Effect of dried powder of *Moringa* leaves combined with fruit peels on water stressed *Solanum scabrum*

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Abstract

This study investigated the effect of *Moringa oleifera* blended leaves and *Moringa oleifera* leaves in combination with banana/plantain-orange peels on the growth performance of water stressed *Solanum scabrum* plants. Seeds of *Solanum scabrum* were first raised in a nursery bed for a period of 4 weeks before transplanting into planting bags with each plant per bag. There were two treatments, *Moringa oleifera* leaves only and *Moringa oleifera* leaves and banana-orange peels which were added to the soil as dry powder a week after transplanting. Nothing was added to the control plants. The plants were subjected to seven days watering regime. The use of *Moringa oleifera* leaves + banana/plantain peel + orange peel had some stimulatory effect on water stressed *Solanum scabrum* plants. There was significant increase in some of the growth parameters measured as compared with the control plants. There was also significant increase ($P \leq 0.05$) in chlorophyll a and b between the treated plants and the control. *Moringa oleifera* leaves applied alone did not yield a positive response as the control plants were found to be significantly higher than the treated plants in most of the growth parameters measured. The study shows that *Moringa oleifera* leaves in combination with banana and orange peel is promising as a cheap and available bio organic fertilizer to improve the growth of *Solanum scabrum* plants as well as its resistance to drought stress.

Keywords: bio organic, fertilizer, African nightshade, drought, vegetables

INTRODUCTION

Solanum scabrum Mill. is a member of the plant family *Solanaceae*. In Nigeria it is traditionally called 'ogunmo' by the Yorubas' and generally, the plant goes by the common names: African nightshade, Black nightshade or Garden huckleberry. The use of this plant ranges from vegetable to therapeutic (medicinal) (Fontem and Schippers, 2004). Leaves and fresh shoots of *Solanum scabrum* are widely used as a cooked vegetable.

The importance of leafy vegetables in developing countries has been recognized due to the fact that they provide cheap and adequate amounts of crude fiber, carotene, a precursor of vitamin A, vitamin C, riboflavin, folic acid and mineral salts like calcium, iron, phosphorous etc. (Prasad et al., 2008). Vegetable growth and productivity are adversely affected by water stress and water scarcity in parts of sub-Saharan Africa is spreading due to a decline in annual rainfall levels and overuse of renewable water sources (Luoh et al., 2014). Calvo et al. (2014) reported that according to the European Biostimulants Industry, one of the effects that biostimulants can have on plants is that in the presence of stressors, plants are able to preserve and bear a high nutritious yield with the help of biostimulants.

Biostimulants can be plant extracts that contain a wide range of bioactive compounds which are usually able to improve the nutrient use efficiency of the plant and enhance tolerance to biotic and abiotic stresses. Biostimulants are not nutrients per se; instead they may facilitate the uptake of nutrients or beneficially contribute to growth promotion or stress resistance (Brown and Saa, 2015). The definition and concept of plant biostimulants is still evolving, which is partly a reflection of the diversity of inputs that can be considered to be biostimulants (Calvo et al., 2014). Van Oosten et al. (2017) and Calvo et al. (2014) both

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agree that the definition proposed by du Jardin (2015) that "A plant biostimulant is any substance or microorganism applied to plants with the aim to enhance nutrition efficiency, abiotic stress tolerance and/or crop quality traits, regardless of its nutrients content" represents the clearest and most concise way to define biostimulants. The major biostimulants (humic and fulvic acids, protein hydrolysates, seaweed extracts, silicon, chitosan, inorganic compounds, beneficial fungi (i.e., arbuscular mycorrhizal fungi; AMF and *Trichoderma* spp.) and plant growth-promoting bacteria (De Pascale et al., 2017) may not be readily accessible to the farmers in rural Nigeria. There is a need to provide biostimulants or bio organic fertilizers that are readily accessible to local farmers interested in organic farming.

Moringa leaf extract is a rich source of antioxidants, some plant secondary metabolites and osmoprotectants. It is also a source of zeatin, a natural derivative of cytokinin, vitamins and several mineral elements, making it a potential natural growth stimulant or biostimulant (Rady et al., 2013). The applications of *Moringa* leaf extract, used as seed soaking or foliar spray, have been shown to improve plant growth (Abd El-Hamied and El-Amary, 2015; Aslam et al., 2016) and tolerance to abiotic stresses, including salinity (Rady et al., 2013; Yasmeen et al., 2013; Howladar, 2014; Rady and Mohamed, 2015). It has been reported that *Moringa* leaf extracts applications maintained optimum tissue water status and membrane stabilities, enhanced antioxidant levels and activated plant defence system, increased levels of plant secondary metabolites, reduced uptake of undesirable Na^+ and/or Cl^-, and enhanced shoot or leaf K^+. These events lead to vigorous seedling growth, maximizing the crop performance (Yasmeen et al., 2012; Rehman et al., 2014).

