

## Growth and Production of *Anogeissus pendula* (Edgw.)-based Silvopastoral System under Different Pruning Managements

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**Abstract:** Growth and production potential of 3-year-old *Anogeissus pendula*-based silvopastoral system was studied where *Chrysopogon fulvus* was a grass and *Stylosanthes hamata* was a legume component. The treatments consisted of three initiations of pruning (4<sup>th</sup>, 5<sup>th</sup>, 6<sup>th</sup> year after plantation), three pruning intensities (25, 50 and 75% of height of the tree from trunk base) and two controls (unpruned trees with pasture and pasture without trees). The results of five-year-study revealed that there were no significant variations in the growth parameters (height, dbh and canopy diameter) due to different treatments. The average MAI for height and dbh of *A. pendula* ranged from 0.44 to 0.51 m and 0.29 to 0.42 cm, respectively, which was above average growth due to better planting material. The dry leaf fodder and fuel wood increased as the pruning intensity increased, but the differences were non-significant except during the year 2000 in case of leaf fodder production. The dry forage yield of understorey forage significantly enhanced with increased pruning intensity. Pooled data of three years showed increase in forage yield by 7, 24 and 40% due to pruning up to 25, 50 and 75% tree height over unpruned trees. However, on an average pure pasture produced 42% higher yield over 75% pruning of trees.

**Key words:** *Anogeissus pendula*, crude protein, forage production, fodder, biomass production, in-sacco degradability, pruning intensity.

Human activities have continuously disturbed life forms as well as land productivity. The disturbances have led to deterioration of soil health and environmental pollution (Lal, 1988). To combat land degradation plantations of trees, shrubs, grasses, legumes, etc., are the effective and reliable measures. *Anogeissus pendula* is one of the best indigenous tree species for regenerating degraded lands due to its wide adaptability and easy establishment in dry tracts especially ravines and rocky terrains.

*Anogeissus pendula*, popularly known as Kardhai, is a small size tree having

drooping branches, widely distributed in the country especially in central and western India between Aravali hills in Rajasthan and Bundelkhand regions and down to Narbada river and Panmahal in Deccan Plateau (Gupta, 1967). It grows in mixture with *Acacia catechu*, *Ziziphus xylopyrus*, *Butea monosperma*, etc. (Singh, 1982) and forms an important component of the arid ecosystem (Kumar *et al.*, 2003). It is an important source of fuel wood, which is sold at higher rates as compared to fuel wood from other tree species. The leaves of tree are palatable and contain 13.61% crude protein on dry weight basis (Rai *et al.*, 1995). Limaye (1939) described it as the toughest wood replacing American

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Hickory and suitable as an all round timber for agricultural implements, tool handles, piker arms, etc. This species after adopting some management practices has wide scope for incorporation in agroforestry systems.

Looking to wide range of adaptability, excellent leaf fodder and fuel wood, the present investigation was carried out (i) to determine the initial age to pruning (ii) optimum pruning intensity and (iii) its impact on understorey forage production.

### Materials and Methods

The experiment was carried out at the National Research Centre for Agroforestry, Jhansi (78°35'E longitude and 25°26'N latitude and 275 m above mean sea level) under rainfed conditions. Average annual rainfall of Jhansi is 900 mm, falling predominantly (>80%) during rainy season between July to mid September. The rainfall (mm) and number of rainy days recorded experimental period (1998 to 2002) was 905.6 (45), 1118.2 (52), 712.9 (37), 1139.6 (47) and 545.7 (19 rainy days), respectively. The soil of experimental area was loamy sand having 76% sand, 13% silt and 11% clay. The pH, electrical conductivity (EC), organic carbon and total N of the soil were 7.15, 0.112 dS m<sup>-1</sup>, 6.1 g kg<sup>-1</sup> soil and 0.57 g kg<sup>-1</sup> soil, respectively.

Six-month-old tissue culture-raised seedlings of *A. pendula* were planted during July 1995 in 30 cm x 30 cm x 30 cm pits at a spacing of 3 m x 3 m in a randomized block design with three replications. The plot size was 9 m x 6 m with six trees per plot. In between the rows of trees, *Chrysopogon fulvus* (grass) slips at a spacing of 1.0 m x 0.5 m were

planted during July-August, 1998 and between these rows, seed of *Stylosanthes hamata* (legume) were sown at the rate of 4 kg ha<sup>-1</sup>. Pruning treatments were initiated during 4<sup>th</sup>, 5<sup>th</sup> and 6<sup>th</sup> year after planting with three pruning intensities (25, 50 and 75% of height of the tree from trunk base) and two control (unpruned trees with pasture and pasture without trees). Total biomass coming up to the respective pruning height from the trunk base of the tree (vertical height) was removed and biomass production was recorded.

