BIOSTIMULATIVE EFFECTS OF WATER HYACINTH (*EICHHORNIA CRASSIPES* (MART.) SOLMS) MULCH ON THE GERMINATION OF OKRA (*ABELMOCHUS ESCULENTUS* (L.)MOENCH) GROWN IN A CRUDE OIL CONTAMINATED SOIL

Offor, U.S.
Iyagba, A.G.
Department of Agricultural Science,
Ignatius Ajuru University of Education, Port Harcourt, Nigeria.
Onwugbuta-Enyi, J.
Department of Biology, Ignatius Ajuru University of Education,
Port Harcourt, Nigeria.

Abstract

A field trial was carried out at the Teaching and Research Farm of the Ignatius Ajuru University of Education, Ndele campus near Port Harcourt, Nigeria to determine the effect of water hyacinth (*Eichhornia crassipes* (Mart.) Solms) mulch as biostimulant in a crude oil polluted soil using okra (*Abelmochus esculentus* (L.) Moench) as a test crop. The experimental treatments consisted of okra planted in a crude oil polluted soil, okra planted in a crude oil polluted soil amended with water hyacinth mulch (15 tons ha^{-1})and okra planted alone as the control. The land was polluted with crude oil at the rate of 6l m^{-2} of land. The treatments were laid out in a randomized complete block design and replicated four times. Okra plants grown in the crude oil polluted soil amended with water hyacinth mulch significantly enhanced okra seed germination at 4, 8 and 12 days after planting (DAP) and produced taller plants and more leaves than the control. Soil amended with water hyacinth mulch showed 6.6, 25.3 and 48.7% increase in seed germination at 4, 8 and 12 DAP respectively over the control. Water hyacinth mulch can therefore be used for the bioremediation of oil contaminated soil for okra cultivation.

Keywords: Okra, germination, crude oil, oil exploration, water hyacinth, mulch, amendment

Introduction

Okra (*Abelmochus esculentus (L.)* Moench belonging to the Malvaceae family is one of the most important vegetables in Nigeria including tropical and sub-tropical countries of the world grown for its immature pods and young leaves. The seeds nutritional composition of okra include calcium, protein, oil and carbohydrates, iron, magnesium and phosphorus (Omotosho and Shittu, 2007). The seeds contain approximately, 21% protein, 14% lipids and 5% ash (Savello, *et al*. 1980). It is a source of vitamins C and A, iron and calcium (Ihekoronye and Ngodd, 1985). Okra is not only used as vegetable but also in rope making and paper industry (Markrose and Peter, 1990). Okra seed oil is being used for biodesel production as well. The flowers can be very attractive and sometimes used in decorating the living rooms (Schippers, 2000). The fruits are exported by some African and Caribbean countries to Europe and America where there is ready demand from the resident ethic groups from tropical and subtropical countries including Indians, West Africans, Pakistanis and Surinamese (Adetula and Denton, 2003). The limiting factors to okra production among others include weed management, tillage practices, low yielding varieties and poor soils (Burnside, 1993; Dikwahal *et al*. 2006; Adeyemi *et al*. 2008). The cultivation of okra in the Niger Delta region of Nigeria which includes Rivers State is on the decline due to oil exploration and exploitation activities in this region (Iyagba and Ojimba, 2012; Ojimba and Iyagba, 2012). These activities have led to environmental degradation. Being among the most heat and drought tolerant vegetable species in the world, it is expected that the stress tolerance emanating from this hydrocarbon contamination (crude oil) would be minimal for the production of okra but observations by Amakiri and Onofeghara (1994) showed that crude oil reduces growth and production of okra.

The crop is propagated through seed, which loses its viability quickly (Thakur and Arora, 1993). When a crop loses viability germination rate is very low and uneven. Black *et al*. (2006) defined seed germination as the potential of a seed lot to germinate under defined conditions. Loss of seed viability can also be caused by dormancy. Seed germination and dormancy are two adaptic traits in plants under the influence of genetic and environmental factors. Seed dormancy according to Hilhorst and Toroop (1997) is the absence of germination of a seed under optimal condition and dormancy can be classified as endogenous and exogenous. Endogenous dormancy is imposed by embryo or other inhibitor components inside the seed coat while exogenous dormancy is attributed to the seed coat (Copeland and McDonald, 2001). Endosperm, perisperm, seed coat integuments, or pericarp are seed coverings that can cause exogenous dormancy (Geneve, 1998). The most common form of exogenous dormancy occurs when seed coats become suberized and impermeable to water, which is commonly known as hardseededness and is typical of many species from families such as Fabaceae, Malvaceae, Chenopodiaceae and Liliaceae (Geneve, 1998; Copeland and McDonald, 2001). The management of okra become complicated when the plant exhibits seed hardness and according to Mohammadi *et al*. (2011). This will interfere with seed germination, weed control, harvesting and other management factors. Time of harvest of pods, the seed moisture content, the fertilizer and growth regulators application, the priming and scarification of seeds are some factors and methods proposed to affect okra hardseedeness. The work of Mohammadi *et al*. (2003) revealed that increasing the nitrogen application rate up to 450 mg L^{-1} N, harvesting seeds at 40 days after flowering (DAF) and collecting seeds from the middle part of the plant could be a useful means for reducing the occurrence of hardseedness and germination percentage of okra seeds.

