RESEARCH ARTICLE

Effect of organo-mineral fertilisation on the growth of *Artemisia afra* plants from vegetative propagation plants in Burkina Faso

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Artemisia afra is a perennial plant native to South Africa, cultivated mainly for its antimalarial properties. The plant gives few or practically no seeds for its reproduction, with low leaf yields due to the poor original soils conditions. The objectives of this study is to identify the best vegetative propagation technique for *A. afra* and to determine the effect of fertilization of plant growth. Two vegetative propagation techniques were evaluated, namely cuttings and layering. For these techniques different fertilizers were applied. The treatment used consisted of eight levels for cuttings and six levels for layering.

The results show that layering is more effective than cuttings. For layering, Compost (CO) and Bokashi plus Compost (BC) significantly (p<0.0001) increased above-ground and root biomass. These fertilisers also improved transpiration (0.1 kg of water lost in 24 hours). Based on these results, layering improves the propagation of *A. afra* plants and the use of compost alone is sufficient to improve plant growth.

Key Words: *Artemisia afra*; *Cuttings*; *Layering*; *Fertilisers*; *Biomass*; *Transpiration*

INTRODUCTION

Artemisia afra is a perennial plant that can live for about ten years. This wormwood forms a small bush used in the fight against malaria thanks to the arginine it contains and the combination of its active ingredients. The poor quality of Africa's tropical soils, the ongoing degradation of these soils combined with the harmful effects of climate change and the poor use of fertilisers are significantly reducing *A. afra* production. Furthermore, high antropogenic pressure and climatic aridity are degrading or even destroying the seed-based production systems and methods of *A. afra* currently practiced in Africa [1]. To feed itself, the plant needs a good root system and soluble nutrients, which can only be released by adequate biological activity. Root development and biological activity in the soil require good aeration, conductive to water to circulation. The original poverty of soils in nutrients and the low use of mineral and organic fertilisers partly explain the low level of crop yields. Proper use of mineral fertilisers can increase production. But mineral fertilisers are not enough to maintain soil fertility, as they have no effect on the organic status of the soil. These findings make soil fertilisation crucial and are just as important, if not more so, than the types of fertilisers and soil amendments required to achieve good and healthy harvests [2].

Formerly cultivated as a medicinal plant, *A. afra* produce few or virtualy no seeds. Vegetative propagation and proper fertilisation would be a promising option for a significant improvement in *A. afra* production. With this in mind, we propose to test the following hypotheses:

- Cuttings would be the best technique for reproducing *A. afra*.
- Soil fertilisation would be a determining factor in the growth and vegetative development of *A. afra*.
- Total biomass yield would be a function of a type of fertiliser applied to *A. afra*.

Thus, in the search for solutions to the problems of *A. afra* reproduction and soil amendment, this study was conducted with the aim of comparing, depending on the type of fertiliser and the vegetative propagation method, the morphophysiological response of *A. afra* cultivated in Burkina Faso in order to identify a method ensuring high production of *A. afra*. Specifically, it was necessary to: (i) Identify the most efficient propagation technique; (ii) Determine the conditions conducive to good emergence of cuttings and layers; (iii) Identify fertilisers that optimize the development of root and aerial biomass of *A. afra*.

MATERIALS AND METHODS

Equipment used

The study was conducted in a greehouse and out door, in the experimental garden of the Life and Earth Sciences Training and Research Unit (UFR/SVT) at Joseph KI-ZERBO University in Burkina Faso, under natural conditions lighting, temperature and humidity conduction. The site is located at an altitude of 303 m, at 1°29 West longitude and 12°22 North latitude. Annual rainfall in the area varies between 800 mm and 1000 mm [3].

The branches used for cuttings and layering come from *Artemisia afra* plants which were popularised at the Diarabakoko agroecological farm, 23 km from Banfora.

The branches of *A. afra* were treated with aspirin and wheat. Indeed, to allow rapid root development efervescent aspirin and wheat seed were use. One end of the *A. afra* branch segments was macerated for 24 hours in 2500 ml of distilled water solution containing 10 aspirin tablets. Aspirin contains acetylsalicylic acid, a rhizogenesis stimulator. After macerating the branches segments we incised the branches at the macerated and to insert wheat seeds before planting the whole. When the wheat seeds germinate, their roots release auxin, a hormone that also stimulates rhizogenesis.

