Annals of Arid Zone 34(2) : 121-125, 1995

Effect of Fertilizer Application on Growth and Biomass Production of *Ailanthus excelsa* on an Arid Land

G.N. Gupta, Neelu Singh*, N.K. Bohra and Bilas Singh
Division of Forest Ecology and Desert Development,
Arid Forest Research Institute, New Pali Road, Basani, Jodhpur 342 005, India

Abstract : A field experiment was conducted on an aridisol in Pali Forest Division of Western Rajasthan to study the influence of different nitrogen (0, 9 and 18 g N per tree as urea) and phosphate (0, 3 and 6 g P_2O_5 per tree as single superphosphate) levels on growth and biomass production of *Ailanthus excelsa*. $N_{18}P_3$ (18 g N + 3 g P_2O_5 per tree) was the optimum level and increased tree height by 49%, 85% and 35% at one, two and three years of age; collar circumference by 56%, 101% and 11% and crown diameter by 47%, 63% and 58%, respectively, at three ages. Increase in total biomass production due to this treatment was 181% at one year and 185% at two year of age. Magnitude of response was higher due to nitrogen application. Combined application of N and P had synergistic influence and enhanced the growth, leaf area and root growth of trees.

Key words : *Ailanthus excelsa*, nitrogen, phosphorus, biomass, height, collar circumference, crown diameter, leaf area, root growth.

Ailanthus excelsa is an important fodder tree, planted widely in arid and semi-arid regions. Its growth and development is slow in arid regions, due to inadequate nitrogen and phosphorus. Research on tree fertilization in humid, subhumid and semi-arid regions has indicated favourable response of trees to the application of inorganic fertilizers (Prasad *et al.*, 1984 ; Singh *et al.*, 1988; Gupta, 1990; Gupta and Prasad, 1992; Johnson and Todd, 1985). The response has been particularly dramatic in the initial years (Brix, 1981; Gupta, 1991). In arid regions, where moisture stress conditions dominate throughout the year, use of inorganic fertilizers may become a risky venture unless added in suitable proportion and optimum quantities. Such information on fertilizer use in plantation species of arid region is lacking. *A. excelsa*, a fast growing species of arid and semi-arid regions yielding fodder for sheep and goat, needs to be provided adequate nutrition for its better growth, biomass and quality of fodder. Therefore a study was under taken to evaluate the effect of different levels of N and P fertilizers on initial growth and biomass production of *A. excelsa*.

* Present address : Tropical Forest Research Institute, Jabalpur, India

Materials and Methods

A field experiment was conducted on an aridisol in Pali Forest Division of western Rajasthan. The mean annual rainfall of the site is about 400 mm. Soil of the experimental site is coarse sand having pH, 8.8; organic matter, 0.06%; available nitrogen, 88 kg ha^{-1} in 0-25 cm layer and 57 kg ha^{-1} in 25 to 50 cm layer and available phosphorus 16 kg P_2O_5 ha^{-1}. Three levels, each of nitrogen (0, 9 and 18 g N per plant as urea) and phosphorus (0, 3 and 6 g P_2O_5 per plant as single super phosphate) comprised 9 treatments in factorial combinations. There were three replicates and the experiment was laid in Randomised Block Design. Each plot had 24 trees at 3 m x 2 m spacing.

Single super phosphate (as per the treatment) was placed in the pits (40 cm x 40 cm x 40 cm) before planting. Urea was mixed with the soil and the treated soil was refilled after planting five month old seedlings of *A. excelsa*, which were about 15 cm tall. Planting was done on 15th July 1989. The seedlings were given four waterings (10 litres per plant), in the months of August, November, March and May in first year. Growth observations (height, collar circumference and crown diameter of trees) were recorded after one, two and three years of planting. Biomass studies were conducted in one and two-year-old plantations by felling one representative tree (having dimensions equivalent to mean of height and girth of trees in the treatment). Fresh weight of foliage and stem of felled trees was recorded. Dry weight was recorded after oven drying the leaf and stem samples at 70°C. Roots of one-year-old trees were excavated and their thickness, spread and biomass were recorded. Dry biomass of roots was determined after oven drying at 70°C. Leaf area of the representative trees in each treatment was determined and Leaf Area Index (LAI) and average leaf size was computed.