The data on growth parameters of trees, viz., plant height, diameter at breast height (dbh) and canopy diameter were measured in December, when trees were 4, 5, 6, 7 and 8 years old. Pruning was done once in a year in December to harvest maximum leaf fodder because *A. pendula* is a deciduous species, which sheds leaves in cooler month of January onwards. By comparison of previous year data, current annual increment was calculated. Representative sample of leaf material and branches were collected separately and oven dried at 80°C till constant weight to determine dry matter content.

The data on forage production was recorded every year during October from 2000 to 2002 and representative samples of understorey vegetation (*C. fulvus* and *S. hamata*) were collected for dry matter determination. Due to very poor establishment of grass and legume in 1998, gap filling of grass and resowing of legume was done in 1999. Therefore, data on forage yield from understorey vegetation could not be recorded during 1998 and 1999. The leaf samples of Kardhai were analyzed for organic matter (OM) and crude protein

Table 1. Effect of pruning initiations and intensities on tree height of *A. pendula* under silvipastoral system

Treatments	Height (m)					MAI (m, at 7.5 years age)
	1998	1999	2000	2001	2002	
T1	1.60	2.00 (0.40)	2.63 (0.63)	3.34 (0.71)	3.50 (0.16)	0.47
T2	1.58	2.28 (0.70)	2.50 (0.22)	3.50 (1.00)	3.70 (0.20)	0.49
T3	1.68	2.18 (0.50)	2.70 (0.52)	3.58 (0.88)	3.30 (0.02)	0.48
T4	1.45	1.76 (0.31)	2.25 (0.49)	3.10 (0.85)	3.30 (0.20)	0.44
T5	1.49	2.04 (0.55)	2.50 (0.46)	3.14 (0.64)	3.30 (0.16)	0.44
T6	1.48	1.78 (0.30)	2.33 (0.55)	3.16 (0.83)	3.40 (0.24)	0.45
T7	1.28	1.62 (0.34)	2.24 (0.62)	3.13 (0.89)	3.50 (0.37)	0.47
T8	1.47	1.76 (0.29)	2.26 (0.50)	3.15 (0.89)	3.50 (0.35)	0.47
T9	1.52	1.90 (0.38)	2.31 (0.41)	3.31 (0.99)	3.60 (0.29)	0.48
T10	1.39	1.72 (0.33)	2.09 (0.37)	3.04 (0.95)	3.80 (0.76)	0.51
CD at 5%	NS	NS	NS	NS	NS	

\* Values in parentheses are current annual increment (CAI m yr<sup>-1</sup>) for respective years

T1 = 25% pruning intensity after 4th year planting

T2 = 50% pruning intensity after 4th year planting

T3 = 75% pruning intensity after 4th year planting

T4 = 25% pruning intensity after 5th year planting

T5 = 50% pruning intensity after 5th year planting

T6 = 75% pruning intensity after 5th year planting

T7 = 25% pruning intensity after 6th year planting

T8 = 50% pruning intensity after 6th year planting

T9 = 75% pruning intensity after 6th year planting

T10 = Un pruned trees with pasture

T11 = pasture without tree

(CP) (AOAC, 1994). Neutral detergent fibre (NDF) (Van Soest *et al.*, 1991) and acid detergent fibre (ADF) (AOAC, 1990) were also estimated. The *in-sacco* degradability of dry matter, organic carbon, crude protein and cell wall fractions were determined according to the method of Orskov *et al.* (1980).

## Results and Discussion

### Growth parameters of Kardhai

The plant height of *A. pendula* did not show significant variations among different treatments during 1998 to 2002 (Table 1). However, in the 8<sup>th</sup> year, the plant height ranged from 3.30 to 3.80 m. The current

annual increment (CAI) did not show any definite trend in any of the year due to different pruning intensities. However, the mean annual increment (MAI) ranged from 0.44 to 0.51 m. The rate of MAI was more than one and half time higher due to superior tissue cultured planting material received from TERI (Tata Energy Research Institute), Delhi, than MAI reported by Singh (1982) in the forests of Rajasthan at 10 years age (0.27 m). Rai *et al.*, 2000 also reported MAI to be 0.3 m in Jhansi conditions at 10-year age under natural grassland of the local species of *A. pendula*. This may be due to better plant types (tissue culture raised seedlings) as well as variation in agro-climatic conditions.

