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Growth and Productivity of Wicker Willow (*Salix triandra* L.) Plantation In Kashmir

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ABSTRACT

An experiment on growth and productivity of wicker willow plantation (*Salix triandra* L.) was carried out on Farmers Field at Batipora (Taibal) in Srinagar district of Kashmir in India. The experiment was laid out in RBD with four treatments fresh plantation (T_1), two year old coppice (T_2), three year old coppice (T_3), four year old coppice (T_4), which was replicated six times.

The initial nutrient status of the soil showed pH neutral to acidic, EC medium, organic carbon high with available NPK, low, high, medium, respectively. Planting distance 15 x 30 cm was maintained in all the treatments. Sprouting vigour was found maximum in T_3 (three year old coppice) and T_4 (four year old coppice) which started and completed earlier than T_2 (two year old coppice) and T_1 (Fresh plantation). Maximum growth and productivity was observed with different age of coppice (i.e., two year and four year old coppice, respectively). The number of shoots per coppice was the deciding factor in contributing yield, number of shoots (7.66) and dry yield (25.10 t/ha). In post harvest processing rods were boiled in water for 10-12 hours and cooled for another 10-12 hours and peeling was done, the bark contributed nearly 25 per cent of weight. The dimensions of processed rods falls into medium category in length and thick category in diameter as per the standards.

Key words: Growth, productivity, processing, grading, chemical properties, *Salix triandra* L.

INTRODUCTION

Willows are the fast growing pioneer species, their allocation of the assimilate transport is concentrated to the growing points of the shoots in the early stages of life (juvenile phase) and later willows invest more and more in the root system. This phenomenon is one of the reason for early harvesting of willows to maintain the juvenile stages. As a result there is high woody biomass production in the stems of willows (Christersson, 2005) Willow have been used by people for many centuries to build shelters, make fences, boats, agricultural implements, tooth picks, preparation of artificial limbs and baskets (Wadoo, 2005.)

Willows are easily propagated by stem cuttings. The cuttings are prepared out of vigorous 2-3 years old shoots free from disease and defects. These are obtained when the trees enter in the dormancy stage and are cut to the size of 20 cm length and mid point diameter 10-20 mm. Cuttings obtained in February to March and prepared from centre half of the shoot.

Forest officers of Kashmir imported famous English bat willow (*Salix alba* cv. Calva = *Salix coerulea*, Smith) from England in 1917 and raised it in Kitreteng wetland nursery (Bijbehara Forest Division of Kashmir). They also imported some varieties of wicker willows from England such as *Salix triandra, Salix purpurea, Salix amygdalina, Salix hypopofolia, Salix viminalis, Salix flabellaries* etc. These are not planted by the departmental agencies as these plantations can be found in Harn, Shalbugh and other areas of Tehsil Ganderbal in the private lands of farmers raised for wicker works where water is readily available (Wadoo, 2005).

The *Salix triandra* L. (Almond willow), most commonly planted wicker willow species in Kashmir is a deciduous shrub upto 5 m height rarely a small tree, bark reddish flaking off in autumn like that of Chinar, leaves 5-10 cm, narrow, finely toothed, dark green and shining above, bluish or green beneath. The leaves have a distinct smell and taste of swe*et al* monds (hence known as almond willow). Winter twigs are brownish green shining above, buds narrow pointed, flowers March-May and some times July and August. Catkins 2.5 to 5 cm long, male catkin with three stamens (Krussnan,1978). The long branches of the almond willow are cut out after one year growth and processed in boiling water, then their bark is peeled off to make the rods water proof and more durable and the wickers are provided as a raw material to small scale industries of Kashmir for the manufacturing of chairs, tables, sofa sets, baskets of various shapes and designs, flower vases and a variety of other fancy items (Fig. 1)

Due to its fast growth, easy rooting, recurrent harvest and having commercial value for wicker works in Kashmir valley. The wicker willow *Salix triandra* L. is preferred over the main food crop of the valley i.e., paddy, due to lack of care and high returns. Till date no study has been done on wicker willow cultivation in Kashmir. Therefore, the present study has been undertaken on the growth and productivity of wicker willow plantation in Srinagar district of Kashmir, where wicker willow is cultivated on wet sites. The survey of the area revealed that wicker willow has been found in all the districts of Kashmir except Kupwara. Also Srinagar district was found in the fore front of wicker willow cultivation (maximum families, area, yield and income).

