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Effects of Nitrogen Fertilizer on Growth of *Indigofera pseudo-tinctoria* in Kyongseodong Waste Landfill, Incheon

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ABSTRACT: Effects of nitrogen addition on the growth of *Indigofera pseudo-tinctoria* (Leguminosae) in the waste landfill site was investigated. Nitrogen fertilization in the nitrogen poor soils of waste landfill may influence the growth of nitrogen fixing plants beneficially or detrimentally. When *I. pseudo-tinctoria* was fertilized with three different levels of nitrogen, the coverage of plants treated with 46 g N/m^2 and 460 g N/m^2 was significantly less than that of plants treated with 23 g N/m^2. The growth rates of plant height treated with 46 g N/m^2 and 460 g N/m^2 were significantly less than those of plants treated with 23 g N/m^2. The growth rates of plant diameter treated with 46 g N/m^2 and 460 g N/m^2 were significantly less than those of plants treated with 23 g N/m^2. Dry weights of whole plants in control sites were higher than those of all the others nitrogen treatment sites. Nodule numbers were higher in control plants than those of plants in all the other nitrogen treatment sites. It is suggested that nitrogen fertilizer addition over 23 g N/m^2 affect the growth of some nitrogen fixing plants, such as *I. pseudo-tinctoria*, negatively.

Key words: *Indigofera pseudo-tinctoria*, Nitrogen fertilization, Nodule, Plant growth, Waste landfill

INTRODUCTION

Until now, the widespread restoration method for vegetation restoration is to provide proper chemical fertilizers, mainly nitrogen addition (Luken 1990). Nitrogen is a major element necessary for plant growth (Barbour *et al.* 1999). Waste landfills are insufficient in nutrient contents, therefore nitrogen addition is very important for vegetation re-colonization (Kim 2001). However, nitrogen fertilization can be harmful to the growth of nitrogen fixing plants if it is not applied properly (Johnsen and Bongarten 1991). Nitrogen fixing plant is one of pioneer plants in disturbed lands like waste landfills (Chan *et al.* 1996). Therefore, The study of nitrogen fertilizing effects on the growth of nitrogen fixing plants is needed to assess results of chemical additions on vegetative landscape in the waste landfills.

Indigofera pseudo-tinctoria is a typical nitrogen-fixing plant that belongs to family Leguminosae. The species has been deployed in waste landfills as a covering shrub in South Korea. It has become a dominant species these days and a widespread species in waste landfills in South Korea. Nitrogen fixing plants play an important role in providing useful nitrogen into deficient soils in waste spoil (Jefferies *et al.* 1981). But, there have been little studies about effects of nitrogen fertilization upon the growth of nitrogen fixing plants. The aim of this study is to estimate effects of nitrogen fertilization upon growth of *I. pseudo-tinctoria*, one of most widespread nitrogen fixing shrubs in the waste landfill, South Korea.

MATERIALS AND METHODS

We selected *Indigofera pseudo-tinctoria* as an experiment species because of its widespread and frequent distribution in the waste landfill. Kyongseodong landfill in Incheon Metropolitan City was selected as a study site because *Indigofera pseudo-tinctoria* grew uniformly on spacious areas in waste landfills for appropriate field experiments. This landfill is reported to be a nutrient poor site, specially nitrogen (Kim 2001). We established four 4 × 4 m sized plots (macroplots) using vinyl cords and plastic stakes from May 30 to June 7, 2000. Each macroplot was quartered to 2 × 2 m subplots (microplots) for the chemical treatment experiment. Before chemical treatments, we tagged 20 plants with consecutive numbers and recorded height and DRC (Diameter at root collar) with a staff and a verniercaliper during the same day. The cover and sociability of all vegetation in each microplot were recorded according to Braun-Blanquet method (Fuller and Conard 1932). We added 23 g, 46 g and 460 g nitrogen per m^2 in each microplot in random orders. These levels of nitrogen fertilization correspond to over double amounts of general nitrogen fertilization to grasses (Lee and Kim 1996). Solid

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urea fertilizers (N content: 46%; $(NH_2)_2CO$) were used as a nitrogen source. Nitrogen fertilizers were sprayed into each microplot evenly. We cautiously tried not to spray into margin up to 50 cm from the edge, considering edge effects. One remaining microplot was given no nitrogen treatment as a control.