Pots with carefully leveled bottom to ensure excess water drains watering to field capacity (CAC) were used. Each pot with 6 kg of growing medium [4,5].

Experimental conditions

Growing method:

- In order to better improve knowledge of water needs of *A. afra*, the segments were grown in pots.
- The cuttings design is in blocks with 3 repetitions and a single factor, the 8-level fertiliser. Each block consists of eight lines, each comprising

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three (3) pots making up the experimental unit. In total, 72 pots were used (72=8 × 3 × 3).

- The layering design is also in block with total randomisation with 3 repetitions and a single factor, the 6-level fertiliser. Each block consists of 6 lines, each comprising three (3) pots constituting the experimental unit. In total 54 pots were used (54=6 × 3 × 3).

Substrate characteristics

The types of fertilizers used to evaluate their impact on the growth of *Artemisia afra* plants are:

- 3 kg of control soil (TS), consisting of the basic medium of ferralitic clay mature.
- Compost (CO) consisting of a mixture of 3 kg of ferralitic clay soil with 1 kg of compost.
- Bokashi (BO) or fermented organic matter consisting of a mixture of 1 kg of bokashi and 3 kg of ferralitic clay soil.
- Organic manure (FO) consisting of a mixture of 1 kg of organic manure and 3 kg of ferralitic clay soil.
- NPK of composition 23-10-5, consisting of a mixture of 3 kg of ferralitic clay soil and 1.6 g of NPK.
- Bokashi plus Compost (BC) consisting of a mixture of 1 kg of BC and 3 kg of ferralitic clay soil.
- Poultry droppings (Fi) consisting of a mixture of 1 kg of droppings and 3 kg of ferralitic clay soil.

Method of measurement

Nine characters were determined. Three related to environmental parameters, namely temperature (°C), relative air humidity (%) and soil temperature (°C). Six characters are related to plant growth such as plant height (cm), number of leaves, number of branches, crown diameter, aboveground and root biomass (g) and leaf transpiration (kg) [6].

Statistical analysis

Descriptive statistics were performed on the collected data. Mean calculations and graphs were performed using an Excel spreadsheet. Statistical analysis of the variables measured was carried out using XLSATAT-Pro software, version 7.5.2. 2016. The different data were subjected to single factor (type of fertiliser) an Analysis of Variance (ANOVA) and the means and interactions were compared by the Newman-Keuls test at the 5% threshold [7].

RESULTS

Cutting and fertilisation

The cuttings experiment was unsuccessful. Indeed, on the 18th days after cutting, the first buds appeared which did not develop. At 30th days after cutting, complete degeneration of the cuttings was observed, thus illustrating the ineffectiveness of *A. afra* propagation by cuttings. The effect of fertilisation could not therefore be assessed [8].

Layering and fertilisation

Environmental parameters:

Temperature, relative air humidity and soil temperature: The ambiant temperature and relative humidity of the air during the experiment varied between 22.70°C and 38.70°C and between 38% and 90% respectively (Figure 1).

Soil temperature was not significantly impacted by the different fertilisers ($p>0.05$). We note, however, that plants treated with organic manure had relatively higher soil temperatures than those treated with the other fertilisers (Figure 2). On the other hand, the control soil temperature was the lowest of the different treatments.

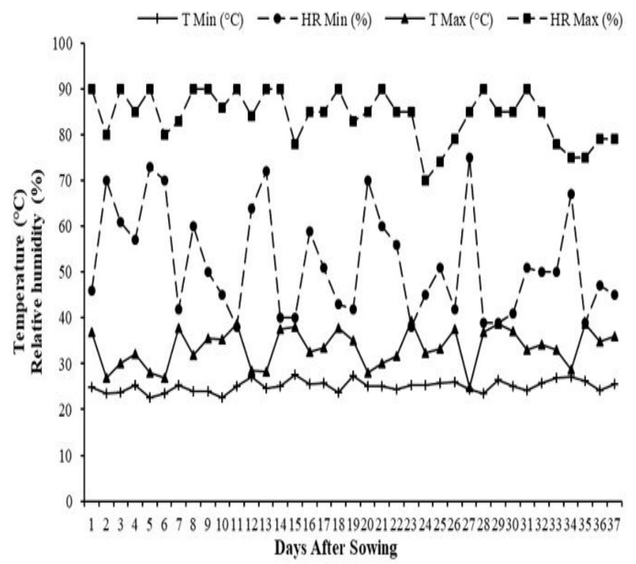

Figure 1) *Curves of minimum and maximum temperature (°C) and relative humidity (%) curves as a function of the number of days after sowing*

