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# Impact of Rhizosphere on Competitive Effects of Neem (*Azadirachta indica* A. Juss.) on Associated Pigeonpea [*Cajanus cajana* (L.) Millsp.] in a Agroforestry System

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## ABSTRACT

**Background:** Sustained agriculture has close intimacy with trees. However, the conventional agriculture had broken this intimacy especially by keeping trees away from the farm land for short term economic considerations. Tree may influence the associated crop either positively or negatively depending on its age, species, density, environment and management practices. Hence, understanding nature and extent of competitive effect is utmost important in adopting management practices to improve overall productivity.

**Methods:** An investigation was carried out to assess yield variation if any in pigeonpea and the primary ecological factors responsible for the same when it was grown in association with neem (25 years old) on field bunds in a traditional agroforestry system during 2018-19 in semi-arid tropics of Karnataka, India at three distances mainly 2-7.4, 7.4-12.8 and 12.8-18.2 m on E and W of N-S and N and S of E-W tree lines.

**Result:** Averaged over directions significantly lower pigeonpea yield (3.76 q $ha^{-1}$) was recorded near the tree line at 2-7.4 m distance, while it increased with increase in the distance from tree line and was the highest (7.61 q $ha^{-1}$) at far away distance (12.8-18.2 m) at which yield was on par with control (without any trees), though soil near the tree line (2-7.4 m) recorded significantly higher soil organic carbon and microbial population (fungi, bacteria and actinomycetes) indicating better soil health and moisture. This leads to the conclusion that it is not merely the rhizosphere characteristics or neem root interference but the above ground factors particularly light availability to pigeonpea as influenced by neem canopy is important in the agroforesty system.


**Key words:** Competitive effect, Direction, Interference, Rhizosphere, Tree line.

## INTRODUCTION

The sustainable agriculture has close intimacy with trees and/or livestock especially, the presence of trees which is known to provide several economical (*viz*., fodder, fuelwood, timber, food, fiber, fertilizer *etc*.) and ecological (such as improvement in soil fertility, soil and water conservation, amelioration of microclimatic condition, pollination and other ecosystem service at landscape level) benefits (Jose, 2009; Chittapur *et al.,* 2017). However, conventional agriculture had broken this intimacy especially by keeping trees away from the farm land for short term economical considerations (Chittapur and Patil, 2017).

In fact the retention of trees on farm land is an age old practice wherein the farmers retain useful naturally regenerated plants or sometimes purposely planted trees (Scroth *et al.* 2004) either scattered in the whole field or on the bunds and boundary of the farm with varying density. For instance, 15 to 40 trees $ha^{-1}$ are found on farmers field in the semi-arid tropics, *i.e.* the study area, of northern Karnataka (Doddabasawa, 2017). Ecological sustainability of such tree based land use systems with different tree and crop species has been established in different parts of the world. However, agroforestry systems are highly complex in structure and function as compared with monocropping or annual intercropping (Muthuri *et al.,* 2005), as the presence of perennial tree component in the system leads to continuous interaction with annual crop(s) present in the system. Trees may influence the associated crop either positively or negatively depending on its age, spread, density, crop and nature of their arrangement in the field, management and other prevailing ecological conditions (Sinclair, 1999; Coe *et al.,* 2014). No doubt, trees are the dominant partners and compete with crops for growth resources such as light, moisture and nutrients besides allelopathic influences in some instances. Hence,

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understanding nature and extent of competitive effect is utmost important in adopting management practices to improve overall productivity. Since the extent and nature of competition/complementary effects depend on kind of species, density, age, arrangement, associated field crop, climate and soil properties an investigation was undertaken to know influence of bund planted neem (*Azadirachta indica* A. Juss.) on the performance of associated pigeonpea [*Cajanus cajana* (L.) Millsp.] at different distances from the tree line in semi-arid tropics.