One hundred-six days after chemical treatments, the covers of all vegetation in each microplot were recorded according to Braun-Blanquet method. We recorded again heights and DRC of tagged plants. After height and DRC measurement, all tagged plants were harvested with a hand shovel. Based on height and DRC data, relative growth rate were calculated following equation I (Norgren 1996) and compared between treatment plots.

$$\text{RGR (Relative Growth Rate)} = \frac{(\ln W_2 - \ln W_1)}{(t_2 - t_1)} \quad \text{(Equation I)}$$

W: height or diameter at root collar, t: elapsed time

After heights and DRC of *Indigofera pseudo-tinctoria* were measured, entire parts of the plant were harvested and transported into the laboratory for further analysis. In the laboratory, leaf parts were separated with hands. Leaf petioles were included in stem parts. Root parts were shaken off elaborately with tap water. Remaining soils in root parts were removed using tweezers. The number of nodule in root parts was counted while branch roots were cut from primary roots by a knife. Kruskal-Wallis test was used because raw data are not normally distributed.

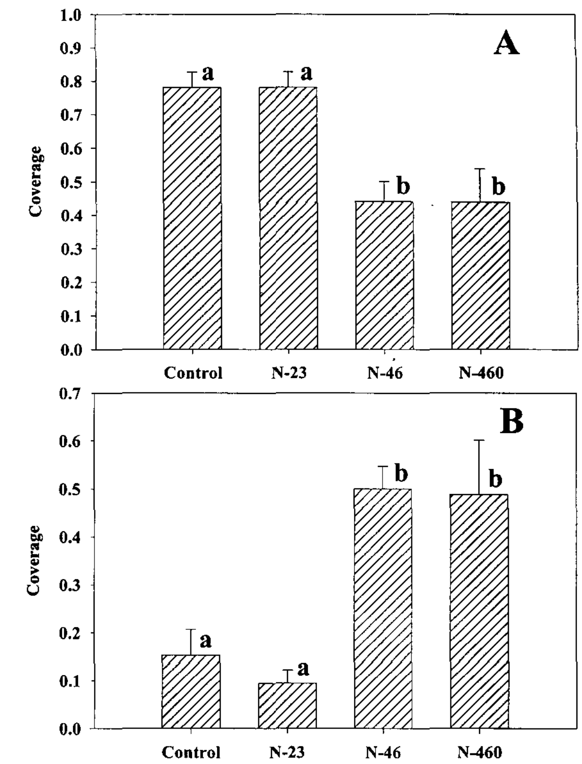

Fig. 1. *Indigofera pseudo-tinctoria* (A) and *Setaria viridis* (B) coverage change after nitrogen fertilization. N-23, N-46 and N-460 represent that 23 g, 46 g and 460 g of nitrogen per m^2 were provided. Dissimilar letters indicate significant differences between mean from Kruskal-Wallis test ($P < 0.01$). The each sample number is 8.

RESULTS AND DISCUSSION

As a result of Kruskal-Wallis test of nitrogen fertilization in *I. pseudo-tinctoria* population, the cover of dominant species differed significantly (Fig. 1A; $P < 0.01$). There was little cover change in plots treated with 23 g N/m^2 but the cover became diminished significantly in plots treated with 46 g N/m^2 and 460 g N/m^2. The cover of *Indigofera pseudo-tinctoria* population became smaller 57% in plots treated with 46 g N/m^2 and 56% in plots treated with 460 g N/m^2. The cover of *Indigofera pseudo-tinctoria* in plots treated with nitrogen fertilizers got diminished whereas the cover of *Setaria viridis*, subdominant species in control plots became higher more than that of *I. pseudo-tinctoria* (Fig. 1B; $P < 0.01$).

Despite the increment of cover of *Digitaria ciliaris*, another species, the difference with control plots was not significant. The rates of cover change of remaining species, *Ambrosia artemisiifolia* var. *elatior*, *Euphorbia maculata*, *Artemisia capillaris*, *Amorpha fruticosa*, *Artemisia princeps* var. *orientalis*, *Erigeron canadensis*, *Echinochloa crus-galli*, *Humulus japonica* and *Aster subulatus* var. *sandwicensis*, showed little significant differences in comparison with control plots. In particular, some species such as *Artemisia capillaris* and *E. crus-galli* invaded into the plots treated with nitrogen fertilizers, but not into control plots.

