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Effects of Nitrogen from Different Inorganic Fertilizers on Growth and Yield of Indian Spinach (*Basella alba* L.)

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Abstract: *A pot experiment was carried to study the effects of N from different inorganic fertilizers on growth and yield of Indian spinach (Basella alba L.). There were six treatments comprising of control, N @ 130 kg ha^{-1} from urea, NH_4NO_3, NH_4Cl, $(NH_4)_2SO_4$, $NaNO_3$. The treatments were arranged in a randomized complete block design with three replications. The results of the study indicated that addition of nitrogen from various inorganic fertilizers significantly affected the number of leaves plant^{-1}, plant height, fresh and dry weight of leaves, stem and root. The maximum number of leaves plant^{-1} and the highest plant height at 45 and 60 days after sowing (DAS) were obtained with supplying nitrogen from urea whereas at 30 DAS these values were obtained with nitrogen from $NaNO_3$. At all the growth stages, the lowest number of leaves plant^{-1} and the lowest plant height were observed with control treatment. The highest fresh and dry weight of leaves, stem and root were found with nitrogen application from urea and the lowest values of these were found with control treatment. The results suggested generally that applying nitrogen from urea was the most effective compared to other sources of nitrogen on the growth and yield characters of Indian spinach.*

Key words: *Indian spinach, Plant heights, root, stem, urea, NH_4NO_3.*

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I. Introduction

Application of fertilizer to the plants greatly affects their growth, production and plant constituents. Nitrogen is the most essential among the nutrients required by plants in large amounts and at the same time, one of the most important growth factors in controlling yield and quality of most vegetable crops [1]. It plays an important role in both plant growth and development [2]. But the response of different plants to nitrogen rate and forms are not considered by the farmers and the usage of nitrogen fertilizers have been gradually increased [3]. Adequate supply of nitrogen fertilizer is beneficial for plant growth and increase crop production but excessive and inappropriate practice makes noxious compounds accumulation in edible products which have a detrimental impact on human health, cause environmental pollution and economic losses [4]. Increasing the levels of nitrogen during the vegetative stage can strengthen and support plant roots, enabling plants to take in more water and nutrients; and allows a plant to grow more rapidly and produce large amounts of succulent, green foliage, which in turn can generate bigger yields, tastier vegetables, and a crop that is more resistant to pests, diseases, and other adverse conditions [5].

Indian spinach *(Basella alba* L*)* is an annual or perennial climbing herb with red or green vines and leaves. It is one of the major popular tropical leaf green vegetable commonly used in the diet of human beings of Bangladesh. It is also gaining popularity in some of the tropical and temperate climates of America, Australia and Europe for its succulent, nutritious greens, and tender stems. Indian spinach is used as fresh vegetable for cooking. Indian spinach is cultivated for its fresh and green leaves ready to harvest in about 45-50 days after sowing. Indian spinach is characterized by high nutritive values and has a high content of dietary fibre and vitamins as well as mineral components [6]. Indian spinach leaves and stem are incredibly rich sources of vitamin A and vitamin C [7]. This green leafy vegetable also contains good amounts of many B-complex vitamins such as folate, vitamin-B6 (pyridoxine), and riboflavin [6]. Basella leaves are very rich sources of minerals like potassium, manganese, calcium, magnesium, and copper [7] Indian spinach is an excellent source of iron, an important trace element, required by the human body for red blood cell (RBC's) production. Not only does the Indian spinach provide food through its edible plant parts, it also exhibits various medicinal properties. Indian spinach has been used from a long time back for the treatment of many diseases like dysentery, diarrhea, anemia, cancer etc [8]. Fresh leaves of Indian spinach are rich sources of several vital carotenoid pigment anti-oxidants such as ß-carotene, lutein, zea-xanthin. These compounds play a healing role in aging and various disease processes [9]. Paste of the root is used as a rubefacient while paste of leaves is used externally as treatment for boils and sores. The leaves and stems are cooked as well and eaten for their laxative properties. The flowers are used as an antidote to poisons. The whole plant is a febrifuge and its juice is reportedly safe for

pregnant women. In fact, during labour, decoction of the plant can be used to ease pain and discomfort. The red juice of the fruit is used as eye drops against conjunctivitis [6].

