

Original Research Article

<https://doi.org/10.20546/ijcmas.2020.910.241>

Effect of Canopy of *Acacia nilotica* on Soil Fertility Status at Varying Soil Depths in Wheat Based Agroforestry System

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ABSTRACT

Keywords

Canopy,
Acacia nilotica,
Soil fertility

Article Info

Accepted:
15 September 2020
Available Online:
10 October 2020

In the present study, a considerable build up in soil organic carbon under tree canopy as compared to open canopy was found and soil organic carbon under tree canopy decreased with an increase in soil depth and increasing canopy distance. The total nitrogen percentage in soil decreased with an increase in depth and canopy. In case of available soil phosphorus, it decreased under the tree canopy with increasing soil depth and canopy distance. The value of available soil phosphorus as well as potassium was found higher under the canopy and available potassium in soil was found higher than the open canopy. However, it was found decreasing towards the depth and canopy. The plantation of *Acacia nilotica* in cropland brought a reduction of soil pH. Therefore a reduction in availability of nutrients under tree canopy was noticed outwards the canopy.

Introduction

Acacia nilotica commonly known as Babul, Kikar or Indian gum Arabic tree has been recognized worldwide as a multipurpose tree. It is widely distributed throughout arid and semiarid zones of the world. It can play a crucial role to improvement of degraded soil through nitrogen fixing ability. Soil is the uppermost fertile layer of the earth crust and provides base for anchoring of plants and crops. It is one of the most important natural resources which are adversely suffering from the removal of tree cover. Most of the soils are infertile and cannot support sustainable

production. Even some soils which were once fertile are now depleted of nutrients and can no longer sustain production. If this precious resource does not get protection, its fertility and productivity will decline and it will become difficult to sustain the human and animal population even its present level. Enhancement and maintenance of soil fertility and productivity are essential for the sustainability of agriculture to meet the basic food needs of the increasing population of India. Maintenance and enhancement of soil fertility are vital for global food security and environmental sustainability (Rosegrant and Cline, 2003, Stocking, 2003). Maintaining

and enhancing the soil fertility of farmlands to grow food grains, as well as tree biomass, can help meet the demand in the future. Tree-based agro-ecosystems have more closed nutrient cycles that help conserve soil productivity. Planting and pruning N-fixing legumes is a feasible way to add Nitrogen to the systems (Mc-Grath *et al.*, 2000). As climate change progresses, the effect of elevated CO₂ itself will have a positive effect on the growth and nitrogen fixation of several Australian *Acacia* species (Schortemeyer, 2002) that grow very well in India. Agriculturally induced succession pathways often lead to dominance by leguminous trees and therefore serve as a mechanism for increasing N oxide emissions from tropical regions (Erickson, 2002). In regions where the green revolution has not been able to make dent due to lack of soil fertility agroforestry may hold promise (Sanchez 2000, 2002).

The present study was carried out examine how soil properties vary under the canopy of *Acacia nilotica* with varying canopy and soil depth. It was hypothesized that the plantation of *Acacia nilotica* at the farmer's field over the years improved soil fertility.

Materials and Methods

The study was carried out at an established field at Gwalior district in Bundelkhand region. The site is located in the semi-arid transitional zone of the central India characterized by undulating topography, variable soil and subtropical climate with low to very high (above 45°C) temperature. In this study, the soil sampling scheme consisted of four canopy viz. C₁ (25 % of canopy), C₂ (50 % of canopy), C₃ (75 % of canopy) and C₄ (100 % of canopy), and three soil depths viz. 0-10 cm (D₁), 11-20 crn (D₂), and 20-30 cm (D₃) under canopy of *A. nilotica*. Wheat was taken as an intercrop. Each sample was