Note: RH: Relative air humidity; T: Air temperature; Min: Minimum; Max: Maximum

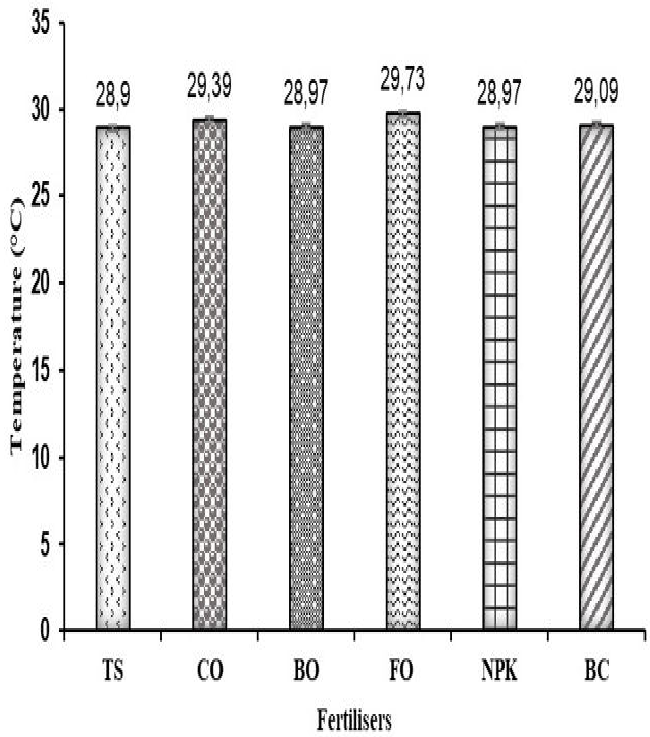

Figure 2) *Evolutionary curves for the number of branches as a function of fertilisers*

Note: TS: control soil; CO: plants amended with compost; BO: plants amended with bokashi; FO: plants amended with organic fertilizer; NPK: plants amended with NPK; BC: plants amended with bokashi+compost.

Plant growth: Fertilisation of the different plants had a significantly different effect on plant height (p<0.0001). At the end of the experiment in week 10, plants treated with CO reached a significantly average height 103.78 ± 1.168 cm than plants treated with other types of fertilizer [9]. Table 1 shows these differences in average heights according to fertiliser at the end of the experiment.

Figure 3 represents average number of branches by plant and per type of growing medium. In the first week, the number of branches was not significantly different. Over the weeks, plants treated with CO and BC showed the greatest number of branches than the other fertilisers (p<0.0001).

The fertilisers used had a significant effect on the biomass of *A. afra*. The root and arial biomass of the plants treated with CO and BC was significantly higher those with other fertilisers (Table 1) (p<0.0001).

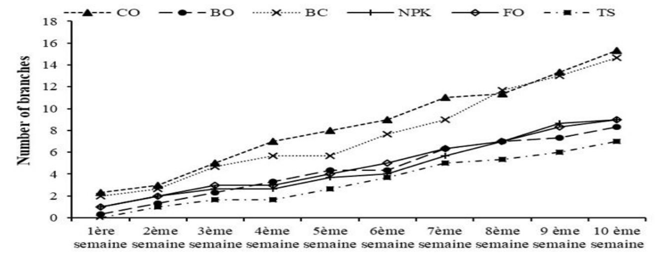

Figure 3) *Evolutionary curves of the number of branches as a function of fertilizers*
Note: Legend: TS: Control soil; CO: Plants amended with compost; BO: Plants amended with bokashi; FO: Plants amended with organic manure; NPK: Plants amended with NPK; BC: Plants amended with bokashi +compost

TABLE 1
Plant growth parameters as a function of the type of experiment fertilizer