Table 2. Effect of pruning on diameter at breast height (dbh) of *A. pendula* under silvopastoral system

Treatments	dbh (cm)				
	1999	2000	2001	2002	MAI
T1	0.92	1.71 (0.79)	2.80 (1.09)	2.84 (0.04)	0.38
T2	0.81	1.62 (0.81)	2.27 (0.65)	3.20 (0.93)	0.42
T3	0.93	1.70 (0.77)	2.06 (0.36)	2.80 (0.74)	0.37
T4	0.63	1.41 (0.78)	1.98 (0.57)	2.20 (0.22)	0.29
T5	0.74	1.53 (0.79)	2.33 (0.80)	2.40 (0.07)	0.32
T6	0.71	1.24 (0.53)	1.97 (0.73)	2.50 (0.53)	0.33
T7	0.60	0.85 (0.25)	2.22 (1.37)	3.00 (0.78)	0.40
T8	0.76	1.46 (0.70)	2.01 (0.55)	2.90 (0.89)	0.39
T9	0.65	1.12 (0.47)	2.01 (0.89)	2.80 (0.79)	0.37
T10	0.77	1.33 (0.56)	2.15 (0.82)	3.00 (0.85)	0.40
CD at 5%	NS	NS	NS	NS	

\* Values in parentheses are current annual increment (CAI cm yr<sup>-1</sup>).

The growth in dbh of *A. pendula* among different treatments showed non-significant differences during all the years of study (Table 2). It ranged from 2.2 to 3.2 cm during 8<sup>th</sup> year of establishment of trees. The CAI did not show any definite trend during all the years of study due to different pruning intensities. However, pruning up to 50% tree height showed higher CAI in 6th year, while in 7th year CAI was

higher at 25% pruning height except in treatment T5 (Table 2). The MAI also did not show any definite trend. However, on an average MAI of dbh was 0.36 cm, which was 33.3% higher than MAI reported by Singh (1982) in the forest of Rajasthan at 10 years of growth.

Canopy diameter of *A. pendula* did not show significant variations due to different years of pruning (Table 3). Further, it was

Table 3. Effect of pruning on canopy diameter of *A. pendula* under silvopastoral system

Treatments	Canopy diameter (m)				
	1998	1999	2000	2001	2002
T1	1.48	1.74	2.22	2.81	2.89
T2	0.98	1.57	2.05	2.76	2.73
T3	0.84	1.52	2.35	2.66	2.45
T4	1.63	1.87	1.89	2.42	2.86
T5	1.66	2.01	1.74	2.53	2.60
T6	1.73	1.67	1.84	2.58	2.39
T7	1.50	1.62	2.17	2.53	2.68
T8	1.57	1.91	2.29	2.52	2.60
T9	1.60	1.87	2.08	2.83	2.47
T10	1.53	1.74	2.15	2.54	2.74
CD at 5%	NS	NS	NS	NS	NS

Table 4. Effect of pruning on dry leaf fodder ( $\text{kg ha}^{-1}$ ) and fuel wood production ( $\text{kg ha}^{-1}$ ) of *A. pendula* under silvipastoral system

Treatments	Leaf fodder						Fuel wood production					
	1998	1999	2000	2001	2002	Total	1998	1999	2000	201	2002	Total
T1	48	20	100	20	30	218	605	300	1840	230	260	3235
T2	88	40	170	60	40	398	840	560	2190	510	300	4400
T3	106	60	310	7	70	616	1123	870	2590	760	740	6083
T4		80	190	30	40	340		720	2090	400	410	3620
T5		140	200	40	50	430		1140	2260	600	460	4460
T6		160	350	50	60	620		1210	3200	780	530	5720
T7			460	40	30	530			3280	210	300	3790
T8			570	60	60	690			3390	260	520	4170
T9			620	60	70	750			3690	380	740	4810
T10	-	-	-	-	-	-	-	-	-	-	-	-
CD at 5%			290	NS	NS				NS	NS	NS	

observed that there was no systematic variation in canopy diameter due to different pruning intensities. However, in 2002 a systematic trend was observed, where canopy diameter decreased as the pruning intensities increased from 25 to 50% and 50 to 75% height.

#### Dry leaf fodder and fuel wood production

Significant ( $P < 0.05$ ) difference was observed in the dry leaf fodder production during 6<sup>th</sup> year (2000), whereas non-significant differences were observed in fuel wood production (Table 4). A clear trend was observed in trees of all the age groups in which biomass production (leaf and fuel wood) increased with increasing pruning intensity. So the biomass production was positively correlated with pruning intensity. Benefits of tree pruning have also been reported by Bhimaya *et al.* (1964), Hocking and Rao (1990), Dijkman (1950), Das and Dalvi (1981), Osman (1981), Pathak *et al.* (1994), and Rai *et al.* (2001). In the present

study total above ground biomass (leaf + wood) recorded was at par in treatments where pruning started during 4<sup>th</sup> or 5<sup>th</sup> or 6<sup>th</sup> year of tree establishment. Thus, the results showed that in *A. pendula* pruning up to 75% tree height can be initiated from 4<sup>th</sup> year of tree planting without affecting tree growth.

