COMPARATIVE TOXICITY OF TWO OIL TYPES AND TWO DISPERSANTS ON THE GROWTH OF A SEASHORE GRASS, *PASPALUM VAGINATUM* (SWARTZ)

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ABSTRACT

The present study consists of assessing the effects of Abura heavy crude petroleum oil (AC) and Oredo light crude petroleum oil (OC) on the survival of Paspalum vaginatum. The effectiveness of two dispersants, Goldcrew and Corexit 9527, in removing oil from P. vaginatum previously sprayed with either Abura of Oredo crude petroleum oil was assessed, the effect of time of dispersant application following crude oil pollution on growth and survival of P. vaginatum was also studied. Plants treated with AC recovered after 8 days while 100% mortality was recorded for plants treated with OC + Corexit 9527 ($O_{24}Co$ and $O_{48}Co$). Corexit 9527 was not effective in ameliorating the lethal effects of Oredo crude oil. Although, P. vaginatum recovery was apparent 70 days after AC pollution and after cleaning with Goldcrew ($A_{24}GC$ and $A_{48}GC$), both treatments resulted in significant ($P < 0.05$) lower biomass and stem density compared to control. It is concluded that plants cleaned with Goldcrew dispersant after 24 h recovered faster than those cleaned after 48 h. Exposure of P. vaginatum to light crude oil or light crude oil + Corexit 9527 is detrimental and can inhibit growth where as it will recover when exposed to heavy crude oil or heavy crude oil + Goldcrew.

INTRODUCTION

Wetlands have been described as a half way world between two extremes and range from very nearly aquatic to almost dry. They are sites created by nature and one of their main attributes is their ability to generate oxygen and in turn absorb carbon dioxide thereby helping to reduce atmospheric pollution (Salu, 2000). They are important in shoreline protection from wave actions (Webb, 1977), provide fish and wildlife habitats and improve water quality (Mitsch and Gosselink, 1993). Wetlands are very rich in flora and fauna and are considered to be one of the world's most productive ecosystem types. Their aesthetic, economic, cultural, scientific and recreational values are other reasons why wetlands are considered very important.

Nigeria, has one of the world's largest wetlands – The Niger Delta, which covers about 20000 sq km. However, this wetland is facing a severe threat from man i.e. pollution through oil spills, gas flaring and other acts of environmental degradation have led to gradual destruction of its flora and fauna. A variety of oil exploration and production activities are going on within the Niger Delta wetland ecosystem. As a result, large amounts of crude petroleum oil is refined, stored or transported through this wetland and the adjacent near shore habitat. These environments are thus exposed to occasional fouling with oil. Up to 1.5 million tons of oil, 50 times the pollution unleashed in the Exxon Valdez tanker disaster, has been spilt in the ecologically precious Niger Delta over the past 50 years (Brown, 2006). The effect of oil on wetland vegetation ranges from reduction in photosynthesis to mortality (Pezeshki and DeLaune, 1993). Burns and Teal (1979) found that oil persisted in salt marsh sediments seven years after an oil spill and may have long term effects on marsh organisms (Alexander and Webb, 1987; Baker *et al*., 1993).

Managing oil spills on wetlands could be difficult since they are low wave energy ecosystems and are routinely sites where oil accumulates after a spill. In addition, inaccessibility of most wetlands makes oil removal very difficult, if not impossible. Traditional methods of cleaning up oil spills concentrate on mechanical removal such as low pressure flushing, use of sorbent pads, booms, burning, skimmers and the clipping and removal of oil impacted vegetation form the site (Owens *et al*., 1993). But wetlands are vulnerable to mechanical damage during removal operations (OTA, 1990). The recognition of these disadvantages has fuelled interest in methodologies that are more efficient at removing the oil and less destructive to wetland structure (Baker *et al*., 1993).