As a result of comparison of height and DRC growth change of *I. pseudo-tinctoria* after nitrogen treatments, all treatments showed different growth rates significantly (Kruskal-Wallis test; $P < 0.01$). As for height growth, height growth rates of *Indigofera pseudo-tinctoria* treated with 23 g N/m^2 and control were significantly higher than those of plants treated with 46 g N/m^2 and 460 g N/m^2 (Fig. 2A; $P < 0.01$). Specifically, the height growth rate of *I. pseudo-tinctoria* treated with 46 g N/m^2 were significantly higher than that of plants treated with 460 g N/m^2 (Fig. 2A; $P < 0.01$). In case of DRC growth, DRC growth rates of *I. pseudo-tinctoria* treated with 23 g N/m^2 and control were significantly higher than those of plants treated with 46 g N/ m^2 and 460 g N/m^2 (Fig. 2B; $P < 0.01$). Particularly, DRC growth rate of *I. pseudo-tinctoria* treated with 46 g N/m^2 was significantly higher than that of plants treated with 460 g N/m^2 (Fig. 2B; $P < 0.01$). As a result of comparison of dry weights by parts, there were significant differences between control and treatments (Table 1; $P < 0.01$). Dry weights

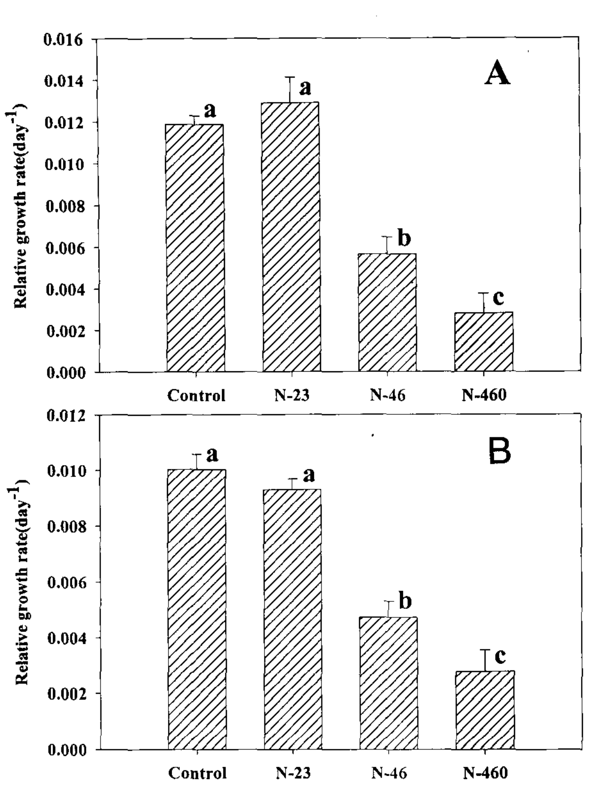

Fig. 2. Relative height (A) and diameter at root collar (B) growth rate of *Indigofera pseudo-tinctoria* treated with nitrogen fertilizers. N-23, N-46 and N-460 represent that 23 g, 46 g and 460 g of nitrogen per m^2 were provided. Dissimilar letters indicate significant differences between mean from Kruskal-Wallis test ($P < 0.01$). The each sample number is 36.

of roots, stems and leaves of plants in control plots were the greatest and as nitrogen fertilizers were added more, dry weights of plants have decreased (Table 1). Nodule was mainly founded in branch roots than in primary roots. As a consequence of examination of relationships between nodule numbers and nitrogen treatment, nodule number of roots treated with control and nitrogen fertilization showed significant differences but there were no significant differences among three nitrogen treatments

Table 1. Harvest biomass of Indigofera pseudo-tinctoria after 106 days of growth at Kyongseodong Landfill sites. N-23, N-46 and N-460 represent that 23 g, 46 g and 460 g of nitrogen per m^2 were provided. Values are mean ± S.E. Dissimilar superscripts letters indicate significant differences between treatments ($P < 0.01$). The each sample number is 35

	Control	N-23	N-46	N-460
Root (g)	$3.23^a \pm 0.40$	$3.01^b \pm 0.32$	$1.20^c \pm 0.27$	$0.77^d \pm 0.26$
Stem (g)	$13.41^a \pm 1.78$	$11.67^b \pm 1.36$	$3.93^c \pm 0.87$	$2.66^d \pm 0.95$
Leaf (g)	$4.56^a \pm 0.64$	$3.85^b \pm 0.49$	$1.85^c \pm 0.44$	$1.27^d \pm 0.41$