The innovation of mixing bio-stimulants with bio organic fertilizers, capitalizing on their synergistic effects is a real contribution in terms of agricultural production. Banana and plantain peels have been described to be rich in adding nutrients to the soil, nutrients like Calcium, zinc, nitrogen, phosphorus and other exchangeable cations. They have high nutritional content to boost the soil in a cheap, natural and effective way (Omoni et al., 2015). Orange peels have also been reported to contain high concentrations of Potassium and Calcium (Assa et al., 2013; Feumba et al., 2016).

The status of biostimulants and bio organic fertilizers in Nigeria is similar to the assessment by Dayan et al. (2009), who reported that a large number of bio-stimulant and bio-control products that have long been known and have been patented for agricultural plant growth-promotion and/or pest management, are still not available commercially, unlike the situation in other countries in the world. The present study was designed with the objective to evaluate the potential effects of the exogenous application of *Moringa oleifera* leaf extract alone and in combination with banana/plantain and orange fruit peels on the changes in growth parameters of *S. scabrum* plants, exposed to water stress, in terms of improvement in growth.

MATERIALS AND METHODS

The experiment was conducted in a screen house in the Department of Botany of Obafemi Awolowo University Ile-Ife (7°31'N and 4°31'E) Nigeria between December and April of the year 2016 and 2017 respectively. Soil was collected inside a black polythene bag of 2 kg size which was used as transplanting bags for the nursery plants.

Experimental set-up

Solanum scabrum seeds were extracted from its berries using sieve and well water. After the seeds were fully extracted they were dried at room temperature to drain-off water. The seeds were treated with Ceiber-plus (fungicide) to prevent fungal attack, then, planted in nursery bowls of about 40 cm diameter and 17 cm deep filled with top soil. The seeds were watered twice daily and seedlings emerged one week after planting.

The seeds planted in the plastic bowls were allowed to grow for a period of 4 weeks in the nursery bed. The plants were now transplanted into planting bags (2 kg size), with a plant in each bag. The transplanted plants were allowed to adjust to their new environment for a week, watering with 75 mL of water every other day, before the treatment started.

The experiment was carried out within a screen house. The screen house had an average temperature of 34°C and light intensity of 2600 lux at full day using a digital lux meter TCX100.

Treatments and application of biostimulants

The leaves of *Moringa oleifera* and banana/plantain and orange peels were collected within Obafemi Awolowo campus, dried and milled into powder form separately and preserved in the refrigerator (4°C).

The plants were separated into control without treatments and the treated plants. Treatments (powdered *Moringa oleifera* leaves alone (DP-M); 50% of powdered *Moringa oleifera* leaves, 25% of powdered banana peel and 25% of powdered orange peel (DP-MOB)- on weight basis; control: no additives) were applied a week after transplanting. To each stand of plant in the planting bag 0.40±0.02 g (200 kg ha^{-1}) of plant material was applied where applicable. The treatment was applied to each plant after watering to avoid leaching. The application was carried out at two weeks' interval by putting them in a small hole dug beside the plant and then covering with soil. The plants were subjected to seven days watering regime (75 mL of water every seven days) in order to examine the effect of water stress on the plant. The control plants and the treated plants were subjected to 7 days watering regime. A week after treatment application, ten seedlings were removed (for analysis) from each of the treatments and control per week for four weeks. The treatments were applied three times during the duration of the experiment which was at the vegetative stage of the vegetable. The experiment was arranged in randomized complete block design.

Plant growth analysis

The number of leaves per plant was counted. Shoot lengths were measured using a meter scale, and the leaf areas (in cm^2) were measured manually by determining the leaf length and width and calculating the area from it using a modified Hoyt and Bradfield (1962) formula:

$$\text{Leaf Area} = L * W * C.F$$

where L and W are the leaf length and width respectively while C.F is the correction factor 0.70. The fresh weight of the plant was taken by cutting out the root, shoot and leaves and their weights were taken respectively on a weighing balance. The cut parts were then carefully placed in individual envelopes and dried in a Gallenkamp oven for 48 h. The dry weight was measured on a weighing balance.

Determination of leaf pigment concentrations

Photosynthetic pigments (chlorophyll a, chlorophyll b) were determined spectrophotometrically. Fresh plant material of 0.5 g from each replicate of each treatment was homogenized in 20 mL of 80% chilled acetone in a darkened room. A pinch of $NaHCO_3$ powder added and the extract filtered through Whatman no.1 filter paper. Final volume of the filtrate was made to 100 mL with 80% acetone. Absorbance measured at 470, 646, and 663 nm wavelength respectively with 80% acetone used as a in order to determine the chlorophyll content.