Use of dispersants / cleaners is one of the methods used to reduce the adverse effects of oil on the environment. The main function of an oil dispersant is to break up surface oil slicks into tiny oil droplets that can be dispersed by surface water turbulence for further dilution and degradation. The excess dispersant in water and the dispersed oil droplets can accumulate in estuarine waters and wetlands thereby becoming a secondary source of pollution to the environment. Chemical dispersants such as Corexit 9527 and Gold crew are frequently used in combating oil spills in the Niger Delta region of Nigeria. Both dispersants are water based with alcohol as solvents. There is no published data about the effect these particular dispersants have on wetland vegetation but studies of another dispersant; Corexit 9580 showed it as an effective cleaner by removing oil from plants, had low toxicity (Fingas *et al*., 1991) and prevented mortality of oiled red mangroves (*Rhizophora mangle*) Teas *et al*., (1993).

Knowing that wetlands offer a variety of flora species not much data are available to evaluate the effect of various oil types and dispersants on plant species. *Paspalum vaginatum* is a warm season turf grass and is also referred to as Silt grass, Salt joint grass, Seaside millet, Sand knot grass and Salt water couch. It is native to East Central South America, but today *Paspalum* grows in tropical areas throughout the world. It is very salt tolerant, has high shoot densities and can handle a large range of pH relative to other grasses. The plant is widely used to maintain golf courses close to oceans where salt water and salt spray is a problem. It is also an excellent deterrent against beach erosion and is a satisfactory forage grass.

The goal of this greenhouse study was to determine how two different Nigerian crude oil types (Abura medium and Oredo light) and two commonly used dispersants in Nigeria (Corexit 9527 and Gold crew) affected the growth of a wetland specie, *Paspalum vaginatum*, commonly found on Nigeria's coastal shores. The importance of timing for cleaning oiled vegetation is also highlighted. This will help the oil spill community in dealing more effectively with oil spills in marshes.

MATERIALS AND METHODS

Plant material and Growth conditions

Rhizomes of *P. vaginatum* were obtained from Escravos, Delta State, Nigeria.

Six rhizomes (containing four nodes each) of *P. vaginatum* were planted in 150 mm x 90 mm pots containing soil sand mixture at ratio 1:3. All experiments were carried out in a climate controlled greenhouse at the University of Benin, Nigeria, with a photoperiod of 12 h and temperatures maintained between 20.3°C - 34.3°C by day and a minimum of 14.6°C to a maximum of 26.5°C by night. Relative humidity averaged 70% while photosynthetically active radiation (PAR) was 300μmol m^{-2} s^{-1}. PAR was supplied from supplemental lighting, 400-W HPI/T lamps, used in the greenhouse and measured with a Licor-Quantum sensor (Li-185B).

Oil and dispersant application

Pots were watered as needed with 50% Hoagland solution (Hoagland and Arnon, 1950). After three months of growth, 48 pots with uniform plant size were randomly selected and divided in two groups of 24 pots each. Treatments were arranged in a randomized block design consisting of 6 replicates. Fresh Abura heavy crude oil and Oredo light crude oil (hereafter referred to as AC and OC respectively) was used as the petroleum source. The first group of 24 potted plants were sprayed with AC and the second group sprayed with OLC at 50 ml per pot. 24 h after oil pollution, 12 pots were randomly selected from each oil group (six pots from each group) and sprayed with 120 ml of Corexit 9527 (10 ml per pot). The same procedure was repeated for Gold crew 24 h. 48 h later the procedure was repeated again. Following dispersant application, lots of water was used to wash off the dispersant and oil from plants. The four treatments were: control with no oil or dispersant, plants sprayed with crude oil and cleaned with either Corexit 9527 or Goldcrew dispersant after 24 h, plants sprayed with crude oil and cleaned with either Corexit 9527 or Gold crew dispersant after 48 h. Plants were harvested 70 d after treatment.

PLANT MEASUREMENTS

Number of leaves produced per plant and live stem density was determined by counting the number of leaves or stems per pot. Plant height was measured from soil level to the terminal bud using a metre rule and the longest leaf for each plant in a pot was measured from leaf base to leaf tip using a meter rule. Readings were taken on day 22, 36, 50 and 64. On day 70 plants were harvested for dry weight determination. Plants were washed free of substrate in tap water, then divided into root and shoot material. Root and shoot material was separated into living and dead fractions which were weighed separately (Cooper, 1981). All harvested shoots and roots were oven dried at 80°C for 3 d to a constant weight before being weighed on an Ohaus precision standard weighing machine.

