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Effect of tree density on productivity of a *Prosopis cineraria* agroforestry system in North Western India

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Abstract

An experiment was initiated in 1991 to evaluate crop productivity and define optimum tree density with advancing age of *Prosopis cineraria* (L.) (Khezri) in an agroforestry system. Plots of *P. cineraria* at densities of 417 (D_1), 278 (D_2) and 208 trees/ha (D_3) were intercropped with *Vigna radiata* (L.) (mungbean) in 1995, 1997, 1999 and 2000 with *Pennisetum glaucum* (L.) R. Br. (pearlmillet) in 1998 and 2001. Tree height and collar diameter increased by 2.5 and 2.2-fold in D_1, 2.2 and 2.4-fold in D_2 and 2.2 and 2.0-fold in D_3 plot, respectively in the 6-year period. The highest crop yields were found in D_2 plots in 1995 and 1996, in D_3 plots in 2000 and in the control plots in 2001. The lowest crop yields were found in D_1 plots throughout the duration of the experiment. Trees produced utilizable biomass of 19.1, 15.8 and 10.3 tones/ha and dry leaf weight of 0.85, 0.67 and 0.50 tones/ha, respectively in the D_3, D_2 and D_1 plots at the age of 12 years (June 2002). Low soil water content at 1 m distance from tree base compared to that at the center of four trees indicated greater utilization of soil water within the tree rooting zone.

The yield of the annual crop increased when density of *P. cineraria* was appropriate (i.e., optimum tree density). But optimum tree density varied with tree size/age due to competition for soil resources. Yield of the annual crops was the highest at optimum tree densities of 278 trees/ha (4 m × 9 m) at 6 and 7 years, 208 trees/ha (8 m × 6 m) at 10 year and <208 trees/ha at 11 years of age. The study indicated greater benefits of *P. cineraria* tree integrated at optimum density through tree produced and synergistic effects on the annual crops.

Keywords: Crop production; *Prosopis*; Soil nutrients; Soil water; Tree biomass

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1. Introduction

Low and erratic rainfall, intense solar radiation, high wind velocity, recurring drought and famines are common features of the Indian arid zone. Farmers have practiced agroforestry as a strategy to ease out these problems (Malhotra, 1984). Farmers maintain and promote growth of randomly and widely spaced trees of *Prosopis cineraria* (L.), *Tecomella undulata* (L.) and *Ziziphus nummularia* (L.) on their cultivated fields. These trees sustain the farmers during the crop failure by producing food, fodder and timber. Current densities of these trees are very low and variable. For example, density of *P. cineraria* ranges from 3 trees/ha in western to more than 80 trees/ha in eastern part of Indian desert (Tejwani, 1994). A density of *P. cineraria* trees $>150\,ha^{-1}$ has also been observed in some cultivated fields (personal observation). Considering an average of only 1.27% forest cover in the arid region of western Rajasthan (Forest Survey of India, 1999), tree cover must be increased in agricultural fields to meet the local need of fodder and fuel. Growing trees at higher densities would be the best option to increase overall productivity of the farmland and to fulfill the increasing demand for fodder and fuel wood. Due to limited resources in arid and semi-arid regions, benefits from agroforestry systems largely depend on the judicious management of soil and water resources (Joshi et al., 1989; Parton et al., 1987). Improved selection of appropriate tree and crop species, growth of trees at optimum densities and adoption of pruning/lopping protocols are important management considerations to increase overall system productivity (Karim and Savill, 1991; Ong et al., 1992).

P. cineraria (L.). (Khezri) is the most widely grown tree in the Indian desert because both its leaves and fruits have high fodder and human food value, respectively. Information on *P. cineraria* cultivation is mostly based on data from randomly growing scattered trees (Aggarwal and Kumar, 1990; Aggarwal et al., 1976; Kaushik and Kumar, 2003; Tejwani, 1994). There is no systematic study to define optimum density of *P. cineraria* on farmland with increasing tree size/age. There is also an urgent need to increase overall productivity of farmland. We hypothesized that sequential thinning depending upon the outputs of agricultural crop yield and tree growth and biomass would provide appropriate tree density.

The objective of the study was to determine the effect of density of *P. cineraria* (L.) trees with advancing age on crop productivity for integrating this tree at a higher density. Tree-crop interactions were evaluated in terms of tree growth and biomass, crop yield and soil water status.

2. Materials and methods

2.1. Site conditions

The experiment was initiated at the Arid Forest Research Institute, Jodhpur with *P. cineraria* seedlings established at varying spacing with different agricultural crops. The site received 340, 515, 440, 516, 296, 293, 429 and 58 mm rain in 1995, 1996, 1997, 1998, 1999, 2000, 2001 and 2002, respectively, with mean annual rainfall of 350 mm. The rain during July–September (monsoon) was 306, 312, 294, 204, 205, 264, 327, 25 mm in the respective years. In July 1997, 1998 and 1999, the rainfall was 50.2, 56.7 and 58.6 mm, respectively. The maximum temperature rises to as high as 48 °C in the summer and the