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Performance of agricultural crops under *Ailanthus excelsa* based agroforestry system in semi-arid region of Haryana

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Abstract
The study was carried out at farmer's field to evaluate the performance of agricultural crops under *Ailanthus excelsa* based agroforestry system during Rabi season 2014-15. A significant yield reduction in potato, onion and wheat was reported under a 2 year old mahaneem based agroforestry system in comparison to the sole cropping system. Maximum yield was observed in onion (18750 kg ha^{-1}), followed by potato (15000 kg ha^{-1}) under agroforestry based system during the study period. However, the maximum yield reduction under the agroforestry based system as compared to the sole cropping (devoid of trees) system was reported in potato (33.3%), followed by onion (21.05%) and wheat (15.0%). Whereas, among all the crops in present study, the maximum net return was obtained in wheat crop (Rs. 7525/ha) followed by onion *i.e.* Rs. 6515/ha during the study period which shows the efficiency of the system.

Keywords: Agroforestry, mahaneem, wheat, potato and onion

Introduction

Tree planting has always been conceived as a potential strategy to meet the needs of the local population besides maintaining the environmental balance since a very ancient times. Therefore, the worldwide interest in the tree planting and management gave birth to several popular terms related with "Forestry" such as social forestry, community forestry, agroforestry etc. (Foley and Barnard (1984); Nair (1993) and Tamale *et al.* (1995)) [5, 8, 13]. Agroforestry is one of the most viable alternatives for social, economic and ecological sustainability. At present agroforestry is recognized as an effective tool for increasing crop productivity, doubling farmer's income and providing immense crop diversification (Amatya *et al.,* 2018) [1]. Therefore, the agroforestry is regarded as the alternate land use systems and technologies involving tree combined with agricultural crops and/or animals on the same land management unit (Nair, 1993; Tamale *et al.,* 1995) [8, 13].

Trees under agroforestry systems are considered as an important natural resources which provide many useful products and services to the society. The existence of trees on agricultural land is an important aspect of our tradition and has been an undifferentiated part of contemporary farming systems in in both developed and under-developed countries (Baral *et al.,* 2013) [2]. Tree crop integration results into many types of interactions for solar radiations, soil moisture and plant nutrients, by changing microclimate, which affect the productivity of component crop. The large crown of trees produces a striking shade effect. Because of the plant height ratio of tree-crop intercropping is far greater than in pure crops, an entirely new pattern for light utilization is formed (Whiting, 2011) [14]. Agroforestry is one of the best options to increase the tree cover outside the forest. The need for agroforestry has been necessitated in many parts of the country, which face several agricultural and ecological problems, predominant of which are soil degradation, large scale deforestation, increasing population pressure of human beings and livestock, and decreasing land: man ratio. Agroforestry is a popular tool to modify the microclimatic under field conditions. Trees mainly modify radiations, relative humidity, carbon dioxide concentration, and wind velocity and soil environment to crop (Dhillon *et al.,* 2016) [4].

Ailanthus excelsa Roxb. Commonly known as 'Ardu' or 'Mahaneem' is a fast growing tree and is extensively cultivated in many parts of India. Mahaneem plantation on community land, farm boundary, road avenues and in agroforestry system helped in maintaining the ecosystem by slowing down the variations in climatic parameters due to climate change.