Data and statistical analysis

Root : shoot ratio was calculated as the ratio of total belowground to total aboveground dry biomass. All data were analysed using SPSS version 11 Differences in means among treatments (α = 0.05) were analyzed using ANOVA and Tukey's studentized range tests.

RESULTS

Morphological changes

Morphological changes observed in plants throughout the duration of the experiment are presented in Table 1. There was marked difference between control plants and those sprayed with crude oil and dispersants. Plants treated with oil only remained wettable for over one week. Plant leaves turned brownish in colour and withered. Eight days later plants treated with AC recovered while 100% mortality was recorded for plants in OC. Though both dispersants were effective in removing oil from the leaf and shoot surfaces, Corexit 9527 was not effective in helping *P. vaginatum* to recover from the effect of OC oiling. For plants oiled with AC it seemed delaying the application of Corexit for 48 h before application had a beneficial effect. There was 41% survival rate for those cleaned 48 h after oiling compared to 10% recorded for those cleaned after 24 h.

OC + Goldcrew after 24 h and 48 h showed regeneration after 8 d and 2 d respectively. Compared to control survival rate was low. AC + Goldcrew after 24 h and 48 h regenerated after 8 d. There was 81% and 82% survival respectively. *P. vaginatum* in either of these treatments grew luxuriantly.

Growth

There was an insignificant 14.17% reduction in shoot length in AC treated plants. Application of Corexit 9527, 24 h after oiling, resulted in a significant 90.53% reduction in shoot length while 38.90% was recorded for 48 h (Fig. 1A). Shoot length of *P. vaginatum* was significantly ($P < 0.05$) reduced by OC treatment. Corexit 9527 applied at the two time levels following treatment with OC was not effective in counteracting the lethal effect of the oil. On the other hand Goldcrew was effective in removing and reducing the detrimental / toxic effect of OC application on *P. vaginatum*. Significant growth enhancement, in terms of shoot length, was induced in OC treated plants after cleaning with Goldcrew (Fig. 1A).

Increase in plant stem density (number of stems per pot) of *P. vaginatum* over time was significantly reduced ($P < 0.05$) by the two types of oil. Application of Corexit 9527 to the two oil types did not increase stem density of *P. vaginatum* significantly (Fig. 1B) compared with control. There was a significant increase ($P < 0.05$) in stem density for AC treated plants after Gold crew was applied. Tiller survival ceased in plants treated with OC and OC + Corexit 9527 after 24 h and 48 h, more importantly regrowth was completely inhibited in both treatments.

Leaves were not produced in plants treated with OC and OC + Corexit 9527 after 24 h and 48 h due to the smothering effect of the oil (Fig. 1C). Leaf production started after 22 d in OC + Gold crew (48 h) treatment and after 36 days in AC + Corexit 9527 (24 h). Leaf production was impaired significantly ($P < 0.05$) in all the treatments except in control and AC + Gold crew (24 h and 48 h). The highest number of leaves was produced in control plants (20.50 ± 1.41 leaves per plant). Goldcrew applied 24 h after AC treatment enhanced the leaf length as seen in Figure 1D. Oiling

TABLE 1: MORPHOLOGICAL CHANGES OBSERVED IN *PASPALUM VAGINATUM* AFTER TREATMENT WITH ABURA HEAVY CRUDE OIL (AC) OR OREDO LIGHT CRUDE OIL (OC) AND COREXIT 9527 / GOLD CREW.

