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Short Communication

Auxin induced rooting of cactus pear (*Opuntia ficus-indica* L. Miller) cladodes for rapid on-farm propagation

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The effect of exogenous auxins on the development of root system in cladodes of *Opuntia ficus-indica* was tested using different concentrations of indole butyric acid (IBA), naphthalene acetic acid (NAA) and a combination of IBA and NAA, and the control treated with 50% aqueous solution of ethanol. Results obtained showed that rooting in cladodes is most effective when treated with 2500 mg L^{-1} of IBA. A non-significant effect on rooting was observed when cladodes were treated with NAA alone or in combination with IBA. The development of *O. ficus-indica* in orchard and farmlands particularly in the dry Sudano-Sahelian zone of Nigeria would provide a valuable source of vegetarian food for humans and feed for livestock.

Key words: *Opuntia ficus-indica*, rooting, cladodes, Indole butyric acid (IBA) Naphthalene acetic acid (NAA).

INTRODUCTION

Cactaceae is a family of perennials with high efficiency in converting water to dry matter due to its characteristic photosynthetic pathway of Crassulacean Acid Metabolism (CAM), surpassing *C-4* plants such as corn by four to five-fold. Cactus pear *(Opuntia ficus-indica)* has become an important crop with great potentials of ensuring sustainable and valuable agricultural production in arid and semi-arid regions of the world. Its products are very popular among rural population in arid and semi-arid areas in its native region of Mexico and in the Mediterranean basin (Barbera, 1995). Cladodes and fruits are useful for a variety of purposes including food, fodder, therapeutics and industrial products (Nobel, 1994). In the last decades, an increase in the demand of tropical fruits has led to establishment of cactus orchards for fruit production in many countries (Synman, 2006). *Opuntia* was reported to be one of the most widespread cacti, primarily due to their edible fruit and vegetable mass used as feed (El-Finti et al., 2013).

Despite the large range of commodities it could provide in areas with scarce available resource, cactus has received little attention in Nigeria. However, recently the cultivated spineless cactus pear was introduced to Jigawa state (Anonymous, 2002). Although cactus pear can be propagated from seeds, cladodes and other asexual methods such as grafting and tissue

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culture (Estrada-Luria et al., 1994), based on whole cladodes are more commonly used in conventional propagation practices. Vegetative propagation relies on the plant's ability to produce new roots and shoots from an existing part of the plant such as a stem or leaf (Kelly, 2009). While the establishment of vast plantations of *Opuntia* requires large quantities of propagated materials, commercial scale propagation of Cactus using tissue culture techniques is posed with a serious problem due to unreliable public utilities in Jigawa State. This underscores the need for a simple technique that will ensure rapid on-farm propagation over a short period of time.

Root dynamics of Opuntia species have been shown to be related to their water potentials under water limiting conditions (Joseph et al., 1998; Synman, 2006). According to Synman (2006) placing the cladodes flat on the soil, more areoles came in contact with the soil and therefore more roots developed in both *O. ficus-indica* and *O. robusta* with an average of only 3.4% areole complexes not rooting. Side roots grew as much as 8 and 5 mm per day for *O. ficus- indica* and *O. robusta*, respectively. Rain roots, grew up to 7 and 5 mm within a day for *O. ficus-indica* and *O. robusta*, respectively. Plant growth regulators (PGRs) have also been shown to influence organ differentiation in Opuntia (Mauseth, 1976). Exogenous Gibberellin (GA_3) inhibits the development of daughter cladodes as well as flower production in the plants (Nobel, 1996). On the other hand, Indole-3-butyric acid (IBA) and Naphthalene acetic acid (NAA) were shown to have a positive effect on root development and increase in cladode weight of *O. ficus-indica* (Mulas et al., 1992, Lazcano et al., 1999). Under *in vitro* condition, IBA was reported to produce more roots in *O. ficus-indica* and other species of *Opuntia* (Mohammed-Yasseem et al., *1995;* Juárez and Passera, 2002). This work aims at enhancing root system development of *O. ficus-indica* cladodes as a means of facilitating its field establishment over a short propagation period.

MATERIALS AND METHODS

The experiment was carried at Jigawa Research Institute, Kazaure (JRI), between the months of February to June 2013. JRI falls within the dry Sudano-Sahelian ecological zone of Nigeria. The cladodes used in this experiment had a mean length of 24.6 cm and a mean width of 14.1 cm and were obtained as mature secondary cladodes of the cultivated species of *O. ficus-indica.* Quick-dip solutions consisting of 2,500, 5,000, 7500 and 10,000 mgL^{-1} of three auxin types; IBA, NAA and a *50:50* mixture of IBA and NAA were prepared with 50% aqueous solution of ethanol. Ten cladodes were used for each treatment including the control, which was treated with 50% aqueous solution of ethanol. Cladodes were treated by dipping 4cm of the basal part into the auxin solutions for four seconds. They were then planted in the field in a randomized complete block design with three replications. Water (equivalent to 300 mm annual rainfall) was applied to the experimental plots to maintain moisture. Rooting was observed after two weeks of establishment by carefully uprooting the cladodes without damaging the roots. They were then washed with clean water and the number and lengths of roots were recorded. The root dry weight was obtained as the final dry weight after drying in oven at 75°C for 42 h. The data obtained was analyzed using SAS ANOVA procedure and means separation using Duncan Multiple Range Test (SAS Institute, 1988).