Results and Discussion

Effect of nitrogen

Nitrogen significantly influenced the growth of *A. excelsa* for continuous three years (Table 1). 9 g N per plant enhanced the tree height by about 35% during first two years and by 15% in the third year. Compared with 98, 158 and 284 cm height of untreated trees (N_0) at one, two and three years of age, tree height due to N_9 treatment was 122, 199 and 328 cm, respectively. Increase in collar circumference was 30 to 37% and crown diameter 18 to 26% during all the three years. Higher dose of 18 g N (40 g urea per plant) only marginally increased the growth. Number of branches, recorded in three year old plantation, increased significantly from 4 to 6 due to 9 g N per plant and to 8 due to 18 g N per plant.

Nitrogen application increased the total biomass of one and two year old plantations (Table 2). On an average, 9 g nitrogen per plant increased the total dry biomass from 104 to 183 g tree^{-1} (76% increase) at one year of age and from 2.52 to 4.01 kg tree^{-1} (59% increase) at two years of age. Higher rate of 18 g N tree^{-1} only marginally increased total biomass in one year old plantation, but in two year old plantation the increase was 24% (4.97 kg tree^{-1}). 9 g N tree^{-1} caused 70% increase in foliage mass and 80% increase in shoot biomass, in one-year-old trees. In two-year-old trees the increase was 36%

Table 1. Growth of A. excelsa due to N and P fertilization on an aridisol

	1 year old				2 year old				3 year old			
Treatment	N_0	N_9	N_{18}	Mean	N_0	N_9	N_{18}	Mean	N_0	N_9	N_{18}	Mean
Height (cm)												
P_0	92	113	121	109	132	189	207	176	266	307	334	302
P_3	105	123	137	122	137	122	178	202	280	339	360	326
P_6	97	130	123	117	164	205	237	202	305	337	334	325
Mean	98	122	127		158	199	229		284	328	343	
C.D. 5%	P:12	N:12	PxN:NS		P:32	N:32	PxN:NS		P:19	N:19	PxN:NS	
Collar circumference (cm)												
P_0	6.6	8.5	9.3	8.1	15.6	22.0	24.6	20.7	19.4	36.1	33.9	29.8
P_3	8.1	10.2	10.3	9.5	20.9	24.7	31.3	25.6	27.8	36.6	41.0	35.1
P_6	7.5	10.3	9.9	9.2	18.9	25.9	29.0	24.6	35.0	37.6	36.0	36.2
Mean	7.5	9.6	9.8		18.4	24.2	283		27.4	36.8	36.9	
C.D. 5%	P:1.4	N:1.4	PxN:NS		P:5	N:5.1	PxN:NS		P:2.1	N:2.1	PxN:3.7	
Crown diameter (cm)												
P_0	38	48	49	45	139	187	196	174	202	287	300	263
P_3	44	51	56	50	192	204	226	207	250	317	319	295
P_6	39	54	48	47	168	197	227	197	265	302	286	284
Mean	40	51	51		166	196	216		239	302	302	281
C.D. 5%	P:NS	N:8	PxN:NS		P:27	N:27	PxN:NS		P:20	N:20	PxN:NS	

N_0, N_9 and N_{18} : 0, 9 and 18 g nitrogen tree^{-1}; P_0, P_3 and P_6 : 0, 3 and 6 g P_2O_5 tree^{-1}
C.D. : Critical difference; NS : Not significant

Table 2. Biomass (dry) production and its allocation to different parts of A. excelsa due to application of N and P fertilizers on an aridisol

Treatment	1 year old (g tree^{-1})				2 year old (kg tree^{-1})			
	N_0	N_9	N_{18}	Mean	N_0	N_9	N_{18}	Mean
Foliage								
P_0	48.6 (0.59)	78.1 (0.66)	92.5 (0.64)	73.1 (0.63)	0.78 (0.40)	1.28 (0.35)	1.42 (0.35)	1.16 (0.37)
P_3	86.1 (0.63)	136.0 (0.61)	150.0 (0.65)	124.0 (0.63)	1.10 (0.39)	1.35 (0.33)	1.90 (0.33)	1.45 (0.35)
P_6	58.8 (0.64)	135.0 (0.64)	128.4 (0.59)	107.4 (0.62)	0.97 (0.35)	1.24 (0.29)	2.07 (0.39)	1.43 (0.43)
Mean	64.5 (0.62)	116.4 (0.64)	123.6 (0.63)		0.95 (0.38)	1.29 (0.32)	1.80 (0.37)	
Stem								
P_0	33.5 (0.41)	39.8 (0.34)	53.0 (0.36)	42.1 (0.37)	1.17 (0.60)	2.38 (0.65)	2.60 (0.65)	2.05 (0.63)
P_3	49.8 (0.37)	85.4 (0.39)	81.2 (0.35)	72.1 (0.37)	1.73 (0.61)	2.78 (0.67)	3.66 (0.66)	2.72 (0.65)
P_6	33.4 (0.36)	75.0 (0.36)	88.4 (0.41)	66.8 (0.38)	1.81 (0.65)	3.00 (0.71)	3.27 (0.61)	2.69 (0.66)
Mean	38.9 (0.38)	66.7 (0.36)	74.2 (0.37)		1.57 (0.62)	2.72 (0.68)	3.18 (0.64)	
Total								
P_0	82.1	117.9	145.5	115.2	1.95	3.66	4.02	3.21
P_3	135.9	221.4	231.2	196.2	2.83	4.13	5.56	4.17
P_6	92.2	210.0	216.8	173.0	2.78	4.24	5.34	4.12
Mean	104.0	183.1	197.8		2.52	4.01	4.97	