Treatments	Observed Effects	
	Corexit 9527	**Gold crew**
Control	Healthy growth. Leaves remained green in colour. New shoots were formed. 100% survival.	Healthy growth. Leaves remained green in colour. New shoots were formed. 100% survival
Abura heavy crude oil (AC)	Leaves became wettable and brownish in colour. Plants withered but some started regenerating after 8 days, producing leaves from stem. Some dead stems did not recover. Formation of new shoots was noticed. there was 37% survival.	Leaves became wettable and brownish in colour. Plants withered but some started regenerating after 8 days, producing leaves from stem. Some dead stems did not recover. Formation of new shoots was noticed. There was 37% survival.
Oredo light crude oil (OC)	Leaves became wettable and brownish in colour. Plants never recovered they looked burnt. There was no formation of new shoots. There was 100% mortality.	Leaves became wettable and brownish in colour. Plants never recovered they looked burnt. There was no formation of new shoots. There was 100% mortality
AC followed by dispersant after 24 h or 48 h.	Leaves were initially wettable and had a slimy feel. The slimy feel disappeared after dispersant application. Initially leaves withered completely. Regeneration of leaves started after 36 days (24 h treatment) while there was regeneration after 8 days for the 48 h treatment. Some plants did not recover. There was 5% and 36% survival respectively.	Leaves were initially wettable and had a slimy feel that disappeared after dispersant application. There was an initial die back but after 8 d there was regeneration in both 24 h and 48 h treatment, with the formation of new leaves. New tillers were formed and the survival was 90% and 58% respectively. Few shoots did not regenerate.
OC followed by dispersant after 24 h or 48 h.	Leaves were initially wettable, had a slimy feel and brownish in colour. Dispersant eliminated the slimy feel and wettable look. The plants did not recover and had a burnt look. There was 100% mortality.	Leaves were initially wettable, had a slimy feel and brownish in colour. Dispersant eliminated the slimy feel and wettable look. There was an initial die back but after 8 d there was regeneration in one plant (24 h), whereas regeneration started after 21 d for 48 h treatment. Survival was 10% and 1% respectively.

with OC and cleaning with Corexit 9527 was not as effective in increasing leaf length as Goldcrew was.

Except in AC treated plants, live aboveground biomass was significantly reduced under other ``oil'' and ``oil + cleaner'' treatments when compared to control (Table 1). A similar trend was followed by live underground biomass. There was no dead aboveground or underground biomass in control pots. This was due to plants actively growing in the absence of any abiotic stress. Low dead aboveground biomass was also observed in OC and $O_{48}GC$ and this may have been caused by plants not recovering from the effect of being polluted by oil. Application of Goldcrew did not seem to help the plants to recover fully. Ratio of total belowground to aboveground dry biomass was decreased in $O_{48}CO$, $O_{48}GC$, $A_{24}CO$, and AC.