Parameters						
Treatment	**HP (cm)**	**NF**	**NR**	**BR/BA**	**BT**	**TT**
CO	103,780± 1,168a	138,700 ± 0,941a	15,667 ± 0,577a	0,277 ± 0,096a	6,190 ± 0,02a	0,134 ± 0,016
BC	99,500 ± 1,322b	137,887 ± 0,500a	15,000 ± 1,000a	0,268 ± 0,031b	5,673 ± 0,03b	0,098 ± 0,011
FO	75,667 ± 1,258c	120,777 ± 0,692b	9,667 ± 0,577b	0,229 ± 0,064	4,730 ± 0,05c	0,096 ± 0,009
NPK	71,333 ± 1,040d	117,887 ± 0,786c	9,333 ± 0,577b	0,248 ± 0,018	3,963 ± 0,02d	0,084 ± 0,016
BO	65,667 ± 1,040e	98,143 ± 0,461d	8,333 ± 0,577b	0,152 ± 0,051	3,650 ± 0,03e	0,036 ± 0,012
TS	58,667 ± 0,763f	90,627 ± 0,611e	7,000 ± 1,000c	0,285 ± 0,067	2,360 ± 0,04f	0,029 ± 0,002
P value	<0,0001	<0,0001	<0,0001	<0,0001	<0,0001	<0,0001

Note: Legend: TS: Control soil; CO: Plants amended with compost; BO: Plants amended with bokashi; FO: Plants amended with organic manure; NPK: Plants amended with NPK; BC: Plants amended with bokashi+compost. In each parameter, values with the same letter are not significantly different according to the TUKEY test at the 5% threshold P: Probability; HP: Plant height; NF: Number of leaves; BR/BA: Root biomass to above-ground biomass ratio; BT: Total biomass; TT: Total Transpiration.

Plants treated with CO, NPK and FO have significantly higher transpiration than those treated with other fertilisers (Table 1). Plants treated with BO and TS have the lowest average transpiration rate with (0.029 kg) and (0.036 kg) respectively.

Figure 4 allowed us to locate periods of high transpiration between 10 am and 3 pm. The midday low was observed between 12 pm and 1 pm. This is the warmest time of day and plants transpire less.

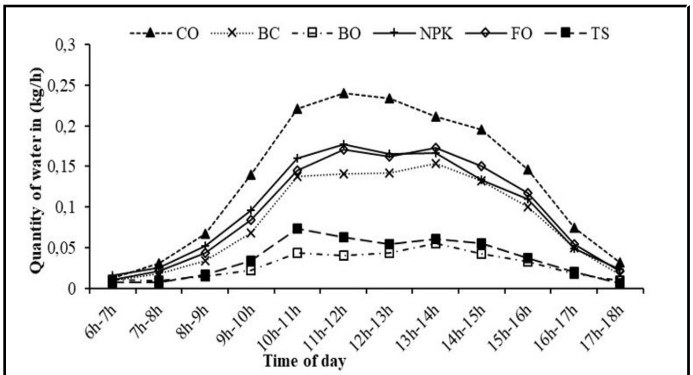

Figure 4) *Evolution of plant transpiration as a function of fertilisers*
Note: TS: Control soil; CO: Plants amended with compost; BO: Plants amended with bokashi; FO: Plants amended with organic manure; NPK: Plants amended with NPK; BC: Plants amended with bokashi and compost

DISCUSSION

The total degeneration of all cuttings in *A. afra* would result, on the one hand, in and early depletion of the cuttings' reserves. This depletion of reserves leads to a loss of energy in the cuttings, which is used to initiate rhizogenesis. Our results corroborate those of [10] on *Ziziphus mauritania lam.* On the other hand, the failure of the cuttings of rooting could also be explained by the non-activation of secondary meristems, the inefficiency of the type of growing medium and unsuitable climatic conditions.

The development of layers can be explained by the fact that they were nourished by the mother plant until the root emission phase. The layering period (June to September) seems to influence the development of the layer. At this time, *A. afra* plants are in sap flow. The high sap flow helps transport the nutrients necessary for their growth, redistribute the organic substances produced by photosynthesis and transport growth hormones, in this case auxin, a hormone that stimulates rhizogenesis.

A. afra plants prefer relative humidity of between 50% and 85% [11]. These facts were confirmed during our experiment (55% to 82.67%). This would explain the good development and growth of *A. afra* plants produced by layering. Relative humidity and temperature vary inversaly. These results corroborate those of [12], who stipulated that temperature controls the intensity of photosynthesis, respiration water uptake and mineral salts from the soil through the opening and closing of the plant's stomata.

