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Enhancement of seedling growth in Kadam [*Anthocephalus cadamba* (Roxb.) Miq.] using bio fertilizers

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Abstract
This experiment was conducted to know the effect of biofertilzers on seedling growth of kadam [*Anthocephalus cadamba* (Roxb.) Miq.] during the year 2019-20, at Net House, College of Forestry, Navsari, Gujarat in Completely Randomized Design with three replication and seven biofertilizer treatments: control, Azotobacter, Azosprillum, Acetobacter, PSB (Phosphate Solubilising Bacteria), Pseudomonas and VAM (Vesicular Arbuscular Mycorrhiza). Among all the treatments, application of VAM @ 10 ml/plant (T7) showed significantly maximum collar diameter (9.62 mm), root length (33.04 cm) and found at par with Azospirillum (T3) at 150 DAT. Whereas, Azospirillum @ 10 ml/plant (T3) exhibited maximum shoot length (80.52 cm), number of leaves/plant (13.33) and found at par with VAM (T7) having 76.50 cm, 13.25 for same growth trait. In biomass, VAM @ 10 ml/plant (T7) produced significantly maximum fresh (96.58 g) and dry weight (19.67 g) at 150 DAT. Overall result showed that an application of VAM @ 10 ml/plant enhance the growth of *A. cadamba* seedlings at 150 DAT.

Keywords: Biofertilizers, Growth, Anthocephalus cadamba, VAM

Introduction
Anthocephalus cadamba (Roxb.) Miq. is Popularly known as Kadamb or Kadam tree belongs to Rubiaceae family. It is a large tropical tree with broad crown and straight cylindrical bole. The branches are characteristically arranged in tiers which create an aesthetic look. The tree is deciduous in nature however sometimes evergreen and semi-evergreen in nature (Bijalwan *et al.*, 2014) [3]. Kadam is native to India, Indo-Malayan region, Java, Sumatra, China, Indonesia, Malaysia, Bangladesh, Sri Lanka, Cambodia, Papua, New Guinea, Philippines and Singapore (Anon., 1985) [1]. It is a light demanding species and can grow on a variety of soils but it prefers deep, moist alluvial soil (Bijalwan *et al.*, 2014) [3]. This species is suitable for soil conservation, agroforestry, jhum cultivation, land reclamation and industrial plantation. The rotation period of Kadam depends upon the objectives of production. For pulpwood and matches, harvesting can start after 4-5 years of planting. For wood production, felling can start approximately from the age of 10 years (Vijayaraghavan, 2014) [21].
The wood of Kadam is lightweight, creamy yellow in color with density range from 290 to 560 kg/m³ at 15 percent moisture content (Krisnawati *et al.*, 2011). Kadam treated wood is durable and used in the variety of services such as ceiling boards, light construction work, packing cases, furniture, planking, carving and turnery. It is also good for making veneers and plywood. It is highly suitable for the manufacture of pencils, match boxes, splints, printing and wrapping paper (Chaturvedi *et al.*, 2017) [5]. *A. cadamba* has minimum shade effect, fast growing, good coppicing ability and no allelopathic effect on the agricultural crop make the species suitable for the agroforestry systems. Kadam is adopted in plantation, particularly in agroforestry with a spacing of 5 m × 5 m or 6 m × 6 m and farm forestry practices in humid tropics for industrial and income generation (Bijalwan *et al.*, 2014) [3]. Beside its important hardwood timber, the other parts of kadam also having the medicinal, fodder and food value. The dried bark can be used to relieve fever or to be consumed as a tonic. The fruit and inflorescences are edible whereas Fresh leaves can be used as fodder to feed the cattle (Orwa *et al.*, 2009) [13]. Biofertilizer is a substance containing growth promoting living microbes: bacteria, fungi, algae etc. These alone or in combinations are known to be increasing plant growth by way of various biochemical activities in the soil such as Nitrogen fixation, breakdown of organic matter, secretion of plant growth hormones and increase the availability of nutrients in a form which can be easily assimilated by plants.