MATERIAL AND METHODS

The experiment was carried out on the farmer's field during the year 2005 at Batipora (Hazratbal), which is located at an altitude of 1587 m asl. with a latitude of 34. 08 ^{o}N and 74.83 ^{o}E. During the growing period the maximum mean temperature was recorded in June (30.72 ^{o}C) and minimum in November –0.80 ^{o}C whileas, rainfall was highest in the month of July (28.3 mm) and minimum in November (3.05 mm) and relative humidity was maximum in October (78.02%) and minimum in June (58.56%).

The data on different parameters for growth and productivity of *Salix triandra* L. commonly known as wicker willow were collected from four treatments T_1 (fresh plantation) which was planted in the first week of March and remaining treatments two year old coppice (T_2), three year old coppice (T_3) and four year old coppice (T_4) were earlier harvested, once, twice and thrice. The common planting distance was maintained at 30 x 15 cm. However, each treatment was replicated six times in RBD (Randomized Block Design).

The number of coppice counted from the marked plots (1 m^2) and were termed as plant density/m^2. The coppice in marked sample plot was tagged and numbered one, two, three, etc. the sample plots were visited after five days interval to record the sprouting percentage. The shoots were counted from the randomly tagged coppice and were expressed as shoots/coppice. The shoot height and collar diameter were recorded at an interval of one month from the date of shoot emergence in cm from the randomly tagged coppice stands of 1 m^2 with the help of metallic scale verneir callipers. Also the number of leaves/shoots were recorded at an interval of one month in 1 m^2 sampling plot from the randomly tagged coppice and were expressed as leaves/shoot.

The maturity indices as perceived by the farmers was taken as harvesting stage and period of harvesting as harvesting time. From each sampling plot shoots were taken from an area of 0.25^2 m to determine the fresh and dry weight of shoots prior to leaf fall and after leaf fall and expressed as kg/0.25 m^2 which was converted to fresh weight (tonnes/ha). The shoots taken were oven dried at a temperature 105 ± 2 ^{o}C for 72 hours and weighed (2). The weight obtained was reported as dry weight kg per 0.25 m^2 and then converted to dry weight t/ha. The moisture percentage in shoots prior and after leaf fall was determined by the formula:

$$\text{Percent moisture} = \frac{\text{Fresh weight} - \text{dry weight}}{\text{Fresh weight}} \times 100$$

After harvest samples were boiled in standard sized boiling tanks (15' x 5' x 5') made of cast iron and heated directly by fuel wood for 10-12 hours and then left for cooling for another 10 to 12 hours. After cooling samples were peeled by fastening the bark of rods between two wooden sticks held at cross with each other and partly embedded in the soil. Then the rods were air dried under sunlight for a weeks time, which was then graded depending upon the diameter and height in (cm) as per the standards into thin, medium and thick with metallic scale and vernier calliper. (Romero-Ablos, 1988).

Fig. 1. Willow raw material for small scale industries.

The soil samples were taken randomly from all the coppice stands of different ages at 0-30 cm soil depth. The samples were air dried under shade, crushed and passed through 2 mm sieve. The sieved samples

were analysed for different chemical properties. The methods used for analysis of various chemical properties are as follows:

Chemical properties	Methods employed
pH (1 : 2..5)	Jackson (1973)
EC (dsm^{-1})	Jackson (1973)
Organic carbon (%)	Walkey and Black (1934)
Available nitrogen (kg/ha)	Subbiah and Asija (1956)
Available phosphorus (kg/ha)	Olsen *et al*. (1954)
Available potassium (kg/ha)	Jackson (1973)

RESULTS AND DISCUSSION

The studies conducted on the soil analysis depicted in Table 1 which revealed that the soil pH decreased and organic carbon increased with the increase in age of the coppice. The pH recorded was suitable for the growth of wicker willow (*Salix triandra* L.) The increase in organic carbon and decrease in pH was due to the reason that leaves of the deciduous trees decomposes readily, which increased the organic carbon and during decomposition of leaves the acids were released which consequently decreased the soil pH. These results were in agreement with the works of Sennerby - Forsse (1990), Cannell (2004) and Savill (2004). The electrical conductivity increased with the increase in age of the coppice and was found in the range of medium to high as depicted in Table1. EC was minimum (0.16 dsm^{-1}) in T_1 (Fresh plantation) and maximum in T_4 (four year old coppice) (0.23 dsm^{-1}) which was best for the growth and development of the willows which are in conformation with Crough and Honeyman (1986).