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Foliage of mahaneem is used by small ruminants to meet the green fodder requirement during lean period and it is also sold in the market to earn some more income to meet the farmer's expenditure to sustain their livelihood in harsh climate. It has been found to be a suitable species for planting in dry areas with annual rainfall of about 250 - 300 mm. It can be grown on a variety of soils but thrives best on porous sandy loams. The tree can be seen growing upto an elevation of 900 meters (Orwa et al., 2009) [9]. Mahaneem is a large deciduous tree of upto 24 m height with a straight cylindrical bole. Bark is light grey and smooth in young trees with large leaf-scars, rough, granular and grayish brown in older trees. Leaves are pinnately compound, upto 90 cm long with 8-14 pairs of leaflets. Flowers small, yellowish in panicles and fruits are single seeded samara (Kirtikar and Basu, 1995) [6]. Due to its fast growing and deciduous nature, agricultural crops can be grown successfully underneath this tree. Different *Ailanthus excelsa* based AFS (Bund/boundary, scattered trees in the existing farming systems) are practiced by the farmers in dry parts of north-west India. However, modern/improved *Ailanthus excelsa* based agroforestry systems are not popular among the farmers. Therefore, the present study was conducted to determine the suitable combinations of different arable crops under *Ailanthus excelsa* based agroforestry system in semi-arid zones of Haryana.

Materials and Methods
Experimental site: The study was carried out on farmer's field to determine the base line data of agricultural crops under a desirable spacing (3.6 × 2.1 m) of mahaneem based agroforestry system. The on farm trail was conducted at Bhiwani district of Haryana, located between 28.19^0 and 29.05^0 north latitudes and 75.26^0 and 76.28^0 east longitudes. Bhiwani district bears semi-arid climatic conditions having hot and dry winds and a high temperature which may exceeds upto 50^0C during summer. The average annual rainfall is 300-400 mm with about 80-90 % of total rainfall being received from south-west monsoon during the months of July to September while remaining 10-20 % rainfall is observed during winter season due to the north-east monsoon. The soils of the study area are sandy loam in texture and are low in the values of available organic carbon (0.39 %), available phosphorus (6 kg ha^{-1}) and medium in available potash (121 kg ha^{-1}). To determine the suitable crop combinations under agroforestry based system three crops *viz.* wheat, onion and potato were assessed to determine the effect of *Ailantus excelsa* based agroforestry system on yield and net returns

from the arable crops.

Results and Discussion
Yield of arable crops under Mahaneem based agroforestry system: A significant variation in the yield of different arable crops in present investigation was reported under the agroforestry based system in comparison to the control (sole cropping system). The data presented in Fig. 1 shows that onion recovered the maximum yield (18750 kg ha^{-1}) followed by potato (15000 kg ha^{-1}). However, the minimum yield (4516 kg ha^{-1}) was reported in wheat under *Ailanthus excelsa* based agroforestry system in comparison to the sole cropping system (control).

It has been observed that light, moisture and nutrients are considered as the most important limiting factors which directly influence the overall yield and productivity under an agroforestry based system. It may be the reason for high level of yield reduction under tree species that could be due to presence of great amount of shading effect and the underground competition for various resources (Prasad et al., 2010) [10]. It was further examined the reduction in yield was not only due to the competition but also due to the loss of land for the tree production as compared to the sole cropping system. Whereas, the other important reason which may be responsible for crop reduction is the competitive interaction between trees and crops for light, moisture and other resources under an agroforestry based system beside the modification of the micro environmental conditions (Bisht et al., 2017) [3].