Regarding the effect of fertilisers on the layering growth, the highest temperatures of soils fertilised with organic manure (29.73°C) would attest to a strong catabolic activity of microorganisms on organic matter into nutrient of plant. The increase in soil temperature around plant roots would promote growth and root development for the search of water [13-15].

Compost (CO)organic manure (FO) and the Bokashi plus Compost (BC) mixture would improve the mineral and water supply to the plants. These treatments would best provide *A. afra* plants with the elements essential for their growth in height and diameter. The use of organic manure-based amendments could improve the physico-chemical and biological properties of the soil, thereby increasing the productivity of the amended plants [16], found that manure releases its nutrient content slowly and gradually, more so than chemical fertilisers (N, P, K), so that plants benefit more. The

Bokashi and soil controls contained few nutrients for the growth of *A. afra* plants. The good height and diameter growth of *A. afra* plants results not only from a good supply of major elements (N, P, K), but also from sufficient availability of trace elements [17]. However organic matter would appear to play a key role in providing these trace elements. According to [18,19], humus promotes the supply of trace elements to *A. afra* plants, which are considered as growth promoters. The development of these plants could also be explained by the fact that fertilisation with compost would improve the mineral nutrition. They corroborate those of [20] on the effect of organic amendments on the growth and yield of potato (*Solanum tuberosum*) and [21] on the effects of amendments on the growth, yield and chemical composition of black nightshade (*Solanum nigrum* L). Some *A. afra* plants fertilised with compost reached a maximum height of 1.25 m and a diameter of 4.5 cm, but authors such as [22] and [23] had higher values in height and diameter, at 2.50 m and 6.7 cm respectively. This difference in size could be explained by our different experimental conditions (the plants were grown in a greenhouse and in six-litre pots).

The improvement in fresh above-ground biomass yields would be attributed to the positive effects of the amendments [24]. The significant root and arial biomass of plants amended with compost, bokashi plus compost mixture, NPK and organic manure compared with the control and bokashi could be explained by the fact that the control soil is poor in nutritive elements and by an unsuitable dosage of bokashi to the nutrient needs of the species, which made fertilisation a limiting factor in rhizogenesis. Fertilisation with compost, the bokashi plus compost mixture, NPK and organic manure would promote the production of root biomass, thus allowing the root system to extract more water by exploring larger soil surfaces [25].

Among fertilisers, compost, along with the growing soil, constitutes a good growing substrate that has a good water retention capacity for *Artemisia afra* [26]. This water retention capacity is due to the physicochemical properties of the compost and caused strong transpiration of plants amended by it. Indeed, the water retained by the compost is absorbed by the root system of plants, which allows the plant transpiration and gas exchange with little affected by the restriction of the soil surface (because the growing surface was made up of 6-litre pots) and therefore photosynthesis. When a plant transpires, there is a loss of water molecules and a gain the CO_2 necessary for photosynthesis. This loss of water through transpiration following the opening of the stomata is the pathway for assimilation of CO_2 from the ambient air, necessary for photosynthesis. The decrease in transpiration during the hottest periods of the day corresponds to the partial closure of the stomata (midday depression). Respectively observed a midday depression in cowpea and soybean when transpiration thresholds are reached during a hot and/or dry day, which allows the plant to avoid water stress. The high transpiration of compost is due to their high leaf biomass of these plants. Because have more leaves and stomata, the more the plant transpires, the better the plant will perform photosynthesize for its growth [27-30]. This correlation is confirmed, because the plants amended with compost transpired the most and also produced more dry biomass, useful in traditional medicine against malaria.

CONCLUSION

This work reveals that *A. afra*, native to South Africa, can tolerate the Sahelian climate of the Burkina Faso. The results obtained during the study allow us to reject the first hypothesis, that the technique of reproduction by cuttings is the best technique for multiplying *A. afra* than layering. These results show that fertilisers influence the production of total biomass, also affect transpiration of *A. afra* plants and confirm the second hypothesis, which states that the type of fertiliser or fertilisation has an effect on total biomass production. The optimization technique we have developed allows the farmer to know the interest of carrying out layering for the multiplication of *A. afra*. As a practical recommendation, it will be a question of proposing the layering technique for vegetative propagation of *A. afra*, given that the production of seeds is almost impossible and use CO for fertilization in normal conditions of plant development.

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