The biofertilizers also control soil or root borne diseases, parasitic nematodes and maintain soil structure (Sharma and Chaubey 2015) [18]. Forest nurseries play a huge role in the production of quality seedlings for the development of plantations of forest trees. The demand for quality forest planting materials is high, so it is required to manage nurseries professionally to produce the desirable quality of seedlings (Shreedher and Mohan 2016) [19]. The healthy nursery seedlings stock can be produce using biofertilizers. Looking into the importance of kadam and very few research work has been done in past on the nursery aspect of kadam for early and healthy production of seedlings, so this experiment was carried out to study the effect of biofertilizers on seedling growth of *A. cadamba* (Roxb.) Miq.

Materials and Methods

The present investigation was conducted at Net House, College of Forestry, Navsari Agricultural University (NAU), Navsari, (Gujarat) from December 2019 to August 2020. Other details are given below.

Fruit collection and seedling production

An orange colored ripened fruits of Kadam were collected from healthy and well developed trees distributed in the campus of NAU, Navsari. The seeds extracted from the fruits were sown in germination bed containing soil and sand for raising seedlings.

Biofertilizer application

The growth of germinated seedlings was very slow therefore they kept in the same condition for two months and then transplanted into the 10" × 8" size black polythene bags containing growing media of soil, sand and FYM (2:1:1) having a seedling height of about 5-6 cm. After one month, different biofertilizers such as T_1: Control (No biofertilizer), T_2: Azotobacter, T_3: Azosprillum, T_4: Acetobacter, T_5: PSB (Phosphate Solubilising Bacteria), T_6: Pseudomonas and T_7: VAM (Vesicular Arbuscular Mycorrhiza) at the rate of 10 ml per plant were directly applied to soil in the polythene bag.

Measurement of various growth parameters

The growth of Kadam seedlings were monitored in terms of their shoot length, collar diameter, number of leaves per plant, root length, total fresh and dry weight of plant were recorded at 150 DAT (Days After imposing Treatment). The experimental data were processed and fed to the data sheet in MS Excel and subjected to statistical analysis using DOS based software developed by Department of Agricultural Statistics, NAU, Navsari in experimental design CRD (Completely Randomized Design).

Results and Discussion

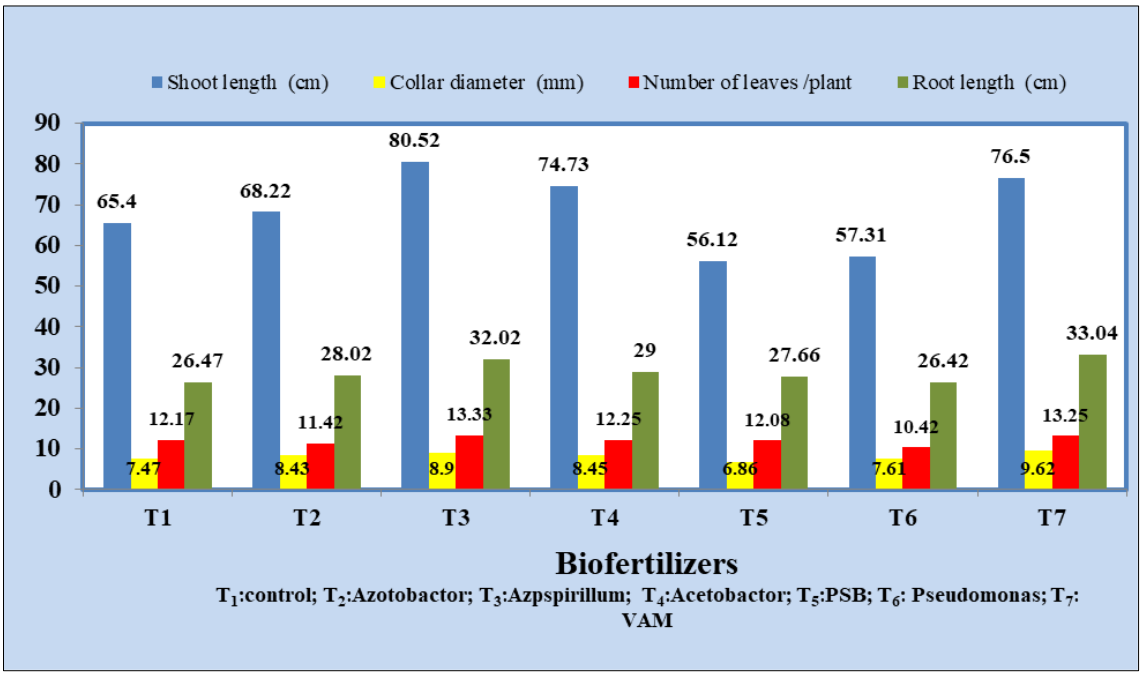
The result showed that effect of biofertilizers such as VAM and Azospirillum on growth parameter: shoot length, collar diameter, number of leaves per plant, root length, fresh and dry biomass of Kadam seedlings was found considerably maximum as compared to other treatments.