The data presented in Fig. 2 shows a clear comparison between the reductions of yield of the different arable crops i.e. onion, wheat and potato under present study in comparison to the sole cropping system (control). It was observed that the maximum yield reduction was reported in potato (33.3 per cent) followed by onion (21.05 per cent) and wheat (15.0 per cent) in comparison to the control (sole cropping). The reduction in yield of crops under an agroforestry based system as compared to sole cropping system clearly demonstrate the existence of competitive interaction as reported by Sarvade et al. (2014) [12]. Similarly, Kumar and Nandal (2004) [7] also reported 16.3, 52.1, 62.3, 80.8 and 82.4 per cent yield reduction for lentil, berseem, wheat, potato, and mustard, respectively under *Eucalyptus tereticornis* based agroforestry system in comparison to sole cropping system which is again a strong evidence for the competitive interactions between the trees and crops in an agroforestry system.
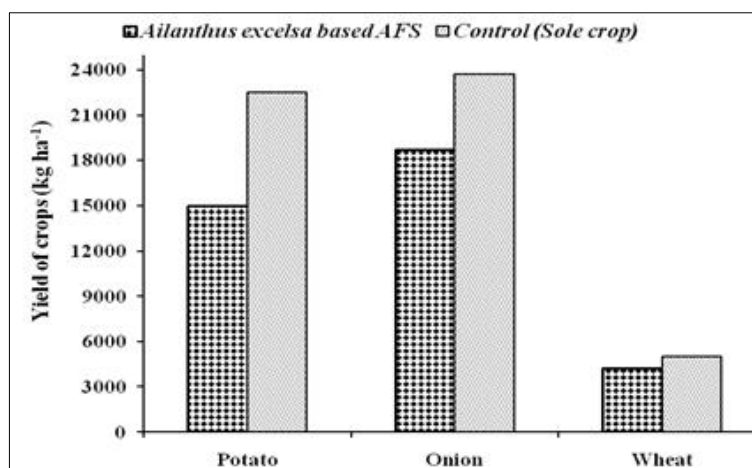

Fig 1: Effect of *Ailanthus excelsa* based AFS on yield (kg ha^{-1}) of different crops
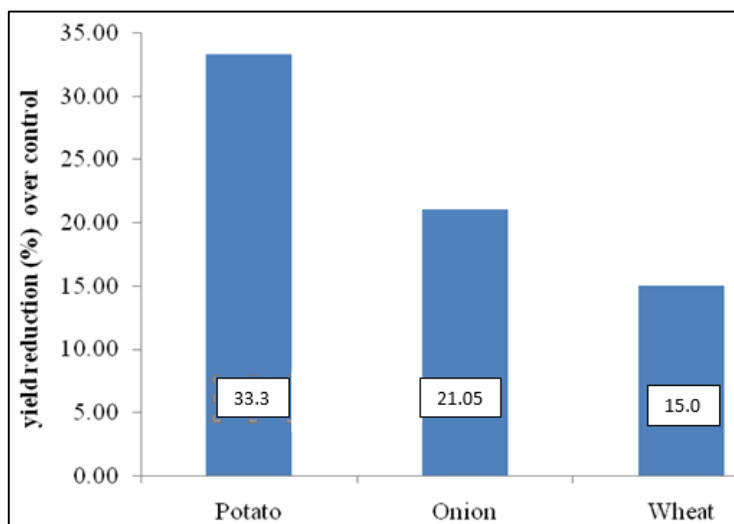
Fig 2: Effect of *Ailanthus excelsa* based AFS on yield reduction (%) of different crops over control

Net return

In spite of having a huge amount of reduction in yield under agroforestry based system, still the wheat crop obtained the maximum net returns (Rs. 7525/ha) in comparison to onion (Rs 6515/ha) and potato (Rs. 3993/ha). However, the net returns under agroforestry based system were significantly lesser as compared to the sole cropping system (control) for all the three crops under study. Similarly, the data presented in Table 1 clearly shows that higher value of benefit: cost ratio for the three crops under study was obtained under control (devoid of trees) as compared to the *Ailanthus excelsa* based agroforestry system. Similarly, Rajalingam *et al.* (2016) [11] reported the significantly lesser net returns and benefit: cost ratio under *Ailanthus excelsa* based agroforestry system in comparison to the mono-cropping system of tomato, brinjal and cluster beans in which tomato was most affected and cluster beans was least affected.

Table 1: Effect of *Ailanthus excelsa* based AFS on Net Return (profit) in Rs./ha of different crops

Sr. No.	Crops	Net Return (Rs.)		B:C Ratio	
		With tree	Without tree	With tree	Without tree
1	Potato	Rs.3993/ha	Rs.57588//ha	1.03	1.57
2	Onion	Rs.6515/ha	Rs.48710//ha	1.04	1.34
3	Wheat	Rs.7525/ha	Rs.25665//ha	1.1	1.38

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