The use of mulch in vegetable production is well known. Mulch is the protective covering over the soil using vegetable or other materials. The importance of mulch, however, is predicated on its effectiveness in the control of weed growth , soil runoff, increasing soil organic matter, improving the soil structure, conservation of soil moisture, reduction of soil compaction by rain drops and temperature regulation (Aniekwe, 2002). Ibe *et al*. (2008) observed that using siam weed (*Chromolaena odorata* (L.) R. M. king and Robinson), a prevalent weed in Rivers State, Nigeria significantly increased the reproductive efficiency, fruit yield and weed control efficiency of okra. Another prevalent weed in the water ways of Rivers State is the water hyacinth (*Eichhornia crassipes* (Mart.) Solms), belonging to the family Pontederiaceae is a floating aquatic macrophyte, rooting in mud if stranded, usually in dense mats with new plantlets attached on floating green stolons. In large mats, it degrades water quality and dramatically alters native plants and animal communities. It contains hemicellulose acid hydrolystate and has been utilized as a substrate for ethanol production (Nigam, 2002). The leaf of the plant contain 49.6% protein, 16.0% total lipids, 26.9% total carbohydrate, 1.7% fibre and 5.8% ash (Bakr *et. al*., 1984). It purifies water, by absorbing the nitrogen and phosphorus on which it strives and for the phytoremediation of waste water polluted with Cu, Pb, Zn and Cd (Liao and Chang, 2004). The work of Ochekwu and Madagwa (2013) revealed the use of this plant in the remediation of crude oil contaminated water in Nigeria. Though this weed is a nuisance in the Niger Delta water ways where it abounds, this work is carried out to determine how to effectively utilize this natural biota in soil amelioration for the germination of okra in a crude oil polluted soil.

Material and Method

The experiment was conducted at the Teaching and Research Farm of the Ignatius Ajuru University of Education, Ndele Campus, near Port Harcourt to study the effect of water hyacinth mulch as biostimulant in a crude oil polluted soil using okra as a test crop. The land was under fallow for about two years after vegetable has been planted and harvested. The experiment was carried out on a plot of land measuring 9m by 9m with spacing of 0.3m X 0.3m between and within the rows respectively. This was laid out in a random complete block design (RCBD) with four replicates. The experimental treatments consisted of okra planted in a crude oil polluted soil (0C), okra planted in a crude oil polluted soil with water hyacinth mulch (0CE) at the rate of 15 tons ha^{-1} and okra planted alone (OP) as the control. Okra seeds were obtained from the Agricultural Development Project Crop Unit of the state Ministry of Agriculture and Natural Resources, Port Harcourt while the crude oil was obtained from Elf Petroleum Nigeria Limited at Obagi in Egi, Onelga, Rivers State of Nigeria. The experimental plot was polluted with crude oil at the rate of 6l m^{-2} of land prior to planting. The application of water hyacinth mulch at the rate of 15 tons ha^{-1} seed bed was carried out a week after pollution of the soil with crude oil. Weeding was done manually two times throughout the duration of the experiment Parameters determined were germination percentage (%), plant height and number of leaves. Germination percentage was observed from four to twelve (4 – 12) days after planting (DAP) and the percentage was calculated using the formula according to the International Seed Testing Association (ISTA, 2009):

$$\text{Germination Percentage (\%)} = \frac{\text{Number of seeds germinated X 100}}{\text{Number of seeds tested}}$$

Plant height was taken with the use of a metre rule from the collar region of the plant to the terminal leaf. Five plants were randomly tagged in each experimental unit. The measurement was carried out three times during the experimental period at 20, 40, and 60 DAP. Data collected were computed and average plant height was taken for each treatment. The number of leaves per plant were randomly tagged, counted and recorded from the five plants. Data collected were subjected to the analysis of variance and means compared using the Duncan's Multiple Range Test (DMRT) at a probability of 5%.