The available nitrogen, phosphorus and potassium was found in the range of low, high and medium as depicted in Table 1. The concentration of available nitrogen was low due to the reasons that the short rotation forest species grow rapidly and bind great amount of nutrients in their biomass and also losses due to leaching, denitrification and amonification of nitrogen is high. While as phosphorus concentration increases due to the addition of litter fall which results into formation of polyhumic substances and coating of aluminium and iron ions thus the higher content of phosphorus in soil may be attributed to the higher content of organic matter in the soil which prevents the fixation of phosphorus ions. While as potassium falls in the medium range due to the reason that potassium is always in the exchangeable form in the soil. So it clearly indicates that nutrient status of the soil is very important in short rotation forestry which is in confirmation with the findings of Hyfonen (1996).

The studies conducted on the growth of *Salix triandra* L. on various parameters revealed that sprouting vigour in T_1 (fresh plantation) was slow than the other treatments as deficited in Table. 2. While as

on 30th March, 100 per cent sprouting was recorded in T_3 (three year old coppice) and T_4 (four year old coppice) stand. Whereas, in fresh and one year old coppice it was observed upto 4th April. Statistically the significant difference were found in T_1 (Fresh plantation) and T_2 (two year old coppice) on 15th, 20th and 25th March while as, T_3 (three year old coppice) and T_4 (four year old coppice) differed significantly on 15th March. The results obtained indicate that more sprouting vigour in T_2 (two year old coppice), T_3 (three year old coppice) and T_4 (four year old coppice) than T_1 (fresh plantation) was obviously due to the higher carbohydrate levels and well established root system in these coppice stands than the fresh cuttings T_1 (fresh plantation), which diverted its reserve in root establishment. Also coppicing effect increases the hormonal changes in the remaining stumps, as willow sprouts from the auxillary buds of recent sprouts and enhances the sprouting due to the hormonal changes. These results are in agreement with the rescarches of Taylor *et al.* (1982), Blake (1983) and Kauppi *et al.* (1987).

Table 1. Initial nutrient status of the soil

Nutrients	Depth 0-30cm				Range	Method employed
	T1(Fresh plantation)	T2 (2 yr. old coppice)	T3 (3 yr. old coppice)	T4 (4 yr. old coppice)		
pH (1 : 2.5)	6.56	6.25	6.10	6.03	Neutraltomild acidic	Jackson(1973)
EC dsm^{-1}	0.16	0.18	0.22	0.23	Medium	Jackson(1973)
OC (%)	1.14	1.40	1.65	1.78	Medium to high	Walkley and Black(1934)
Available N (kg/ha)	236.50	213.50	217.50	231.00	Low	Subbiah and Asija (1956)
Available P (kg/ha P_2O_5)	28.66	33.00	36.16	36.16	High	Olsen *et al.* (1954)
Available K (kg/ha) K_2O}	224.00	223.66	224.50	225.33	Medium	Jackson (1973)

Table 2. Sprouting percentage of wicker willow (*Salix triandra* L.)

Treatment/month	Per cent sprouting				
	15th March	20th March	25th March	30th March	4th April
T_1 (Fresh plantation)	1	25	75	98	100
T_2 (2 yr. old coppice)	2	40	84	99	100
T_3 (3 yr. old coppice)	2	42	88	100	100
T_4 (4 yr. old coppice)	3	44	90	100	100
Mean	**2**	**37.75**	**84.25**	**99.25**	**100**
CD (0.05)	**0.12**	**4.06**	**6.35**	**NS**	**NS**