Statistical analysis

Analysis of variance (ANOVA) was carried out on the data collected using a SAS statistical computer package. means were separated using Duncan's multiple range test at 0.05 confidence limit (alpha level).

RESULTS

Only shoot height, shoot fresh and root dry weight were stimulated by the DP-MOB treatment being significantly higher than the stressed control plants. Number and area of leaves per plant, total fresh and dry weight of stressed plants treated with DP-MOB though

7.5, 14.6, 22.3 and 7.3% higher respectively than in the stressed control plants, were not significantly different from them.

Growth parameters of stressed plants treated with DP-M were not significantly different from the control plants although number of leaves and shoot fresh weight were significantly lower. The effect of *Moringa oleifera* and banana/plantain and orange peels on chlorophyll contents of leaves of stressed *Solanum scabrum* plants is shown in Table 1.

Table 1. Effect of *Moringa oleifera* and banana/plantain and orange peels on chlorophyll contents of leaves of stressed *Solanum scabrum* plants.

	Control	DP-M	DP-MOB
Chlorophyll a	15.040b	7.195c	18.894a
Chlorophyll b	10.470b	30.735a	26.105a

Values with the same letters along the row are not significantly different at $p<0.05$.

DISCUSSION

At seven days watering regime, plants were already wilting. The stimulatory effect of PMOB whether significant or insignificant, shows that it has the potential of functioning as a bio organic fertilizer that can ameliorate the effect of drought stress in *Solanum scabrum* plants. The mixture of *Moringa* leaves, orange and banana/plantain peels contains high concentration of Nitrogen (248.3 mg 100 g^{-1}), Ca (30.9 mg L^{-1}), Mg (20.7 mg L^{-1}) and K (215. 1 mg L^{-1}). This could serve as a booster source of essential nutrients for the plants. Orange Peels (OP) have been reported to have a high nitrogen content, whereas banana/plantain peels (BPP) have higher quantity of phosphorous and potassium (Jariwala and Syed, 2016). This was also reflected in this study where OP contained 492 mg 100 g^{-1} of nitrogen as compared to BPP with 240.6 mg 100 g^{-1} while, BPP contained 240.4 mg L^{-1} potassium as compared to 124.6 mg L^{-1} in OP. Stimulatory effect on shoot height could be as a result of the potassium content of the mixture which helps in strengthening stems. Shoot fresh and root dry weight were also stimulated, phosphorus helps rooting and nitrogen is the primary nutrient necessary for foliage growth. PMOB application ameliorated the negative effects of water stress not only through preventing decreases in leaf photosynthetic pigment content (Chl *a*, Chl *b*) but also significantly increasing them. This could also promote shoot and root growth by improving photosynthetic capacity.

The stimulatory effect of *Moringa* extracts have been documented by several authors (Rady et al., 2015; Aslam et al., 2016; Pervez et al., 2017). These reports and others have shown that application of *Moringa* extracts improved crop performance. However, in the present study, this improvement was not evident when *Moringa* was utilized alone. This could be as a result of several factors which could include the fact that leaves alone was utilized. Abdalla (2013) and Anyaegbu (2014) recommended the use of leaves and twigs. It could also be as a result of form of application. Most reports are based on liquid formulation. However, a major factor could be the concentration. Most reports are based on foliar application but this factor may not be as important as concentration. Pervez et al. (2017) reported 12.5% as best concentration for use of *Moringa* leaf extract. This study used, 50% in combination with dried fruit peels. An earlier study by this researcher used 10% and achieved significant increases in leaf area, plant fresh and dry weight, shoot height and root length. However, since powder formulation was used, the concentration was increased on the basis that the nutrients will be released slowly. Apparently, this was not the case. The present result suggests that *Moringa* extracts at high concentrations may be inhibitory to plant growth. Zaki and Rady (2015), reported that *Moringa* leaf extracts act at low or even diluted concentration of 1:30, and the chemical composition of this extract may vary with species, season of collection and extraction procedure used. The mitigating effect of biostimulants is building up and triggering of natural defense mechanism and acquired resistance, the action is preventive, and intervention must always start at earliest possible time to have the best results (Divinagracia, 2010).

CONCLUSIONS

The present result suggests that if properly formulated, used at the right concentration and at the earliest stages of plant life, extracts of *Moringa* leaf with banana and orange peels have potential to improve growth and reduce the effect of drought stress in *Solanum scabrum* plants.

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