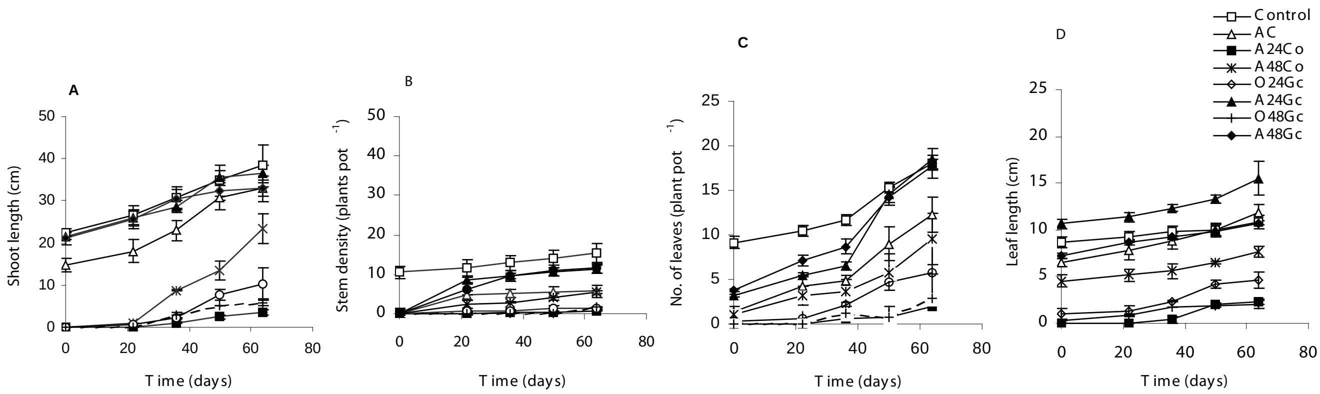

FIG. 1. EFFECT OF OILING AND DISPERSANT APPLIED AT TWO TIME INTERVALS ON THE GROWTH OF *PASPALUM VAGINATUM*: (A) SHOOT LENGTH (CM), (B) STEM DENSITY, (PLANTS POT^{-1}), (C) NUMBER OF LEAVES (PLANT POT^{-1}), D) LEAF LENGTH (CM). DATA WAS COLLECTED EVERY 2 WEEKS AFTER TREATMENT FOR 8 WEEKS. VALUES ARE MEAN ± SE. N = 6. TREATMENTS WITH ZERO READINGS WERE NOT INCLUDED IN GRAPHS. KEY: OC = OREDO CRUDE, AC = ABURA CRUDE, $O_{24}CO$ = OREDO CRUDE + COREXIT 9527 (24 H), $A_{24}CO$ = ABURA CRUDE + COREXIT 9527 (24 H), $O_{48}CO$ = OREDO CRUDE + COREXIT 9527 (48 H), $A_{48}CO$ = ABURA CRUDE + COREXIT 9527 (48 H), $O_{24}GC$ = OREDO CRUDE + GOLDCREW (24 H), $A_{24}GC$ = ABURA CRUDE + GOLDCREW (24 H), $O_{24}GC$ = OREDO CRUDE + GOLDCREW (24 H), $A_{48}GC$ = ABURA CRUDE + GOLDCREW (48 H).

TABLE 2. DRY BIOMASS ACCUMULATION (IN GRAMS POT^{-1}) AND THE RATIO OF BELOWGROUND TO ABOVEGROUND BIOMASS (MEANS ± SE) IN *PASPALUM VAGINATUM* GROWN IN ELEVEN TREATMENTS OF (OIL X DISPERSANT X TIME) FOR 70 DAYS. THE F AND P VALUES FROM TWO WAY ANOVA ARE GIVEN. WITHIN COLUMNS, VALUES FOLLOWED BY DIFFERENT LETTERS ARE SIGNIFICANTLY DIFFERENT AT P ≤ 0.05 AS SEPARATED BY TUKEY STUDENTIZED RANGE TESTS. N = 6. KEY: OC = OREDO CRUDE, AC = ABURA CRUDE, $O_{24}CO$ = OREDO CRUDE + COREXIT 9527 (24 H), $A_{24}CO$ = ABURA CRUDE + COREXIT 9527 (24 H), $O_{48}CO$ = OREDO CRUDE + COREXIT 9527 (48 H), $A_{48}CO$ = ABURA CRUDE + COREXIT 9527 (48 H), $O_{24}GC$ = OREDO CRUDE + GOLDCREW (24 H), $A_{24}GC$ = ABURA CRUDE + GOLDCREW (24 H), $O_{24}GC$ = OREDO CRUDE + GOLDCREW (24 H), $A_{48}GC$ = ABURA CRUDE + GOLDCREW (48 H).