In the present study number of shoots per coppice is presented in table 3 which revealed that maximum shoots per coppice were recorded in T_4 (7.66) on 15th April and minimum on 15th November (6.97) followed by T_3, T_2 and T_1. Table 3 also reiterates that mortality percentage was highest in T_4 with 9.00 per cent followed by T_3 (5.68%), T_2 (4.66%) and lowest in T_1 (4.41%), in one growing season. So from the results it can be concluded that both number of shoots as well as mortality percentage increased with increase in age of the coppice. It is obviously due to the reason that the fast growing species needs complete over head light so with the increase in shoots the maximum shoots does not capture complete light, thus resulting lower photosynthetic efficiency which in turn accounted for reduction in net assimilation rate, so mortality percentage was increased. These results are in conformity with the findings of Tolonen (1988), Bullard *et al*. (2002), Smallukas and Noreika (2005) and Wadoo (2005).

Table 3. Average number of shoots/coppice of wicker willow (*Salix triandra* L.) and mortality(%)

Treatment/month	Average number of shoots		Mortality (%)
	15th April	15th November	
T_1 (Fresh plantation)	1.36	1.30	4.41
T_2 (2 yr. old coppice)	3.00	2.86	4.66
T_3 (3 yr. old coppice)	4.57	4.31	5.68
T_4 (4 yr. old coppice)	7.66	6.97	9.00
CD (0.05)	**0.33**	**0.30**	**0.95**

The perusal of data in Tables 4, 5 and 6 clearly indicated that *Salix triandra* L. showed three main period of growth namely 15th April to 15th June, 15th July to 15th August and 15th August to 15th November. The average shoot height, average collar diameter and number of leaves increased significantly rapid during

the first two stages and then in 3rd stage it increased with decreasing rate and finally becomes very steep. The highest average mean increment in shoot height (55.7 cm), collar diameter (0.61 cm) and number of leaves (22.45) was recorded from 15th June to 15th July. The average maximum shoot height (142 cm), collar diameter (1.12 cm) and number of leaves (6.79) was recorded in T_2 (two year old coppice). Statistically, the increase in average height, collar diameter, number of leaves differed significantly in T_1 (fresh plantation), T_3 (three year old coppice) and T_4 (four year old coppice) upto August while as in T_1 (fresh plantation) it increased significantly upto 15th September. Maximum mean average height (187.64 cm), collar diameter (1.51 cm) and number of leaves (75.05) was recorded on 15th November and minimum value of average height, collar diameter and number of leaves on 15th April (20.15 cm), (0.10 cm) and (8.07), respectively. These values were attained in a period of one growing season which indicated the fast growth of this species. The shoot height, collar diameter and number of leaves were found minimum in T_3 (three year old coppice) and T_4 (four year old coppice) due to the reasons that the number of shoots were higher than that of other T_1 (fresh plantation) and T_2 (two year old coppice) and the nutrients gets distributed in the more number of shoots. In T_1 (fresh plantation) the root system was not fully developed so maximum nutrients were used by the cutting for the development of root system. These results are in conformity with the findings by various scientists (Fricsson, 1981; Cannell *et al.,* 1988 and Smallukas and Noreika, 2005).

The results indicated that maximum growth occurred during the warmer seasons i.e, June and July with rich precipitation (28.3 mm rainfall), and the species under study was found to invest more photosynthetic products to above ground parts during the early growth which ultimately facilitated plants to capitalize more light and allow fast above ground growth (Perttu *et al.*, 1984; Cannell *et. al.*, 1988).

Harvesting indices is reported to be one of the important factor for the management of coppice stand. The harvesting was observed best when the colour of the lower leaves started to change from green to brown and finally turned to yellowish. While as harvesting time started when complete or greater than 75 per cent of leaf fall occur/shedding took place i.e., during dormant period. It is obviously due to the reason that when days becomes shorter and nights longer indicates the harvesting stage. So with the decrease in photoperiod, temperature and number of leaves, photosynthesis decreased and content of abscisic acid increases, which indicated dormant period was best time of harvesting of *Salix triandra* L. These results are in agreement with those recorded by (16,271. The relevant data on green and dry weight of shoots before and after leaf fall is presented in Tables 7 and 8 which reveales that with the increase in age of the coppice the green and dry weight increased significantly. The maximum green weight of shoots was obtained in T_4 (four year old coppice) (54.3 t/ha.) and lowest in T_1 (fresh plantation) (16.7 t/ha), while as dry weight figures obtained after leaf fall for the treatments were subsequently maximum in T_4 (four year old coppice) (23.21 t/ha) and lowest in T_1 (fresh plantation) (6.78 t/ha). The maximum shoot weight in T_4 (four year old coppice) was obviously due to the maximum number of shoots than other treatments. The variation in yield before leaf fall and after leaf fall was due to the reason of continued photosynthesis. The green and dry yield reached maximum when complete leaf fall took place i.e., when photosynthesis ceases. The moisture per cent calculated did not differ significantly among the treatments because in all the treatments growth was of one

