The Pharma Innovation Journal 2021; 10(12): 1881-1883

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(12): 1881-1883

www.thepharmajournal.com
Received: 25-10-2021
Accepted: 27-11-2021

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Growth performance of *Ailanthus excelsa* under varying planting geometry

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Abstract
This article presents growth performance of *Ailanthus excelsa* under varying planting geometry, *i.e.*, 10×20m (50 trees ha$^{-1)}$, 10×10m (100 trees ha^{-1}), 10×6.5 m (150 trees ha^{-1}), and 10×5 m (200 trees ha^{-1}) of *Mahaneem* based agro-forestry system during 2019-20 and 2020-2021. Four varieties of wheat *viz;* WH-1105, WH-711, HD-3086 and HD-2967 were intercropped with Ailanthus. The results revealed that the maximum height (12.21 m) of Mahaneem was recorded under 10×5 m plant geometry during 2019-20, whereas, the maximum GBH and crown spread was recorded under 10×20 m plant geometry and decreased with the decrease in the plant geometry of trees. Nutrient concentration of Mahaneem leaves was also recorded.

Keywords: *Ailanthus excelsa*, *Mahaneem*, wheat, growth parameters

Introduction
Ailanthus excelsa Roxb., commonly known as *Mahaneem*, *Maharukh,* or *Ardu* is a tree of considerable economic importance as its cultivation is being promoted for fodder and soft wood purposes in arid and semi-arid regions. The wood of the plant is in great demand for making matchwood boxes and match splints in match industry. The wood is extensively used in cottage industries for making wooden toys and economic cricket bats. Branches are used for making packing cases or boxes. *Mahaneem* is also recognized as a valuable tree in sustainable development and enhancing livelihood of resource-poor farmers in semi-arid regions because of its wider adaptability, fast growth and higher tolerance to biotic and abiotic stresses, supplying timber for plywood (Jat *et al*., 2011) [2]. *Mahaneem* plantation on community land, farm boundary, road avenues and in agro-forestry systems helped in maintaining the ecosystem by slowing down the variations in climatic parameters due to climate change. Foliage of *Mahaneem* is used by small ruminants to meet the green fodder requirement during lean period and it is sold in the market to increase the farmer's income for sustaining their livelihood in harsh climate.

Material and Methods
The field experiment was conducted at Chaudhary Charan Singh Haryana Agricultural University Regional Research Station, Bawal, Rewari, Haryana, India during winter season of 2019-2020 and 2020-2021. In which four different wheat varieties *viz*. WH-711, WH-1105, HD-2967, HD-3086 were intercropped with six and half years old mahaneem (*Ailanthus excelsa*) plantation planted at different plant geometries, *i.e*., 10×20, 10×10, 10×6.5 and 10×5 m. The growth performance of tree and nutrient concentration of leaves were estimated.
The height of Ailanthus trees was measured from ground level up to the tree terminal with the help of altimeter and was expressed in meter. The girth at breast height (GBH) was measured at 1.37 m from the ground level with the help of a measuring tape. The average spread of tree was worked out by measuring crown spread in north-south and east-west directions and their mean values were calculated and expressed in meter.

The nutrients concentration in tree leaves was worked out with following methods

1	Total nitrogen (%)	Modified Kjeldahl method (Bremner and Mulvaney, 1982)
2	Total phosphorus (%)	Vanadate phosphomolybdate yellow colour method (Koenig and Johnson, 1942)
3	Total potassium (%)	Flame photometer method (Toth and Prince, 1949)

Results and Discussion

Growth pattern of *Mahaneem* under different spacing followed a rising trend with age. The data presented in table 1 reveal that maximum height (11.56 m) of Mahaneem before sowing of the crop was recorded under 10×5 m plant geometry, which decreased with the wider plant geometry. A similar pattern in height of *Mahaneem* was observed after harvesting of crop and the maximum height, *i.e*., 12.21 m was recorded under 10×5 m plant geometry, while the minimum height was recorded under 10×20 m plant geometry of agro-forestry system during 2019-20. The maximum height was recorded under 10×5 m spacing in agro-forestry system may be due to more number of irrigations. Similar growth performance of *Mahaneem* under different agro-forestry based systems with slight variation has already been reported by several researchers (Meena *et al*., 2001; Rajalingam *et al*., 2017) [5, 6]. Kaushik *et al*. (2017) [3] recorded significantly higher growth of *Shisham* and *Khejri* under agro-forestry (agri-silvi-horti) systems than sole plantation. More height under closer spacing of 3×3 m has also been recorded by Kumar *et al*. (2017) [4] in *Eucalyptus tereticornis*.