The yield of Indian spinach depends on vegetative growth which may express in terms of number of leaves and plant height etc. Nitrogen supply of such a leafy vegetable crop, takes the superiority as a result of the relatively higher demand from this element; since, it plays an essential role in overall metabolism of plant enzymes activity, building up protoplasm, amino acids and proteins, which induce cell division and initiate meristematic activity. Therefore, to meet the N-demand of Indian spinach plants using large quantities of nitrogen fertilizer in mineral form still being practiced by growers [10]. Rop et al. [11] reported that increasing N fertilizer resulted in increasing in some vegetative growth and yield of Indian spinach. However, information on the growth and yield of Indian spinach as affected by nitrogen from different inorganic source is very scarce. Keeping this view, the present work was under taken to study the effects of nitrogen from different inorganic source on growth and yield of Indian spinach.

II. Materials and Methods

2. 1. Pot experiment

A pot experiment was carried out at glass house of the Department of Soil Science, University of Chittagong, Bangladesh to study the effects of nitrogen from different fertilizers on growth of Indian spinach *(Basella alba* L*)*. Collected soil for pot experiment was air dried, larger and massive aggregates were broken down by gentle crushing with wooden pluck. Dry roots, grasses and other particulate materials were removed from the soil and processed for pot experiment. Eight kilograms soil was placed in each earthen pot. There were six treatments; one control and five other treatments comprising of N @ 130 kg ha^{-1} from urea, NH_4NO_3, NH_4Cl, $(NH_4)_2SO_4$, $NaNO_3$.The experiment was arranged based on randomized block design with three replication of each treatment. Each pot received phosphorus and potassium in the form triple superphosphate and muriate of potash @ 60 kg ha^{-1} P and 60 kg ha^{-1}K, respectively. According to Bangladesh Agricultural Research Council [12] recommendation, half N and K, and whole of P were applied during soil preparation. Remaining N and K were applied in two equal installments after 2 and 4 weeks of seedling emergence. Five healthy and uniform seeds of Indian spinach were sown at equal distance in each pot. After two weeks of seedling emergence, three seedlings were kept in each pot. Care was taken to keep uniform seedlings in the pots. Irrigation was applied as and when necessary. The experimental pots were kept free of weeds by regular weeding. To control the pests and diseases, necessary plant protection measures were done as and when required.

2. 2. Data collection

Plant height and number of leaves were recorded at 30, 45 and 60 days after sowing (DAS) to assess plant growth. Plants were harvested a 60 DAS. At harvest, root samples were separated from stem and washed carefully to remove any soil. Fresh and oven dry (65^0 C to constant weight) weights of leaves, stem and root were recorded.

2. 3. Analysis of soil

Prior to the initiation of the experiment, soil texture was determined by hydrometer method [13], soil pH was measured in a 1:2.5 soil/water suspension with glass electrode pH meter, organic carbon by wet-oxidation method [14], total nitrogen by micro-Kjeldahl digestion and distillation and CEC by 1N NH4OAC saturation [15], and available phosphorus by Olsen method [16]. The experimental soil was clay loam (36% sand, 21% silt and 43% clay) with pH 5.2, organic matter content 1.12%, cation exchange capacity (CEC) 8.66 cmol kg^{-1}, total nitrogen 0.14%, and available P (Olsen P) 13 mg kg^{-1}.

2. 4. Statistical analysis

The significance of differences between the means of the treatments was evaluated by one way analysis of variance followed by Duncan's Multiple Range Test at the significance level of 5%. The statistical software Excel [17] and SPSS version 12 [18] were used for these analyses.

III. Results and Discussion

3.1 Number of leaves plant^{-1}

The number of leaves plant^{-1} of Indian spinach was recorded at 30, 45 and 60 days after sowing (DAS). The analysis of variance showed that the differences in the number of leaves plant^{-1} of Indian spinach under different N fertilizer source were statically significant and the values are presented in Fig. 1. It was evident from the results that the maximum number of leaves plant^{-1} was obtained with applying nitrogen from urea followed by NH_4NO_3 at 45 and 60 DAS while the minimum number of leaves plant^{-1} was found with control treatment. At 30 DAS, the highest number of leaves plant^{-1} was observed with nitrogen from $NaNO_3$ followed by urea and

NH_4NO_3 whereas the lowest number of leaves plant^{-1} was found with control treatment. The addition of nitrogen from urea, NH_4NO_3 and $NaNO_3$ significantly increased the number of leaves plant^{-1} compared to control at all growth stages. However, there was not significantly difference between urea and $NaNO_3$ and between urea and NH_4NO_3 in producing the number of leaves plant^{-1} of Indian spinach at 30 and 45 DAS, respectively. The percent increase in number of leaves plant^{-1} with nitrogen from urea compared to control was 50, 113 and 200% at 30, 45 and 60 DAS, respectively.