## MATERIALS AND METHODS

The present investigation was carried out at farmer's field inYadagir District of Notrth Eastern part (North eastern dry zone) of Karnataka, falling in the agroclimatic region 10 - Southern plateau and hill region of India during 2018-19. The climate of the region is semi-arid with an average rainfall 750 mm, mean annual temperature ranges from 18.6 to 32.5°C and the soil of the study area is red sandy loam. Farmer in the study area retained 25 years old neem trees on the field bunds at a density of 44 trees in 80 m long bund each on North-South (N-S) and East-West (E-W) orientations under rainfed condition. The average height of the trees was 13.2 m (±1.54) with girth (o.b) of 131.6 cm (±27.27). The competitive and complimentary effects of bund planted neem trees were analyzed at three distances from tree line at 2-7.4 m, 7.4-12.8 m and 12.8-18.2 m and averaged over directions (E and W of N-S tree line and N and S of E-W tree line) and field without trees was taken as control for comparison. The productivity of pigeonpea was assessed in terms of grain yield with net a plot size of 6 m × 5 m. Randomized complete block design with four replications was used for the study. Pigeonpea crop (cv. TS3R) was sown on 17$^{th}$ of June 2018 in different directions as per treatment in east-west and north-south tree line of neem on the bund and in control without trees. The experimental plot was ploughed twice and was brought to fine tilth by harrowing and the pigeonpea crop was sown at the seed rate of 12 kg ha$^{-1}$ with the spacing 90 cm × 30 cm. The fertilizer dose used was 25:50:00 N, P, K kg ha$^{-1}$ and the entire quantity of fertilizer in the form of urea and single super phosphate was applied to the crop at the time of sowing as basal dose. The crop was thinned at 20 DAS to maintain optimum population and two hand weeding and one intercultivation were done at 25, 40 and 60 DAS, respectively to check the weed growth and to keep the plots free from weeds during whole experiment.

The mature crop (24$^{th}$ of December 2018) was harvested at ground level, later grains and haulms were separated and dried, Further, the grain and haulm yield were weighed, computed and extrapolated to per hectare basis. The composite soil samples were collected at depth of 0-15 cm at each distance and directions separately and were subjected to chemical analysis by following standard procedures for available nitrogen, phosphorus, potassium and organic carbon respectively (Jackson, 1973; Subbiah and Asija, 1956; Walkley and Black,1934). Similarly, general microbial populations were analyzed by using dilution plate count technique and were expressed in cfu (colony farming unit) per g of dry soil (Bunt and Rovira, 1995).

## RESULTS AND DISCUSSION

The results revealed significantly lower pigeonpea grain yield (3.76 q ha$^{-1}$) near the tree line at a distance of 2-7.4 m from the base of the tree ($D_1$) (Fig 1). Yield increased with increase in distance from tree line and was the highest at a distance of 12.8-18.2 m ($D_3$) (7.61 q ha$^{-1}$) where it was on par with control (without any trees) (7.8 q ha$^{-1}$) which had 29 per cent higher yield compared to the average pigeonpea yield in association with neem. Low yield of pigeonpea in agroforestry could be attributed the competing influence of trees for light and space as trees in the study were 25 years old and unmanaged. The competition between trees and crops decreased with increase in distance from trees and probably was almost nil at a distance of 12.8-18.2 m as the yield was on par with control at that distance. The results are in concurrence with earlier reports were also similar drastic reduction in yield near the tree line were reported, for instances reduction of maize yield by 36 per cent with Paulownia trees (Newman *et al.* 1997), 16, 52 and 62 per cent in lentil, berseem and wheat respectively when intercropped with *Eucalyptus terticornis* (Kumar and Nandal, 2004), 36 per cent in wheat yield with Grevillea trees (Muthuri *et al.,* 2005), 5 to 66 per cent cob yield of sweet corn when grown with different aged Poplar trees and 12-14 per cent in pigeonpea grain yield with neem based agroforestry system (Doddabasawa *et al.*, 2020).