	Aboveground (g / pot)		Underground (g / pot)		Total (g / pot)		
Treatment	Live	Dead	Live	Dead	Aboveground	Belowground	Ratio
Control	10.38 ± 0.09a	0.00 ± 0.00c	4.28 ± 2.33a	0.00 ± 0.00d	10.38 ± 0.09a	4.28 ± 2.33a	0.41
OC	0.00 ± 0.00e	0.60 ± 0.72b	0.00 ± 0.00c	0.09 ± 0.01c	0.60 ± 0.72d	0.09 ± 0.01d	0.15
AC	10.42 ± 2.77a	1.77 + 0.28a	4.32 + 0.32a	0.27 + 0.06b	12.19 ± 1.20a	0.59 ± 0.16c	0.05
$O_{24}Co$	0.00 ± 0.00e	2.43 ± 0.36a	0.00 ± 0.00c	0.39 ± 0.27b	2.43 ± 0.36c	0.39 ± 0.27c	0.16
$A_{24}Co$	0.63 ± 0.03d	1.60 ± 0.29a	0.02 ± 0.01c	0.08 ± 0.02c	2.23 ± 0.29c	0.06 ± 0.02d	0.03
$O_{48}Co$	0.00 ± 0.00e	1.63 ± 0.06a	0.00 ± 0.00c	0.01 ± 0.01d	1.63 ± 0.06d	0.01 ± 0.01d	0.01
$A_{48}Co$	1.47 ± 0.47c	1.55 + 0.26a	0.00 ± 0.00c	0.92 ± 0.04a	3.02 ± 0.26c	0.92 ± 0.04c	0.30
$O_{24}Gc$	2.69 ± 0.01c	2.10 ± 0.35a	1.73 ± 1.50b	0.04 ± 0.03d	4.79 ± 0.35b	1.77 ± 0.03b	0.37
$A_{24}Gc$	5.22 ± 0.32b	2.31 ± 0.83a	2.94 ± 0.51b	0.11 ± 0.02c	7.53 ± 0.74a	3.05 ± 0.51a	0.41
$O_{48}Gc$	0.89 ± 0.09 d	0.69 ± 0.04b	0.01 ± 0.00c	0.03 ± 0.01d	1.58 ± 0.34c	0.04 ± 0.01d	0.03
$A_{48}Gc$	3.16 ± 0.16c	2.17 ± 0.50a	1.71 ± 0.84b	0.33 ± 0.09b	5.33 ± 0.50b	2.04 ± 0.09b	0.38
Statistic							
F	97.928	3.89	8.65	2.817	19.88	6.806	2.313
P	<0.0001	0.0020	<0.0001	0.0180	<0.0001	0.0001	0.038

DISCUSSION

The present results show that *P. vaginatum* recovered after pollution with AC and AC + Goldcrew after 24 h in 8 d. It is well known that plants show high variability in their growth response when exposed to oil spillages (Pezeshki *et al*., 1997; DeLaune *et al*., 1979; Pezeshki and DeLaune., 1993). Factors that may influence the response of plants to crude oil pollution include type and concentration of oil, time of spillage, type and time of dispersant application, weather condition and soil type.

Complete fouling of *P. vaginatum* plants initially caused rapid death of all leaves. However, new leaf production began within 8 days in AC oiled plants. Similar results were obtained by Pezeshki *et al*. (1995), when *Spartina. alterniflora* plants oiled with South Louisiana crude caused rapid death of all leaves but new leaf production began within 2 weeks. Similar conclusions have resulted from other experiments with *S. alterniflora* and *Juncus roemerianus* (DeLaune *et al*., 1979; Smith *et al*., 1984; Pezeshki and DeLaune, 1993). Though leaves of plants *P. vaginatum* directly subjected to AC oil treatment showed signs of recovery, stem density of live shoots measured during the 10th week remained significantly lower in oiled pots as compared to the control pots. The significant decrease in stem density did not have an effect on biomass accumulation compared to control at the end of the experiment. Pezeshki *et al*., (1997) reported that the number of live shoots per unit area was significantly reduced in response to oiling in *S. alterniflora*. The ability of *P. vaginatum* treated with AC to recover as shown in Fig. 1 (A-D, implies that given adequate time, recovery is possible in plants polluted with heavy crude oil, even if not cleaned with dispersants. DeLaune *et al*. (1979), Pezeshki and DeLaune (1993) and Smith *et al*. (1984) also discovered that under greenhouse conditions oiled *S. alterniflora* and *J. roemerianus* initially showed a high percentage of mortality but recovered two months after oil application.