At the start of experimentation maximum GBH 90.85 cm and crown spread (5.72 m) was observed under 10×20 m plant geometry which further decreased with the narrow plant geometry. The same pattern of growth in GBH and crown spread was followed by trees after harvesting of wheat crop. It might be due to availability of more space to each tree in all the four directions under wider spacing. The use of fertilizer and irrigation for agricultural crops may also be the reason for uniform growth of trees observed in association with crops. Deswal *et al*., (2021) [1] revealed that the 20 x 10 m planting spacing was found better for planting of *Ailanthus excelsa* with or without intercrop**.** However, Current annual increment (CAI) exhibited non significant variation for height, GBH and crown spread. Similar trend of results was also recorded during the year 2020-21.

Table 1: Growth of *Mahaneem* under different plant geometries during years 2019-20 and 2020-21

2019-20									
Plant geometry (m)	**Before sowing**			**After harvesting**			**CAI**		
	Height (m)	**GBH (cm)**	**Crown Spread (m)**	**Height (m)**	**GBH (cm)**	**Crown Spread (m)**	**Height (m)**	**GBH (cm)**	**Crown Spread (m)**
10x20	10.02	90.85	5.72	10.38	92.40	5.88	0.36	1.55	0.16
10x10	10.06	89.32	5.44	10.46	90.67	5.58	0.40	1.35	0.14
10x6.5	11.45	81.95	5.16	12.07	83.23	5.27	0.62	1.28	0.11
10x5	11.56	77.17	4.75	12.21	78.40	4.84	0.65	1.23	0.09
CD at 5%	0.85	5.05	0.23	0.63	2.24	0.32	-	-	-
2020-21									
Plant geometry (m)	**Before sowing**			**After harvesting**			**CAI**		
	Height (m)	**GBH (cm)**	**Crown Spread (m)**	**Height (m)**	**GBH (cm)**	**Crown Spread (m)**	**Height (m)**	**GBH (cm)**	**Crown Spread (m)**
10x20	10.81	93.64	5.68	11.08	94.99	5.83	0.27	1.35	0.15
10x10	10.94	91.87	5.56	11.27	93.19	5.69	0.33	1.32	0.13
10x6.5	12.57	84.40	5.14	12.92	85.62	5.24	0.35	1.22	0.10
10x5	12.74	79.47	4.78	13.12	80.65	4.87	0.38	1.18	0.09
CD at 5%	0.49	5.03	0.38	0.63	3.97	0.31	-	-	-

The effect of various spacings was found to be non-significant on nutrient concentration *i.e*, Total nitrogen (%), Total phosphorus (%), Total potassium (%) and Crude protein (%) whereas, crude protein yield was found significant with maximum value (91242.88 and 89664.68 kg/ha) at 10×5 m spacing followed by followed by 10×6.5m (68496.43 and 67638.12 kg/ha), 10×10m (45829.70 and 46219.89 kg/ha) spacings and the minimum (23357.66 and 22441.80 kg/ha) under 10×20 m spacing during 2019-20 and 2020-21, respectively (Table 2). Singh *et al*. (2011) [7] reported that *Ailanthus excelsa* has high nutritional value viz., crude protein: 16 –20%, crude fiber: 13-21%, phosphorus: 0.17-0.24%, calcium: 1.48-2.11%.

Table 2: Nutrients concentration in tree leaves

Plant geometry (m)	**2019-20**				
	Total nitrogen (%)	**Total phosphorus (%)**	**Total potassium (%)**	**Crude protein (%)**	**Crude protein yield (kg/ha)**
10x20	3.42	0.25	0.20	21.38	23357.66
10x10	3.45	0.24	0.21	21.56	45829.70
10x6.5	3.41	0.23	0.23	21.31	68496.43
10x5	3.43	0.24	0.20	21.44	91242.88
CD at 5%	N/A	N/A	N/A	N/A	3683.80
Plant geometry (m)	**2020-21**				
	Total nitrogen (%)	**Total phosphorus (%)**	**Total potassium (%)**	**Crude protein (%)**	**Crude protein yield**
10x20	3.39	0.25	0.20	21.19	22441.80
10x10	3.43	0.24	0.21	21.44	46219.89
10x6.5	3.45	0.23	0.22	21.56	67638.12
10x5	3.41	0.25	0.21	21.31	89664.68
CD at 5%	N/A	N/A	N/A	N/A	1989.02

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