year and moisture per cent ranged between 56.32 to 55.14. Due to the obvious reasons that one year shoots grows fast to capture light and LAI reaches maximum which increases the rate of photosynthesis. These results were in agreement with the findings of Ericsson (1981) and Szezukawski *et al*., (2005).

Table 4. Average shoot height of wicker willow (*Salix triandra* L.)

Treatment/month	Average shoot height (cm)					
	T_1 (Fresh plantation)	T_2 (2 yr. old coppice)	T_3 (3 yr. old coppice)	T_4 (4 yr. old coppice)	Mean	Monthly increment (cm)
15th April	19.28	20.96	20.52	19.83	**20.15**	-
15th May	47.04	60.80	54.01	53.79	**53.91**	33.76
15th June	84.12	107.05	95.49	88.53	**93.80**	39.89
15th July	113.13	167.84	155.51	141.52	**149.50**	55.7
15th August	174.42	188.30	178.92	160.76	**175.60**	26.1
15th September	189.21	195.12	183.96	165.80	**183.52**	7.92
15th October	194.29	197.87	186.58	170.62	**187.34**	3.82
15th November	194.58	198.06	186.64	171.27	**187.64**	0.30
Mean	**129.51**	**142.00**	**132.71**	**121.52**	**-**	**-**

$CD_{(0.05)}$
Month = 5.75 Treatment = 4.07 Month x treatment =11.51

Table 5. Average collar diameter of wicker willow (*Salix triandra* L.)

Treatment/Month	Average collar diameter (cm)					
	T_1 (Fresh plantation)	T_2 (2 yr. old coppice)	T_3 (3 yr. old coppice)	T_4 (4yr.old coppice)	*Mean*	Monthly increment (cm)
15th April	0.09	0.11	0.10	0.10	**0.10**	-
15th May	0.23	0.30	0.26	0.26	**0.26**	0.16
15th June	0.50	0.78	0.64	0.60	**0.63**	0.37
15th July	1.17	1.33	1.27	1.20	**1.24**	0.61
15th August	1.44	1.52	1.39	1.30	**1.41**	0.17
15th September	1.55	1.64	1.42	1.33	**1.48**	0.07
15th October	1.62	1.65	1.43	1.35	**1.51**	0.03
15th November	1.63	1.65	1.43	1.35	**1.51**	0.00
Mean	**1.03**	**1.12**	**0.99**	**0.94**	**-**	**-**

CD $_{(0.05)}$

Month = 0.10 Treatment = 0.07 Month x treatment = NS

Table 6. Average number of leaves/shoot of wicker willow (*Salix triandra* L.)

Treatment/ month	Average number of leaves					
	T_1 (Fresh plantation)	T^2 (2 yr. old coppice)	T_3 (3 yr. old coppice)	T_4 (4yr.old coppice)	*Mean*	Monthly increment (No)
15th April	7.71	8.38	8.23	7.95	**8.07**	-
15th May	1.81	24.31	21.60	21.51	**21.56**	13.49
15th June	33.64	42.81	38.19	35.40	**37.51**	15.95
15th July	53.91	67.13	62.20	56.60	**59.96**	22.45
15th August	69.76	75.31	71.56	64.30	**70.23**	10.27
15th September	75.67	78.04	73.58	66.31	**73.40**	3.17
15th October	77.71	79.14	74.63	68.24	**74.93**	1.53
15th November	77.82	79.22	74.65	68.50	**75.05**	0.12
Mean	**51.88**	**56.79**	**53.08**	**48.60**	**-**	**-**