Values in parentheses are ratio of biomass to total biomass (biomass alloction)

in leaf and 73% in stem mass. Thus at two years of age stem growth improved more than the foliage growth. Application of N and P fertilizers enhanced the biomass allocated to stem. Ratio of stem biomass to total biomass in two year old plantation was the highest (0.71) in N_9P_6 treatment as compared to 0.60 in N_0P_0 treatment (Table 2).

Response of *A. excelsa* to higher dose of nitrogen at two years of age seems logical owing to increased nitrogen requirement of trees with advancing age. It may be necessary to repeat the application of nitrogen in suitable quantity and at suitable time. This may be particularly beneficial for increasing foliage yield of *A. excelsa* which is harvested for fodder after 3 to 4 years of age. Besides foliage yield, other leaf characteristics as affected by fertilizer application are presented in Table 3. Average leaf area increased by 42% (18.48 to 26.2 m^2 tree^{-1}) due

Table 3. Influence of fertilizer application on leaf characteristics of two-year-old A. excelsa

Treatment	N_0	N_9	N_{18}	Mean
Leaf Area (m^2/tree)				
P_0	15.58	26.96	27.95	23.49
P_3	19.25	23.65	38.60	27.16
P_6	20.63	28.01	40.64	29.76
Mean	18.48	26.20	35.73	26.80
Leaf Area Index				
P_0	2.60	4.49	4.66	3.91
P_3	3.21	3.94	6.43	4.52
P_6	3.44	4.66	6.77	4.95
Mean	3.08	4.36	5.95	4.46
Leaf Size (cm^2)				
P_0	43.60	54.80	51.90	50.10
P_3	44.00	40.40	36.60	40.30
P_6	40.80	40.00	35.00	38.60
Mean	42.80	45.10	41.10	43.00

to 9 g N tree^{-1} and further by 36% (35.73 m^2 tree^{-1}) due to 18 g N tree^{-1}. Average leaf area index (LAI) increased from 3.08 in N_0 to 4.36 in N_9 and 5.95 in N_{18} treatments. Average leaf size remained unaffected due to nitrogen fertilization.

Effect of phosphorus

Effect of phosphate application was significant on tree growth, when added at the rate of 3 g P_2O_5 tree^{-1} (Table 1). Higher dose of 6 g P_2O_5 tree^{-1} did not further improve the growth. Trees in plots receiving 3 g P_2O_5 tree^{-1} were taller by 12%, 18% and 8% at 1, 2 and 3 year of age, when compared with trees of untreated plots. Increase in collar circumference was 17%, 24% and 18% at three ages, respectively. Crown diameter due to 3 g P_2O_5 tree^{-1} increased by 11%, 19% and 12%, respectively, after one, two and three years of planting. Thus, increase in growth due to phosphate application was relatively less than that due to nitrogen. Influence of phosphate application was more on improving collar circumference than on tree height and crown spread. Number of branches increased only marginally (from 5 to 7) due to phosphate application.

Total biomass production increased from 42.1 to 72.1 g tree^{-1} at one year and 1.16 to 1.45 kg tree^{-1} at two years of age, amounting to 70 and 25% increase, respectively, due to 3 g P_2O_5 tree^{-1}. The foliage mass increased from 73.1 to 124.1 g tree^{-1} (70%) in one-year-old plantation and 1.16 to 1.45 kg tree^{-1} (25%) in two-year-old plantation. Magnitude of increase in stem mass was 71% and 33%, respectively, at one and two years of age. Higher dose of 6 g P_2O_5 tree^{-1} did not further increase the growth and biomass of *A. excelsa*. Thus, 3 g P_2O_5 tree^{-1}, placed at 40 cm depth just before planting, continued to influence tree growth for three years with maximum advantage being during the second year. Decline in growth response to added P after two years of planting may be attributed to reduction in readily available P due to plant uptake and conversion of applied P to insoluble forms.