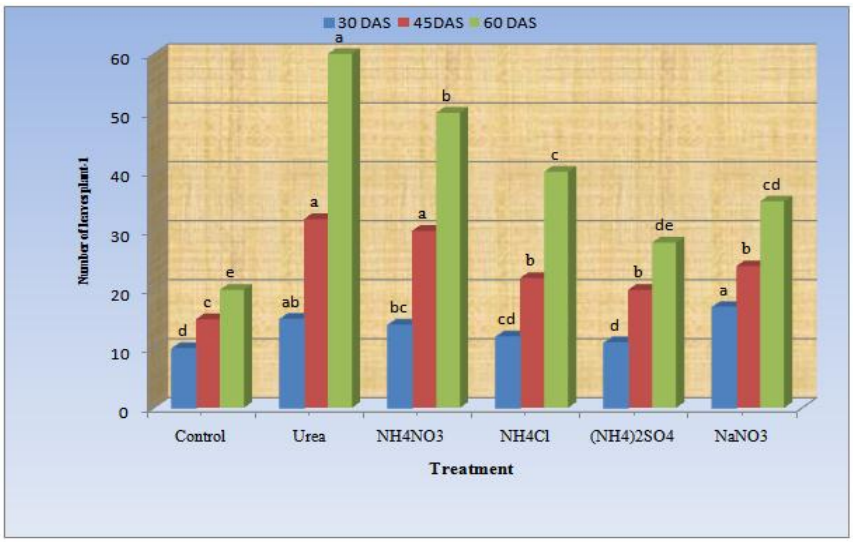

Figure 1 Number of leaves plant^{-1} as affected by applying N from different inorganic fertilizers. Bars having the same letter(s) are not significantly different at $p \leq 0.05$ among treatments.

3.2 Plant height

Plant height is considered to be the most important morphological character of growth of plant. The height of Indian spinach was measured from base of plant to tip of top leaf. It was observed that the height of plants at different growth stages was significantly affected by nitrogen applied from different inorganic fertilizer sources. Plant height among the treatments varied from 7.20 to 14.50 cm, 14.00 to 33.00 cm and 20.00 to 65.00 cm at 30, 45 and 60 days after sowing , respectively (Fig. 2). The highest plant height was found with applying nitrogen from $NaNO_3$ followed by from urea at 30 days after sowing. At 45 and 60 days after sowing, the highest plant height was observed with supplying nitrogen from urea but it was statistically similar to that found with nitrogen from NH_4NO_3 at 45 DAS. At all the growth stages, the lowest plant height was observed with control treatment. The plant height with nitrogen from NH_4Cl, $(NH_4)_2SO_4$ and $NaNO_3$was significantly higher than that with control but lower than that with urea at 45 and 60 days after sowing.

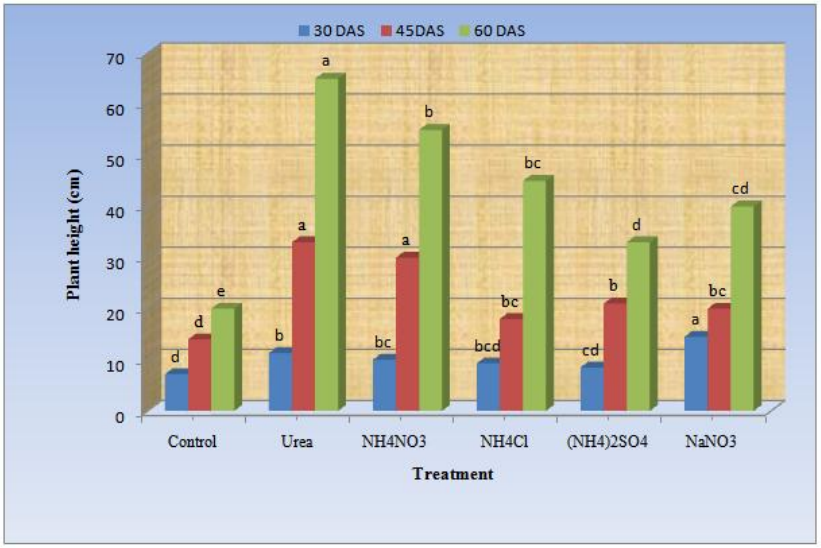

Figure 2 Plant heights as affected by applying N from different inorganic fertilizers. Bars having the same letter(s) are not significantly different at $p \leq 0.05$ among treatments.