#### Chemical constituents and in-sacco degradability

*A. pendula* leaves contained 10.1% crude protein (Table 5). However, Rai *et al.* (1995) noticed a higher (13.61%) level of crude protein in the leaves of *A. pendula*. The NDF content was 29.13%, indicating the presence of higher cell contents i.e., soluble nutrients. Higher levels (40.62 to 51.55%) of NDF in different species of leguminous trees were reported by Bhadauria *et al.* (2002) and Pailan *et al.* (2005). The in-sacco degradability of *A. pendula* leaves is presented in Table 6. The higher degradability of dry matter,

Table 5. Chemical constituents (% DM basis) in leaves of *A. pendula*

Constituents	Tree leaf
Dry matter (DM)	96.01
Crude protein (CP)	10.01
Organic matter (OM)	94.58
Neutral detergent fibre (NDF)	29.13
Acid detergent fibre (ADF)	19.29
Cellulose	6.54
Hemi-cellulose	9.84
Lignin	6.30
Ash	54.20

organic matter, represented the better quality as animal feed. But, in legumionous shrubs (*Dichrostachys cinera* and *Mimosa hamata*), a comparatively lower degradability for various nutrients were noticed by Pailan *et al.* (2004). In the present investigation, the higher degradability for various nutrients confirmed its better quality and showed the potentiality of *A. pendula* leaves for

Table 6. In-sacco degradability (%) of *A. pendula* leaves

Constituents	Degradability
DM	89.08
OM	88.54
CP	91.98
NDF	70.62
ADF	67.24
Hemicellulose	77.27

higher growth and production of livestock during lean period.

#### Dry forage production

There were significant differences in dry forage yield due to different pruning initiations during 2001 and 2002, while non-significant differences were observed

during 2000 (Table 7). Dry forage yield increased as the pruning intensity increased in all the three years. However, enhancement in production from 25 to 50 or 50 to 75% pruning height did not show significant differences. Forage yield under un-pruned tree was although lower than pruned trees, but differences were non-significant. Forage production without tree (pure pasture) was significantly higher than under other treatments indicating interactive effect of trees on forage production. On the basis of average of three years, the forage yield decreased by 99, 80, 59 and 42% in unpruned trees, by pruning up to 25, 50 and 75% height, respectively, over pure pasture. It seems to be the first report regarding the effect of pruning initiation and intensity in *A. pendula* on understorey forage production. Rai *et al.* (2001) reported decreasing trend in understorey forage production in the presence of *Anogeissus latifolia*, although the magnitude of decrease in yield was low. Similarly, tree decreased the understorey forage production and it varied from 25 to 30% for *Cenchrus ciliaris*, while complete failure occurred in a stylo pasture under 8-year-old *Leucaena* trees (Rao and Osman, 1994). Shankarnarayan *et al.* (1987) also reported that forage yield decreased with an increase in age of MPTs based silvopastoral system. However, Sharma *et al.* (1996) observed little difference in forage yield of *C. ciliaris* under a 20-year-old *Prosopis cineraria* canopy compared to the yield of pasture alone.

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Table 7. Effect of pruning of *A. pendula* on dry forage yield ( $t\ ha^{-1}$ ) of understory vegetation

Treatments	2000	2001	2002	Average of three year
T1	1.44	1.75	1.84	1.67
T2	1.60	1.89	1.98	1.82
T3	1.60	1.90	2.07	1.86
T4	1.23	1.71	1.60	1.51
T5	1.44	1.86	1.94	1.75
T6	1.92	1.88	2.80	2.20
T7	1.06	1.62	1.92	1.55
T8	1.44	1.83	1.98	1.75
T9	1.60	1.87	2.26	1.91
T10	1.39	1.16	1.72	1.42
T11	2.42	2.82	3.26	2.83
CD at 5%	NS	0.53	0.77	-

providing established field of *A. pendula* for conducting experiment. Thanks are due to Head, PAR Division, for facilities for chemical analysis and in-saroo degradability of leaves, Dr. A.K. Samantra for discussions of leaf quality and Shri U.P. Singh for assistance in recording field observations.

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