Effect of N-P interaction

Combined application of nitrogen and phosphorus was beneficial in improving the growth of *A. excelsa* (Table 1 & 2). $N_{18}P_3$ was the best treatment causing height increase from 92 to 137 cm at one year, 132 to 244 cm after two years and 266 to 360 cm after three years of planting amounting to 49%, 85% and 35% increase, respectively. Increase in collar circumference; when compared with trees of control plot was, 56%, 101% and 11%, respectively, in three consecutive years after planting. Improvement in crown diameter due to $N_{18}P_3$ treatment was of the order of 47%, 63% and 58%, respectively, after one, two and three years. Total biomass production due to $N_{18}P_3$ treatment was higher by 181% at one year and 185% at two years of age, when compared with biomass production of trees in control plot (N_0P_0). The proportionate increase was relatively higher in foliage mass (209%) in first year and in stem mass (213%) in the second year. N-P interaction effect in general, was lower in magnitude, showing only tendency of two elements to exhibit synergism.

Root Growth

Root growth of one-year-old trees was studied by excavating roots of felled tree from each treatment. Though there is lack of consistency in data with increase in N and P levels, the treatment effect in general was conspicuous (Table 4). The root spread in particular was affected by fertilizer application. Combined application of nitrogen and phosphorus increased the number of rootlets, the maximum (24) being in N_9P_6 treatment. The application of N and P increased the development of fine roots. Trees in control plot had only main root, whereas fertilized trees had lateral roots ranging from 4 to 23. Influence of nitrogen was more prominent on root girth. The root girth increased from 5.0 to 8.3 cm due to 9 g N tree^{-1}. Whereas phosphate application increased the root girth from 5 to 5.5 cm (P_3) and 7.5 cm (P_6). Total dry rootmass, which was

Table 4. Root growth of one-year-old A. excelsa due to N and P fertilization on an aridisol

Treatment	N_0	N_9	N_{18}	Mean
Leaf Area (m^2/tree)				
P_0	5.0	8.3	8.5	7.3
P_3	5.5	7.8	6.3	6.5
P_6	7.5	8.5	7.0	7.7
Mean	6.0	8.2	7.3	
Leaf Area Index				
P_0	1	5	4	3
P_3	6	14*	7	9
P_6	5	23	15*	17
Mean	4	14	9	
Leaf Size (cm^2)				
P_0	31.6	100.0	67.3	66.3
P_3	62.2	70.7	49.7	60.9
P_6	48.2	54.7	63.3	55.4
Mean	47.2	75.1	60.1	

* Plenty of fine roots

31.6 g tree^{-1} in control, varied from 48.2 to 100.0 g tree^{-1} in treated plots, thus enhancing root growth by 50 to 200%.

Acknowledgements

Authors express their grateful thanks to Shri R.N. Mishra, Director, AFRI, Jodhpur, for providing necessary facilities and encouragement. Assistance in data recording and processing by Mr. N.K. Limba and Ms. Kusumlata, Technical Assistants, is thankfully acknowledged.

References

Brix, H. 1981. Effects of nitrogen fertilizer source and aplication rates on foliar nitrogen concentrtion, photosynthesis and growth of Douglas-fir. *Canadian Journal of Forest Research* **11**: 775-780.

Gupta, G.N. 1990. Integration of moisture and fertilizer management practices for early growth and establishment of *Eucalyptus* on a skeletally degraded dryland. *The International Tree Crops Journal* **6**: 123-142.

Gupta, G.N. 1991. Effect of mulching and fertilizer application on initial development of some tree species. *Forest Ecology and Management* **44**: 211-221.

Gupta, G.N. and Prasad, K.G. 1994. Effect of N and P fertilizers on nutrient uptake by *E. grandis* on degraded grassland. *Journal of the Indian Society of Soil Science* **42**(1): 60-64.

Johnson, D.W. and Todd, D.E. 1985. Nitrogen availability and conservation in young yellow poplar and labbolly pine plantations fertilized with urea. *Agronomy Abstracts* **77**: 220.

Prasad, K.G., Gupta, G.N., Singh, S.B. and Mohan, S. 1984. Fertilization in Eucalyptus grandis on a severely truncated soil. II. Biomass production, *Indian Forester* **110**(2): 142-149.

Singh, S.B., Prasad, K.G., Gupta, G.N. and Subramaniam, V. 1988. Cause of decline of *Eucalyptus grandis* in Nagarampara range, Kerala - A Survey. *Journal of Tropial Forestry* **4**: 259-268.