replicated three times. Thus, 36 soil samples were drawn for the investigation. Each soil sample soil so augured was mixed thoroughly and collected about 500 gm soil in labeled polybags by quartering. Soil samples were brought into the laboratory and spread for air dry in the shade. After air drying, soil samples were ground and passed through 2 mm sieve. A portion of the 2 mm sieved soil was further sieved through a 0.2 mm sieve for the estimation of soil organic carbon. Soil pH was determined by electronic method with Systronic pH meter model 322-1 glass electrode assembly in 1: 2.5 soil-water suspension (Richards, 1954). Organic carbon in the soil was estimated by Walkley and Black, (1934) method. This method involved oxidation of organic matter with chromic acid and the excess potassium dichromate was back titrated against ferrous ammonium sulphate. Total nitrogen was calculated from the approximation Jackson, (1971). Available phosphorus was determined colorimetrically by extracting the soil with 0.5N NaHCO₃ at pH 8.5. Olsen *et al.*, (1954) and measuring the intensity of blue colour developed by ammonium molybdate stannous chloride. Available K in soil was determined by extracting the soil with IN neutral ammonium acetate Metson, (1956) and measured the concentration in the filtrate using a flame photometer. The effect of *Acacia nilotica* on soil variable was tested employing ANOVA using the Factorial experiment. Thereafter, by calculating the critical difference at 5% probability significance of treatment means were tested.

Results and Discussion

The data given in (Table 1) showed that the effect of *A. nilotica* on soil pH was found to be non-significant. Under the C₄ canopy of *A. nilotica*, the highest value (8.30) soil was observed at D₂ depth and the maximum mean value of soil pH was recorded 8.33 under C₄

canopy whereas the mean soil pH was highest (8.23) at D₃ soil depth. Across the canopy, the mean soil pH increased with increased in soil depth. However, the highest value of soil pH (8.33) was recorded under tree canopy at D₃ soil depth and C₄ canopy while the soil organic carbon at D₁ soil depth and C₁ canopy was found lowest (8.03). The results revealed that, under the canopy of *A. nilotica* decreases the soil pH decreased. The lowering of pH under tree canopy can also be explained on the basis that organic acids were produced during the decomposition of organic matter. Lowering of pH in agroforestry system were also reported by Parthiban and Rai (1994)

The results depicted showed in (Table 2), that soil depth and the canopy of *A. nilotica*, affected the mean organic carbon % in soil, significantly. Irrespective of soil depth the mean soil organic carbon (0.56%) was found significantly higher at C₁ canopy. The value of mean soil organic

carbon was recorded highest 0.56 % in C₁ canopy whereas the mean soil organic carbon was highest (0.52 %) at D₁ soil depth in comparison to D₂ & D₃ soil depth. Across the canopy, the mean soil organic carbon decreased with increase in soil depth.

The mean soil organic carbon at a reduction in the availability of organic carbon in soil under this tree was observed outwards the canopy. However, the highest value of soil organic carbon percentage (0.67 %) was recorded under tree canopy at D₁ soil depth and C₁ canopy while the soil organic carbon at D₃ soil depth under C₄ canopy was found lowest (0.37 %). The availability of organic carbon in soil under its canopy was found significant. The higher amount of organic carbon in soil under tree canopy could be explained from the fact that the major avenue for the addition of organic matter from the tree to the soil in the form of litter fall Singh *et al.*, (2004).

Table.1 Soil pH under the canopy of *A. nilotica* at different soil depth

Soil Depth	Canopy				Mean
	C ₁	C ₂	C ₃	C ₄	
D ₁	8.03	8.10	8.17	8.26	8.14
D ₂	8.07	8.20	8.20	8.30	8.19
D ₃	8.10	8.23	8.27	8.33	8.23
Mean	8.07	8.18	8.21	8.30	
C.D. (5%)	C= NS	D= NS	C*D=NS		

Table.2 Organic carbon % in Soil under the canopy of *A. nilotica* at different soil depth

Soil Depth	Canopy				Mean
	C ₁	C ₂	C ₃	C ₄	
D ₁	0.67	0.51	0.47	0.44	0.52
D ₂	0.57	0.45	0.44	0.41	0.47
D ₃	0.43	0.42	0.38	0.37	0.40
Mean	0.56	0.46	0.43	0.41	
C.D. (5%)	C=	D=	C*D= NS		

Table.3 Total Nitrogen % in Soil under the canopy of *A. nilotica* at different soil depth

Soil Depth	Canopy				Mean
	C ₁	C ₂	C ₃	C ₄	
D ₁	0.058	0.044	0.039	0.038	0.044
D ₂	0.049	0.039	0.038	0.035	0.04
D ₃	0.037	0.036	0.032	0.031	0.034
Mean	0.048	0.039	0.036	0.035	
C.D. (5%)	C=	D=	C*D=		