RESULTS AND DISCUSSION

The soil of the study area is predominantly sandy with a pH of 8.5, low level of organic matter (1.04%) and high levels of Phosphorous (90.0 ppm) and Potassium (108 ppm). The prevailing climate at the time of the experiment is characterized by no rain, very low humidity and high day temperature of 35 to 39°C. Rooting was observed in the treatments, including the control and only 5% of the cladodes became putrid due to fungal infection. Analysis of variance in this experiment indicates that block effect was not a significant factor in rooting of cladodes. However, treatments with different levels of auxin had a significant effect in the rooting (Table 1). Root number, length and dry weight were significantly higher ($p<0.005$) in cladodes treated with IBA than in those treated with NAA or IBA+NAA. The result showed that greater root number, root length and root dry weight were obtained with 2500 mg L^{-1} IBA. Treating c1adodes with NAA or IBA+NAA did not significantly affect the root length and dry weight in cactus pear. There was some increase in the root number when cladodes were treated with NAA or IBA+NAA, with corresponding decrease in root length. The root length in control treatment was higher than root length in cladodes treated with NAA or IBA+NAA. Indole-3- butyric acid at 2500 mg/L significantly increased root dry mass.

There were significant differences in rooting among IBA-treated and NAA-treated, IBA+NAA-treated and the untreated cladodes of *O. ficus-indica.* In the presence of IBA, cladodes rooted with high frequency, while the untreated cladodes rooted poorly and tended to produce fewer roots. The best result in terms of root number, root length and root dry weight was obtained with IBA at concentration of 2500 mgL^{-1}. The findings of this experiment show that rooting response in cladodes of O. ficus-indica can be improved by applying exogenous IBA. Similar observation was reported by Lazcano et al., (1999) under field conditions. El- Finti et al., (2013) also reported that the rooting of in vitro-generated shoots was achieved most efficiently on half-strength MS basal medium supplemented with 0.5 mgL-1 of indole-3-butyric acid (IBA) or IAA and with rooting frequencies were in the range from 95 to 100% and the highest mean number of root (19.1) was obtained with IBA. Currently IBA is the most widely used auxin to stimulate rooting in many plant species because of its high ability to promote root initiation (Nobel, 1996), mild toxicity alias great stability when compared with NAA and IAA. Although Auxins have been reported to stimulate enzymatic reactions and

Table 1. Effect of different concentrations of auxins on root system development in cladodes of Cactus.

Auxin Conc. (mgL^{-1})	Mean No. of Roots/cladode			Mean root length/cladode (cm)			Mean Root Dry Weight/ Cladode (g)		
	IBA	NAA	IBA/NAA	IBA	NAA	IBA/NAA	IBA	NAA	IBA/NAA
*Control	3.3^{d}	3.6^{d}	3.5^{d}	3.3^{bc}	3.3^{bc}	3.2^{bc}	2.0^{bc}	2.0^{bc}	2.0^{bc}
2,500	26.7^{a}	8.3^{bcd}	8.9^{bcd}	6.3^{a}	2.5^{c}	2.6^{c}	5.1^{a}	$2,5^{bc}$	2.7^{bc}
5,000	19.1	8.0^{bcd}	8.0^{bcd}	4.8^{ab}	2.0^{c}	2.1^{c}	2.7^{bc}	2.6^{bc}	2.9^{bc}
7,500	14.7^{b}	7.5^{cd}	7.1^{cd}	4.5^{b}	2.0^{c}	2.1^{c}	2.7^{bc}	2.4^{bc}	$2,5^{bc}$
10,000	14.7^{b}	3.7^{d}	5.0^{d}	2.8^{c}	1.7^{c}	2.0^{c}	2.3^{bc}	1.9^{bc}	1.9^{bc}
SE (±)		0.96			0.62			0.63	

Means followed by same letter(s) within a parameter are NOT significantly different using Duncan. Multiple Range Test (p=0.05). * = 50% aqueous solution of ethanol.

thus increase the rate and quality of root production in high concentration, they can have the opposite effect and retard or inhibit the formation of roots. The effectiveness of auxins can also vary among species of plant, thus the optimum concentrations and combinations of auxins may differ among species. Root dry weight decreased with increase in concentration of auxins from 5,000 mg/L to 10,000 mg/L. Although the number of roots in cladodes treated with NAA and IBA+NAA was not significantly ($p<0.005$) different from the control (Table 1), the rate at which the roots were produced as measured by their length was lower than control. NAA and IBA+NAA did not significantly increase root dry weight in cladodes of *O. ficus-indica,* and apparently a decrease in the root dry weight occurred along with increases in the concentration of auxins.

Conclusion

IBA application at concentrations between 2500 to 10000 mgL^{-1} has a positive effect on the root number of *O. ficus-indica.* The best rooting in terms of root number, root length and root dry weight was recorded with 2500 mgL^{-1} of IBA. Treating cladodes with NAA and IBA+NAA at concentrations used in this experiment did not significantly increase root number, root length and root dry weight. Root length and dry weight decreased with increase in IBA concentration. Treatment with 2500 mg L^{-1} IBA is an alternative technique for enhancing root system development that should be tested for the establishment of Cactus orchards and farms in semi-arid parts of Nigeria.

Conflict of interests

The authors have not declared any conflict of interests.

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