An application of VAM @ 10 ml/plant (T_7) exhibited the maximum collar diameter of 9.62 mm followed by Azospirillum (8.90 mm) @ 10 ml/plant (T_3)) in *A. cadamba* seedlings at 150 DAT. However, application of Azospirillum @ 10 ml/plant (T_3) observed maximum shoot length (80.52 cm) and number of leaves per plant (13.33) and found at par with VAM @ 10 ml/plant (T_7) having 76.50 cm and 13.25 at 150 DAT (Graph-1). The growth of seedlings in nursery stage normally depends upon the growing media: its type, nature along with the types of inoculants applied. The growth of seedlings in early stages also depends upon the tree species and growth characteristics. The increase in collar diameter and shoot length can be credited to VAM as it help in the transfer of nutrients from the soil into the root system via specialized structures known as vesicles and arbuscules. The fungal hyphae enhance the uptake of phosphorous and other nutrients. They also help the plant to uptake a large amount of water from the roots; increase plant tolerance to various biotic and abiotic stresses and reduce the needs of chemical fertilizers (Nosheen *et al.*, 2021) [12]. Similarly, Azospirillum has been attributed to several mechanisms including secretion of phytohormones (auxins and gibberellins), biological nitrogen fixation and enhancement of mineral uptake of plants (Mrkovack and Milic, 2001) [11]. This results are in agreement with the findings of Budi and Christiana (2012), Shreedher and Mohan (2016) [19]. Budi and Christiana (2012) recorded maximum plant height and collar diameter with application of Arbuscular Mycorrhizal Fungi (AMF) in seedlings of *A. cadamba*. Shreedher and Mohan (2016) [19] reported that application of combination of VAM and Azospirillum in *Neolamarckia cadamba* seedlings exhibited maximum shoot length, collar diameter, leaf area ratio. Chiranjeevi *et al.* (2018) [6] also found the application of VAM increase the seedling height (24.13 cm), seedling girth (0.63 cm), number of leaves per plant (18.86) in *Embellica officinalis*. Similar findings also reported by Vairamani and Rajendran (2021) [20] in *Casuarina junghuhniana*; Sharma and Chaubey (2015) [18] in *tectona grandis*; Ravikumar *et al.* (2011) in *Jatropha curcas*.