Table.4 Available P (Kg/ha) in Soil under the canopy of *A. nilotica* at different soil depths

Soil Depth	Canopy				Mean
	C ₁	C ₂	C ₃	C ₄	
D ₁	41.67	39.83	37.5	35.33	38.58
D ₂	40.07	39.17	36.67	34.66	37.64
D ₃	38.53	38.16	35.5	34.5	36.67
Mean	40.09	39.05	36.56	34.83	
C.D. (5%)	C=	D=	C*D=		

Table.5 Available K (Kg/Ha) in Soil under the canopy of *A. nilotica* at different soil depth

Canopy	Soil Depth				Mean
	C ₁	C ₂	C ₃	C ₄	
D ₁	286.33	280.66	275	272.67	278.66
D ₂	283.67	279.66	273.67	269.33	276.58
D ₃	281.32	278	272.33	268.66	275.08
Mean	283.77	279.44	273.67	270.22	
C.D. (5%)	C=	D=	C*D=		

The data presented in (Table 3) indicates that irrespective of a canopy of *A. nilotica* the highest value (0.044 %) of mean total nitrogen in soil was observed at D₁ canopy. While irrespective of soil depth, the mean total nitrogen in soil was found highest with the value of 0.048 % at C₁ canopy as compared to total nitrogen percent at other soil depths. Across the canopy, the mean total nitrogen in soil decreased with increasing distance of the canopy. However, the highest value of total nitrogen in the soil (0.058 %) was recorded under tree canopy at D₁ soil depth and C₁ canopy while the percentage of total nitrogen in soil at D₃ soil depth under C₄

canopy was found lowest (0.031 %). Significant variation was found in total nitrogen % in soil under its canopy at different soil depths.

The maximum value of nitrogen content in soil under tree canopy may be attributed primarily to its restitution to the soil through litter fall (Parthiban & Rai, 1994). Higher stem flow and root decay might be one of the reasons for the enrichment of soil in total nitrogen under tree canopy (Young, 1997). These observations are in conformity with the experimental findings of Pandey *et al.*, 2000 for *A. nilotica*;

It was observed from the data in table 4, that irrespective of soil depth, the highest (40.09 kg/ha) value of mean available phosphorus in soil under *A. nilotica* was recorded at C₁ canopy. Whereas, mean available soil phosphorus was found decreasing with increasing distance of tree canopy. Under tree canopy, the mean available soil phosphorus was highest (38.58 kg/ha) at D₁ soil depth. However available phosphorus decreased with increases in soil depth. However, the maximum value (41.67 kg /ha) of available soil phosphorus was recorded under tree canopy at D₁ soil depth and C₁ canopy radius, while the available soil phosphorus at D₃ soil depth under C₄ canopy was recorded minimum (34.50 kg /ha). Higher availability of phosphorus in soil under tree canopy might be due to the addition of phosphorus through litter formation and sloughing of tree roots. Tree induced increase in available phosphorus was also reported by Singh *et al.*, (2004).

The observation recorded in (Table 5) indicates that under the canopy of *A. nilotica*, irrespective of soil depth, the highest value (283.77 kg/ha) of mean available soil potassium was recorded at C₁ canopy. Irrespective of tree canopy, the mean available soil potassium at D₁ soil depth was found highest (278.66 kg/ha) in comparison to D₂ and D₃ soil depth. The mean available soil potassium decreased with increases in soil depth. However, the highest value (286.33 kg/ha) of available soil potassium was found under tree canopy at D₁ soil depth and C₁ canopy radius. While the value of available soil potassium at D₃ soil depth under C₄ canopy of this tree was found lowest (268.66). Significantly affect the availability of potassium in soil. The increase in available K in soil may also be ascribed to litter fall. These findings are in close conformation with experimental findings of Parthiban & Rai, 1994 who studied the effect of trees on soil fertility. Tree induce an increase in the

availability of potassium in soil was also reported by Singh *et al.*, (2004).

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How to cite this article:

Chatar Singh and Shayma Parveen. 2020. Effect of Canopy of *Acacia nilotica* on Soil Fertility Status at Varying Soil Depths in Wheat Based Agroforestry System. *Int.J.Curr.Microbiol.App.Sci*. 9(10): 1980-1988. doi: <https://doi.org/10.20546/ijcmas.2020.910.241>