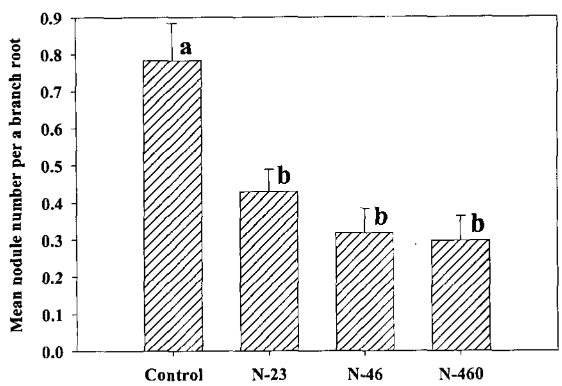

Fig. 3. Mean nodule number per a branch root of *Indigofera pseudo-tinctoria* treated with nitrogen fertilizers. N-23, N-46 and N-460 represent that 23 g, 46 g and 460 g of nitrogen per m^2 were provided. Dissimilar letters indicate significant differences between mean from Kruskal-Wallis Test ($P < 0.01$). The each sample number is 35.

(Fig. 3; $P < 0.01$). Nitrogen fixing plants in family Leguminosae play an important role in providing nitrogen into nutrient poor soils, which result in driving into vegetative succession (Jefferies *et al.* 1981). It is necessary to examine the effects of nitrogen fertilization on a portion of legume plants when providing nitrogen source to the nitrogen deficient waste landfills. The mean contents of total nitrogen of soils in the Kyongseodong landfill are known to be 0.14 ± 0.01 %, which is lower than those in the abandoned old-field (Kim 2001, Lee and Kim 1996). This study results shows that many legume plants such as *Robinia pseudo-acacia*, *Amorpha fruticosa*, *Lespedeza bicolour* and *Indigofera pseudo-tinctoria* were dominant shrubs locally and a certain amounts of nitrogen fertilization showed detrimental effects on growth of *I. pseudo-tinctoria* (Fig. 3). If nitrogen sources are provided in high contents, they presume to obstruct nodule formation and it leads to hindrance to growth. In this experiment, nitrogen fertilization over 23 g N/m^2 resulted in growth reduction in *I. pseudo-tinctoria*. Genus *Indigofera* plants are reported to be well adapted to disturbances and grow well in barren areas like acid soils (Jha *et al.* 1995, Kanmegne *et al.* 2000). Additionally, other factor influencing nodule activity is landfill gas that consists of methane and CO_2 and it pushes oxygen and leads to oxygen scarcity and finally nodule activity drops (Zhang *et al.* 1995). However, landfill gas maybe affect nodule activity of this plant in control and nitrogen treatments in a similar extent due to a close distance in this experiment. Therefore, other factors except nitrogen fertilization have no possibility in influencing the growth of this plant. To the contrary, in some legume species nitrogen addition is known to increase growth of legume plants like *Robinia pseudo-acacia* (Reinsvold and Pope 1987). Nitrate ion in nitrogen fertilizer may augment nitrogen concentration and nitrogen productivity and hence facilitate plant growth. Maybe about

23 g N/m^2 supply can be critical nitrogen fertilization for growth facilitation or suppression in *I. pseudo-tinctoria*. In a case of *Robinia pseudo-acacia*, minimum amount of nitrogen provision can help nitrogen fixation. However, if nitrogen is applied high, it also impedes growth (Reinsvold and Pope 1987). Nitrogen addition will increase plant growth and acetylene reduction and dry weights of nodule (Reinsvold and Pope 1987). As nitrogen adds continuously, dry weight of nodule declines because allocations of biomass to nodule will be reduced (Johnsen and Bongarten 1991). The declines in total acetylene reduction and nodule biomass at high soil N concentrations and increases at low N concentrations are generally observed with herbaceous legumes (Streeter 1988). The active nodule estimation are really needed to investigate effects nitrogen fertilization on growth and activity of nodule. In conclusion, when nitrogen is added into nitrogen poor waste landfill sites where legume plants are widespread, nitrogen should be fertilized with care not to reduce legume plant performance.

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