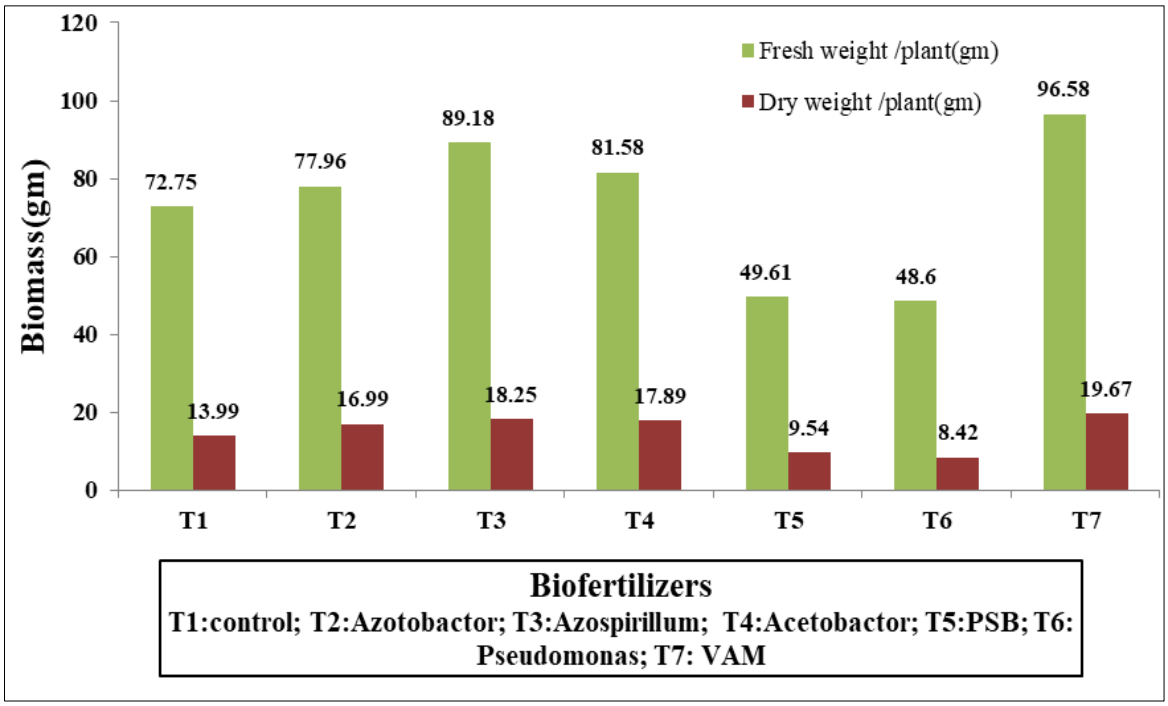
The maximum root length (33.04 cm) was recorded in VAM @ 10 ml/plant (T_7) and found at par with Azospirillum (32.20 cm) @ 10 ml/plant (T_3) (Graph-1). The rhizosphere is a dynamic soil environment formed by living plant roots and their associated microorganisms and fauna. These microbes have multiple functions like nitrogen fixation, phosphorus solubilization and mobilization (Sen and Paul 1957) and stimulating root development by producing metabolites like indole acetic acid (IAA) and other growth hormones (Lynch 1990) [8]. The effect of plant growth promoting microbes on the growth performance varied with the host plant species (Shreedher and Mohan 2016) [19]. The present result of maximum root length with application of VAM was supported by the findings of Maharana *et al.* (2018) [10], where AM (Arbuscular Mycorrhiza) + PSB + Novel treated seedling in *Gmelina arborea* showed maximum root length (30 cm) at 210 days after inoculation. Similarly, Chiranjeevi *et al.* (2018) [6] also found the maximum root length (16.33 cm) in *Embellica officinalis* with VAM application. An application of VAM @ 10 ml/plant (T_7) exhibited significantly maximum fresh (96.58 g) and dry weight (19.67 g) of plant and followed by Azospirillum @ 10 ml/plant (T_3) of 89.18 g and 18.25 g in *A. cadamba* at 150 DAT (Graph-2). VAM normally enhances the surface area of roots which helps in absorption of available nutrient and water to larger extent as compared to other biofertilizer. So it may ultimately enhance the growth and biomass production of seedlings (Saini, 2019) [16]. The present result of higher biomass production with application of VAM supported by the findings of Shreedhar and Mohan (2016) [19] in Kadam where seedlings inoculated with AM

fungi and PGPR exhibited higher biomass production. Morever, Maharana *et al.*, (2018) [10] recorded that combine inoculation of AM (Arbuscular Mycorrhiza) + PSB + Novel to *G. arborea* seedlings produced maximum biomass; Raj *et al.* (2010) [14] found maximum biomass when treated with VAM + Azospirillum + Phosphobacterium in *T. grandis* seedlings. Balasubramanian and Srinivasan (1995) [2] found that seedlings inoculation with four AM fungi in *Ailanthus excelsa*, *Tectona grandis* and *Dalbergia sissoo*, significantly increased the total biomass, Madan *et al.* (1995) [9] reported that seedlings inoculated with AM fungal showed better shoot and root dry weight in *A. excels*, *Pongamia glabra* and *Cassia siamea.*

Graphs



Graph 1: Effect of biofertilizers on shoot length, collar diameter, number of leaves/plant and root length in *A. cadamba* seedlings at 150 DAT



Graph 2: Effect of biofertilizers on fresh and dry weight of seedlings in A. cadamba at 150 DAT

Conclusion

The results from the study indicated that inoculation of VAM in the seedlings of *Anthocephalus cadamba* gives better seedlings growth in collar diameter, root length, fresh and dry biomass with the maximum shoot length and number of leaves per plant in nursery stage as compare to other biofertilizer treatments and control therefore, VAM can be used for early and higher production of quality seedlings to support the ever increasing plantation requirement.

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