Interestingly, in the present investigation the competitive effects did not result in depleting soil health (nutrients and microbial population) near the tree line (Fig 2 and 3). In fact, soil near the tree at 2-7.4 m had higher organic carbon and available nutrients because of leaf shedding and partly due to additions from root sloughs (Fig 1). Together with root excretions probably they helped in holding more

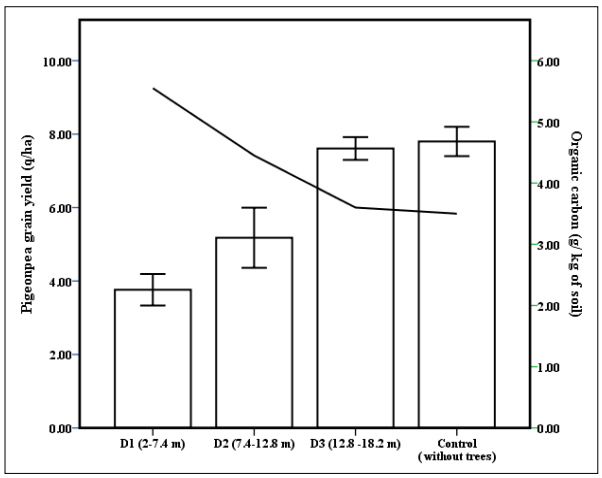



**Fig 1:** Grain yield of pigeonpea and soil organic carbon at different distances in agroforestry and control (without trees).

moisture and hence consequently helped in increasing rhizosphere biota (Fig 2a and 2b). The correlation analysis also revealed significant and positive correlation between soil organic carbon and available NPK and soil microflora (Table 1) at different distances. The results are also in conformity with the findings of Doddabasawa *et al*. (2018) who reported significantly higher microbial population in neem and teak based agroforestry systems under two contrasting ecosystems respectively as compared with open field and they attributed it to higher organic carbon and favorable microclimatic condition near tree lines. Similarly, Sumpam *et al*. (2009) reported positive correlation between microbial population and organic carbon and nitrogen under traditional agroforestry systems in north-eastern parts of India.

These improvements together with higher available nutrients (NPK) near the tree line compared to control (Fig 3a and 3b) should have resulted in better performance of pigeonpea near the tree, but in reality, it was not so (Fig 1). Therefore, the correlation between different rhizosphere

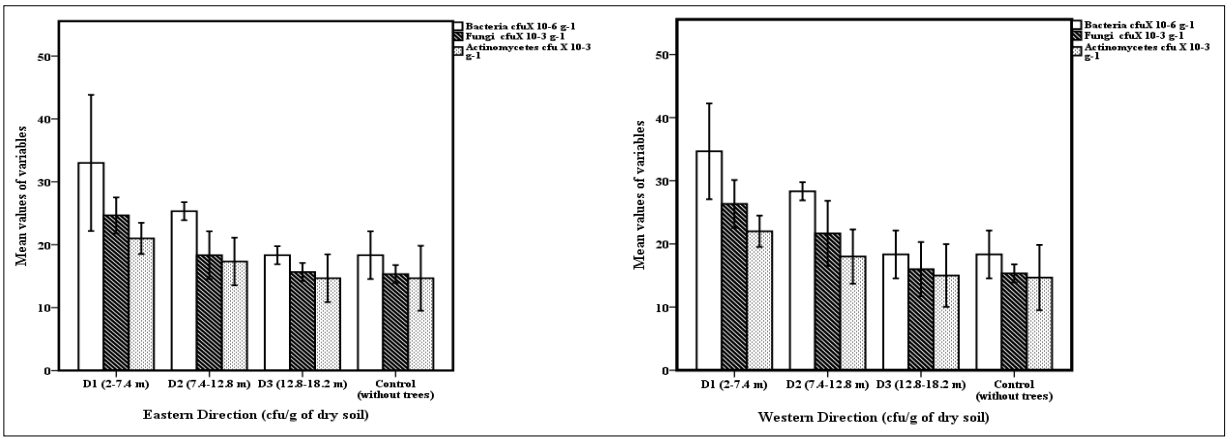



**Fig 2a:** Soil microbial population at different directions and distances from the North-South tree line and control (without trees).