CD $_{(0.05)}$

Month = 2.34 Treatment = 1.65 Month x treatment = 4.68

Processing is important for storage of raw material. After boiling for 10-12 hours withies or rods debarked by fastening the bark in the two wooden sticks embedded 1/3 in the soil. Then dried for a week time under sun light. Boiling softens the bark and bark tannins was absorbed into stem wood which gives buff tint to rod and make it water proof and increases its durability. As well as prevents the raw material from deterioration, increases strength and quality. The sun drying is found to be most cost effective and the rods dried 10 times slower with bark than debarked because maximum moisture per cent is present in bark (Gigler *et al.*, 200).

Table 7. Average green and dry weight of shoots (t/ha) and moisture percentage of wicker willow (*Salix triandra* L.) before leaf fall on 15th September

Treatment	Green weight (t/ha)	Dry weight (t/ha)
T_1 (Fresh plantation)	16.7	6.78
T_2 (2 yr. old coppice)	34.6	14.20
T_3 (3 yr. old coppice)	42.4	18.24
T_4 (4 yr. old coppice)	54.3	23.21
CD (0.05)	**0.73**	**0.17**

Table 8. Average green/dry yield in (t/ha) of wicker willow (*Salix triandra* L.) after leaf fall on 15th November

Treatment	Green yield (t/ha)	Dry yield (t/ha)
T_1 (Fresh plantation)	17.5	7.85
T_2 (2 yr. old coppice)	35.2	15.76
T_3 (3 yr. old coppice.)	43.5	19.00
T_4 (4 yr. old coppice)	56.3	25.10
CD (0.05)	**1.41**	**1.62**

Raw material after processing were graded on the basis of rod length and diameter. The average rod length varied from 162.9 to 187.3 cm and average diameter 1.26-1.54 cm as depicted in Table 9. It indicates that average length falls in the medium and diameter in the thick grade – these dimensions are in agreement with the dimensions of standards reported by (Romero Ablos (1988).

Average rod length and diameter (Table 10) after processing were measured which revealed that the maximum length and diameter was found in T_2 (two year old coppice) (187.30 and 1.54 cm) followed by T_1 (fresh plantation) (186.50 and 1.52 cm), T_3 (three year old coppice) (175.74 and 1.34 cm) and T_4 (four year old coppice) 162.90 and 1.26 cm). Statistical analysis revealed that length of the rods differed significant among the treatments, while as collar diameter was not found significant among the treatments. The rod

length and collar diameter was found less than that recorded before processing due to obvious reasons that during processing the bark and succulent tips were removed. The bark and tips removed contributed nearly 25 per cent of its total weight. These results were in confirmation with the findings of Decei (1975).

Table 9. Dimensions of basket willow of (*Salix triandra* L.) (wicker willow)

Grade	Required length (cm)	Observed length (cm)	Required diameter (cm)	Observed diameter (cm)
Thin	80-160	-	0.2-0.4	-
Medium	180-280	162.90-187.30	0.5-1.1	-
Thick	300-400	-	1.2-1.5	1.26-1.54

Table 10. Average rod (withies) diameter and length after processing of wicker willow (*Salix triandra* L.) (cm)

Treatment	*Diameter after debarking (cm)	Length after debarking (cm)
T_1 (Fresh plantation)	1.52	186.5
T_2 (2 yr. old coppice)	1.54	187.3
T_3 (3 yr. old coppice)	1.34	175.74
T_4 (4 yr. old coppice)	1.26	162.90
CD $_{(0.05)}$	**NS**	**6.49**

* Diameter recorded from thick end

CONCLUSIONS

Results from the study had showed that the soil pH was neutral to acidic, EC medium, organic carbon high with available NPK, low, high and medium respectively. Sprouting vigour was maximum in T_3 (three year old coppice) and T_4 (four year old coppice) which commenced and completed earlier than T_2 (two year old coppice) and T_1 (fresh plantation). The number of shoots per coppice was the deciding factor in contributing yield. However, the bark contributed nearly 25 per cent of the total weight. Dimension of processed rods falls in medium category in length and thick category in diameter.

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