 3-4 years of planting growth and yield of traditional crops is drastically reduced.

The technology developed for growing the climber type of medicinal plants such as *T. cordifolia* (giloe) and *A. racemosus* (shatawari) directly on the poplar trees, does not require any additional space or extra input. However, it adds to the net income of the farmer. The benefit of the farmer, in case of adopting the present recommended system increases about three times more than that of growing only traditional crops. As in the presently recommended silvi-agri-medicinal system, the farmer will be able to generate income from: The traditional crops during first three years, growing climber type of perennial medicinal plants (giloe, shatawari) directly on the trees, simultaneously during the later 3-4 years of tree growth and the wood yield from trees.

Hence, the poplar growing farmers can plan to include shatawari and giloe as additional crops along with the traditional crops, in poplar based agroforestry for additional benefit.

ACKNOWLEDGEMENTS

The authors are sincerely thankful to the National Medicinal Plants Board, Delhi, for sanctioning a research project, providing funds to undertake the research work.

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