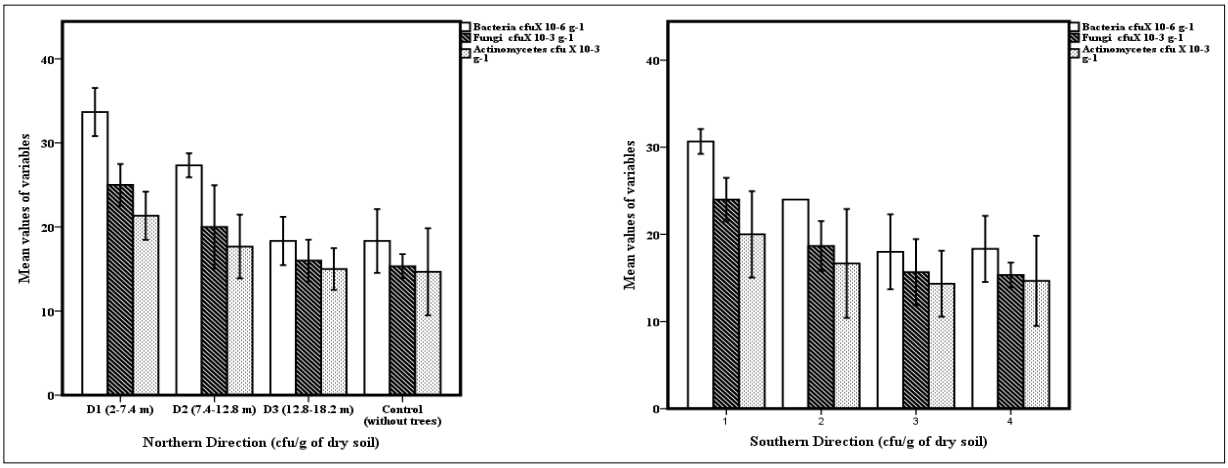



**Fig 2b:** Soil microbial population at different directions and distances from the East-West tree line and control (without trees).

**Table 1:** Pearson's correlation values between soil biota, chemical properties and pigeonpea grain yield.

| | Bacteria | Fungi | Actinomycetes | Organic carbon | Avil. nitrogen | Avil. phosphorus | Avil. potassium | Grain yield |
|---|---|---|---|---|---|---|---|---|
| Bacteria | 1.00 | .981** | .958** | .981** | .981** | .961** | .977** | -.976** |
| Fungi | | 1.00 | .982** | .976** | .990** | .967** | .993** | -.966** |
| Actinomycetes | | | 1.00 | .959** | .982** | .945** | .975** | -.945** |
| Organic carbon | | | | 1.00 | .984** | .940** | .974** | -.966** |
| Av. nitrogen | | | | | 1.00 | .972** | .984** | -.949** |
| Av. phosphorus | | | | | | 1.00 | .963** | -.911** |
| Av. potassium | | | | | | | 1.00 | -.967** |
| Grain yield | | | | | | | | 1.00 |