Results and Discussion

Effect of water hyacinth on seed germination

Crude oil contaminated soil treated with water hyacinth mulch showed significant increase (P= 5%) in okra seed germination for the different days after planting as compared to the control (Table 1). Soil amended with water hyacinth mulch showed 6.6, 25.3 and 48.7% increase in seed germination at 4, 8 and 12 DAP respectively over the control.

Table 1: Effect of soil condition on seed germination at days after planting (DAP)

Soil condition	Days after planting		
	4	8	12
OC	15.0b[1]	25.2b	30.1c
OCE	40.5a	70.8a	93.8a
OP	38.0a	56.5a	63.1b
Mean	31.2	50.8	62.3
SE ±	14.1	23.3	31.9

[1]Values followed by the same letter in a column are not significantly different at 5% level using DMRT.

The result showed enhanced okra seed germination from the soil mulched with water hyacinth more than the control at longer days after planting. This could be attributed to the decomposition of the water hyacinth mulch to improve the soil fertility by releasing nutrients especially nitrogen and phosphorus it had absorbed from its habitat. The work of Mohammadi *et al*. (2013) noted that increasing the N application from 150 to 450 mg L^{-1} N increased okra seed germination irrespective of the cultivar. Also mulch decomposition will lead to increase in soil moisture content. The presence of crude oil will reduce soil moisture content thus, lower seed germination. Water is critical for seed germination for two reasons: seeds must absorb sufficient water before they can germinate and secondly, seed embryo die if their growth media dries out after germination. Underwatering dessicates seeds. Soil moisture activates enzymatic reaction necessary for germination. The enzymes which are necessary for seed germination have been reported to be significantly higher under high moisture at particular stages of germination (Naz *et al*., 2012). Naz *et al*. (2012) also noted that seed germination stimulation, growth and development at lateral stages might be attributed to a combined effect of biochemical, physiological and metabolic changes as well as enhance enzymatic activities. Water hyacinth has also been known to absorb toxic chemicals and used in remediating crude oil contaminated water and soil (Ochekwu and Madagwa, 2013; Udeh *et al*., 2013).

The better performance of the soil treated with water hyacinth mulch with respect to the higher rate of germination may also be due to the effective micro-organism and other profile bacteria in water hyacinth mulch which would have enhanced the production of phytohormones like auxins and gibberellins. These may have stimulated the growth characters as evidenced from the work of Xu *et al*. (2000) and Hartwigsan and Evans (2000).

The poor performance of the crude oil contaminated soil without treatment is attributed to the negative effect of the crude oil in the soil. Crude oil when spilled on land affects the physicochemical properties of the soil such as temperature, structure, nutrient status and pH. Atuanya (1987) reported that crude oil hamper soil aeration as oil film on the soil surface acts as physical barrier between air and soil thereby causing a breakdown of oil texture followed by soil dispersion. This is capable of inhibiting germination of okra seeds.

Effect of water hyacinth mulch on plant height and number of leaves.

Table 2 showed the effect of soil condition on plant height and number of leaves produced. Okra plants in the soils treated with the water hyacinth was significantly taller than the others. The shortest plants were obtained from the untreated crude oil contaminated soil. The treated soil also produced

Table 2: Effect of soil condition on plant height (cm) and number of leaves.

Soil condition	plant height	No. of leaves
OC	9.8b[1]	40.2b
OCE	12.6a	59.8a
OP	10.4b	49.6b
Mean	10.9	49.9
SE ±	1.5	9.5

[1]Values followed by the same letter in a column are not significantly different at 5% level using DMRT.

significantly higher number of leaves than the rest. The least number of leaves were produced by the untreated soil. The plots mulched with the water hyacinth added N and P to the soil from their tissues thereby increasing the level of N and P. The work of Omotosho and Shittu (2007) revealed that okra plants that received 450 NPK kg ha^{-1} were taller than those that received lower rates of NPK application due to higher nitrogen content which induced higher plant height, number of leaves, leaf area, root length and number of branches hence the taller plants and more leaves produced from the treated soil.

Previous work by Kanimozhi (2004) has shown that organic manure influence plant growth by modifying the physiology of plants and by improving the physical, chemical and biological properties of soil (Amakiri and Onofeghara, 1994). Using water hyacinth for bioremediation of crude oil contaminated soil in this work is in agreement with the findings of Udeh *et al*. (2013) who also reported using water hyacinth in the remediation of crude oil polluted land using beans seed in the Niger Delta area of Nigeria. However, their work advised that better remediation result would be obtained if the water hyacinth mulch is allowed to remain on the land for a longer period of time.

Conclusion

This work has been shown that water hyacinth mulch can be used in the bio-remediation of crude oil contaminated soil to grow okra. Thus the positive effect of water hyacinth has combined influence on better performance of okra.

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