However, this was not the case when plants were oiled with OC and OC + Corexit 9527. Oiling of *P. vaginatum* plants with OC resulted in 100% mortality of plants. There was no regrowth and plants did not recover throughout the duration of the experiment (Tables 1, and 2). Lin and Mendelssohn (1996) found that *Spartina patens* suffered complete mortality at oil dosages of 8l / m^2 when oiled with South Louisiana crude. Corexit 9527 did not alleviate the effect of OC oiling on *P. vaginatum*. In contrast, field studies by Webb (1994) demonstrated that oil removed using Corexit 9580 had no adverse effect on selected marsh plants. Exposure of *P. vaginatum* to either OC or AC and Corexit 9527 had long term deleterious effect on production of leaves, plant height, stem density and biomass accumulation. This finding is in agreement with previous work by Pezeshki *et al*. (1995), when *S. alterniflora* was oiled with Bunker C. This also resulted in complete plant mortality and no recovery. During a spill, one of the most common fates of the spilled oil is its penetration into the soil, this can cause acute and chronic damage to the plants, including reductions in stem height, stem density and aboveground biomass as well as resulting in plant mortality (Krebs and Tanner, 1981; Ferrel *et al*., 1984, Alexander and Webb, 1987; Lin and Mendelssohn, 1996). Plants treated with OLC and OLC + Corexit 9527 had the lowest live belowground biomass components. Perhaps oil acted with the dispersant to depress root formation i.e. the dispersant and crude oil may have had some synergestic effect on the plant. In general, light oils appear to kill plant tissue on contact, while crude oil effectively prevents plant gas exchange (Pezeshki and DeLaune, 1993; Webb, 1994).

Both types of oil turned *P. vaginatum* leaves brown and wettable. The oil caused a change in the leaf surface property and removed the waxy cuticle. The cuticle is known to make leaf surface impermeable to water and its removal makes leaves become wettable (Stace, 1975). Other studies reported significant recovery from oiling for other marsh species that was evident from stomatal conductance measurements on newly developed leaves, regeneration of new shoots and leaf elongation rate (Pezeshki and DeLaune, 1998, Pezeshki *et al*., 2001).

Though oil pollution had negative effects on all growth parameters measured, plant height increased with time in unpolluted samples and AHC oil treatment. In unpublished data recorded during the experiment, control and AC oil treated soils contained 0.30 and 0.24 ppm Nitrogen respectively, compared to OLC treated soils which had 0.13 ppm. It is possible that growth was stimulated in AC treated plants due to uptake of nutrients especially nitrogen obtained from decomposed oil applied to the soil. Progressive increase in plant height in oil polluted soils has been reported in *Chrysophyllum albidum* and *Dacroydes edulis* by Egharevba and Osunde (2001), Gudin and Syratt (1975) and Baker (1968).

In plants subjected to crude oil and dispersant treatment, the aerial portion was adversely affected initially and there was need for resources in the aerial portion of the plant. But due to the stress in the aboveground portion, the roots rapidly mobilized the movement of stored products from the rhizome to the portion of oiled plants and plants treated with dispersant so was to allow the aboveground portion recover. The process of regeneration then ensued. This probably led to decrease in the root biomass. Live above – ground biomass of AC oiled plants showed no significant difference from that of control, this maybe due to the natural shoot regeneration and leaf development replacing dead foliages (Pezeshki and DeLaune, 1993; Pezeshki *et al*., 1995).

Preliminary results in this work showed that survival rate in *P. vaginatum* oiled with AC was enhanced when Corexit 9527 was applied 48 h after pollution. One could suggest that delaying the use of Corexit 9527 for a few days after heavy crude oil pollution could prove beneficial to plants. On the other hand Goldcrew enhanced survival significantly when it was used within 24 h in both oil types. There is no other published data to support this so further field experiments will be suggested.

CONCLUSION

The potential for habitat restoration after an oil spill was demonstrated in this study. The effect of two oil types (AC and OC) cleaned with two types of dispersants (Corexit 9527 and Goldcrew) applied at two time lapses (24 h and 48 h) on *P. vaginatum* was studied. OC had devastating effects on *P. vaginatum* and plants did not recover throughout the experimental period of 70 days. On the other hand, although, initially AC appeared to have toxic effects on plants, however, the plants were capable of recovery from oiling over the long term. Such a response underlies the fact that various crude oils may have different impacts on a given species. Plants cleaned with Goldcrew 24 h after pollution by both oil types had a greater chance of recovery than those cleaned after 48 h. In plants sprayed with AC + Corexit 9527, time also played a significant role. There was 36% regeneration in those cleaned 48 h after pollution and 5% in plants cleaned after 24 h.

There is need to conduct further research on the effect of various crude oils and time of application of cleaners commonly used on existing wetland vegetation, so that a reliable database can exist for predicting species response in the event of an oil spill.

BIOGRAPHY

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