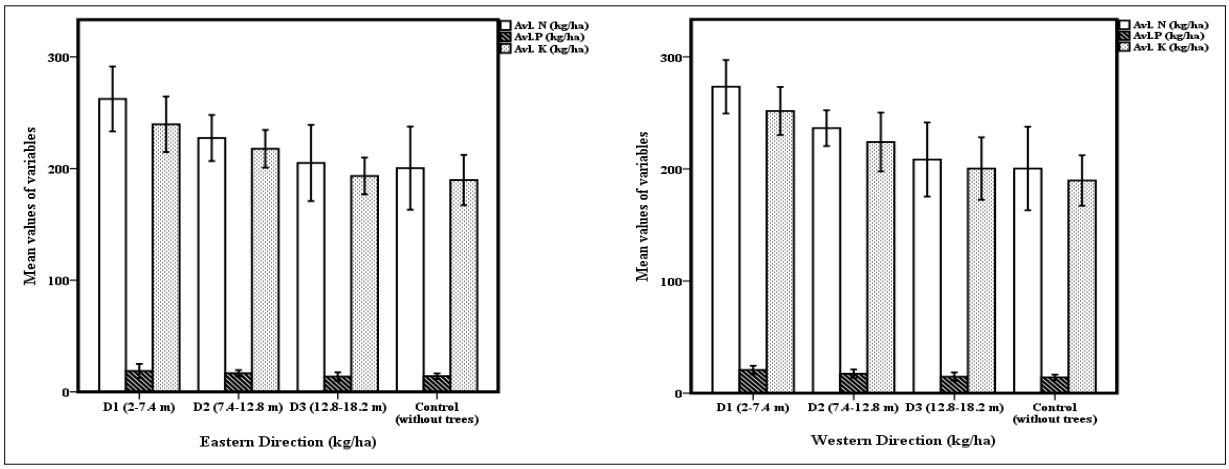



**Fig 3a:** Available soil nutrients at different directions and distances from North-South tree line and control (without trees).

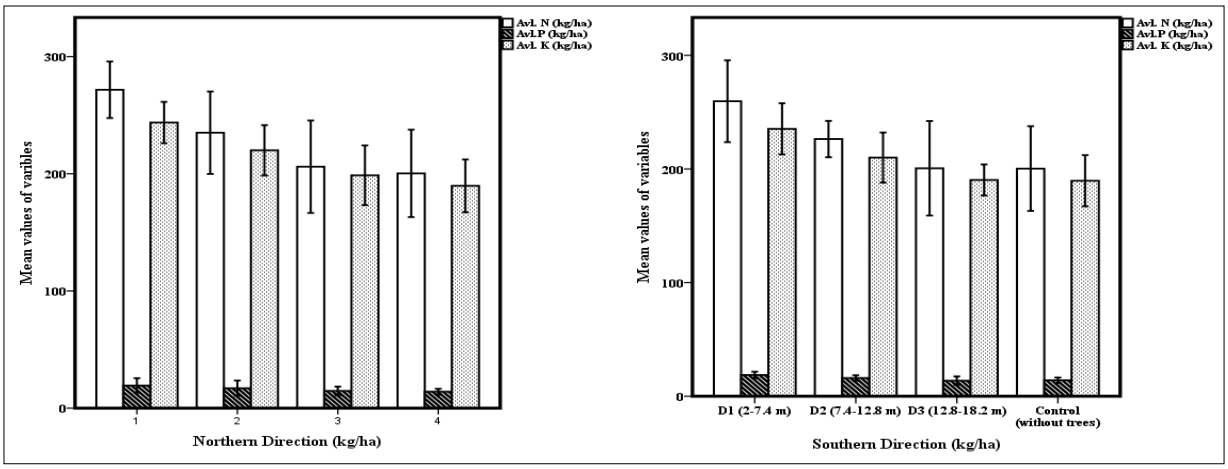



**Fig 3b:** Available soil nutrients at different directions and distances from East-West tree line and control (without trees).

factors and yield revealed significant negative correlation (Table 1). This clearly indicates that it is not the limiting rhizosphere characteristics but something above ground, particularly sunlight in this instance is influencing the performance of pigeonpea. Shading below the tree canopy and its extension with the diurnal movement of the sun is deciding the length of inhibitory influence (up to 12.8 m in the present study) from the tree line.The results are in line with Bazie *et al.* (2012) who reported light as the dominant and limiting factor for crop growth that causes substantial yield loss through the reduction in the amount of PAR (Photosynthetically Active Radiation) reaching the soil and crops by shading.

## CONCLUSION

The present investigation suggests that the productivity pigeonpea was lower in near vicinity under neem based agroforestry system probabely due to shading effect and this could be improved by adopting appropriate management practices such as pruning of branches during cropping period, wider spacing or growing shade tolerant short duration field crops near the tree line.

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### Informed consent

Informed consent was obtained from all individual participants included in the study.

### Conflict of interest

The all authors certify that they have seen and approved the final version manuscript being submitted further the article is original work of authors has not received prior publication and is not consideration of publication elsewhere and declare that they have no conflict of interest.

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