3.3 Fresh weight of leaves, stem and root

The variation in growth response of Indian spinach in terms of fresh weight of leaves, stem and root is presented in Fig. 3. Fresh weight of leaves, stem and root varied from 120.21 to 203.74 g pot^{-1}, 79.31 to 157.91 g pot^{-1} and 17.66 to 24.44 g pot^{-1}, respectively. Compared to the control (no nitrogen fertilizers), application of nitrogen from different sources resulted in significantly increase in fresh weight of leaves, stem and root. The highest fresh weight of leaves, stem and root was found with applying nitrogen from urea while the lowest values of these characters were found with control treatment. Applying nitrogen from NH_4NO_3, NH_4Cl, $(NH_4)_2SO_4$ and $NaNO_3$ gave significantly higher fresh weight of stem than control treatment but lower than urea. However, there were not significantly differences in fresh weight of leaves and root among the treatments of urea, NH_4NO_3, NH_4Cl and $(NH_4)_2$ SO_4.

3.4 Dry weight of leaves, stem and root

Dry weight of leaves, stem and root of Indian spinach were significantly affected by fertilizer treatments. Applying nitrogen from urea produced the maximum dry weight of leaves, stem and root while the lowest dry weight of leaves, stem and root was found with control treatment (Fig. 4). The dry weight of leaves and root found with nitrogen from NH_4NO_3 were statistically similar to that found with nitrogen from urea. The dry weight of leaves found with nitrogen from $(NH_4)_2$ SO_4 and $NaNO_3$ and stem dry weight with nitrogen from NH_4NO_3 and NH_4Cl were significantly higher than those with control but lower than those with urea. Applying nitrogen from $(NH_4)_2SO_4$ and $NaNO_3$ produced statistically similar amounts of stem and root dry weight compared to control.

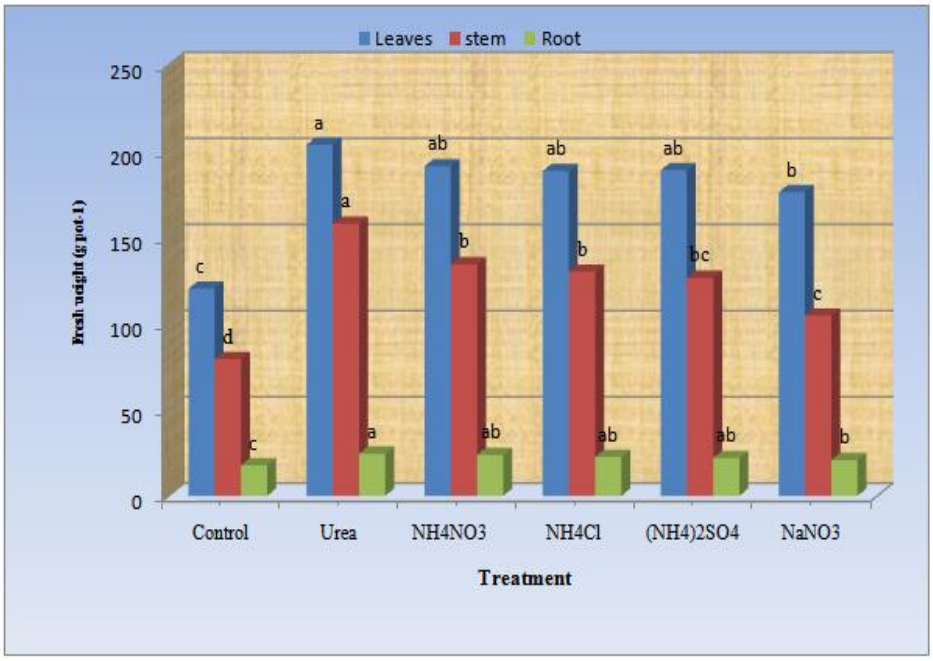

Figure 3 Fresh weights of leaves stem and root as affected by applying N from different inorganic fertilizers. Bars having the same letter(s) are not significantly different at $p \leq 0.05$ among treatments.

The findings of the study revealed significant effect of nitrogen from various inorganic fertilizers on the number of leaves $plant^{-1}$, plant height, fresh and dry weight of leaves, stem and root. The significant increase in growth parameters of Indian spinach due to applied N fertilizer compared to control confirm the deficiency of N in the experimental soil. Indian spinach can grow under conditions of moderate soil fertility but production is enhanced with application of fertilizer. The addition of nitrogen @ 130 kg ha^{-1} from urea, NH_4NO_3 and $NaNO_3$ fertilizers significantly increased the number of leaves $plant^{-1}$ compared to control at all stages of growth recorded at 30, 45 and 60 DAS. The finding of the present study is in concurrence with Rop et al. [11]. The essentiality of nitrogen for plant cell division especially during early vegetative growth in plant [19] implies that application of nitrogen is crucial in production of leafy vegetables. There was increased cell division (mitotic activity) and enlargement resulting in many leaves.

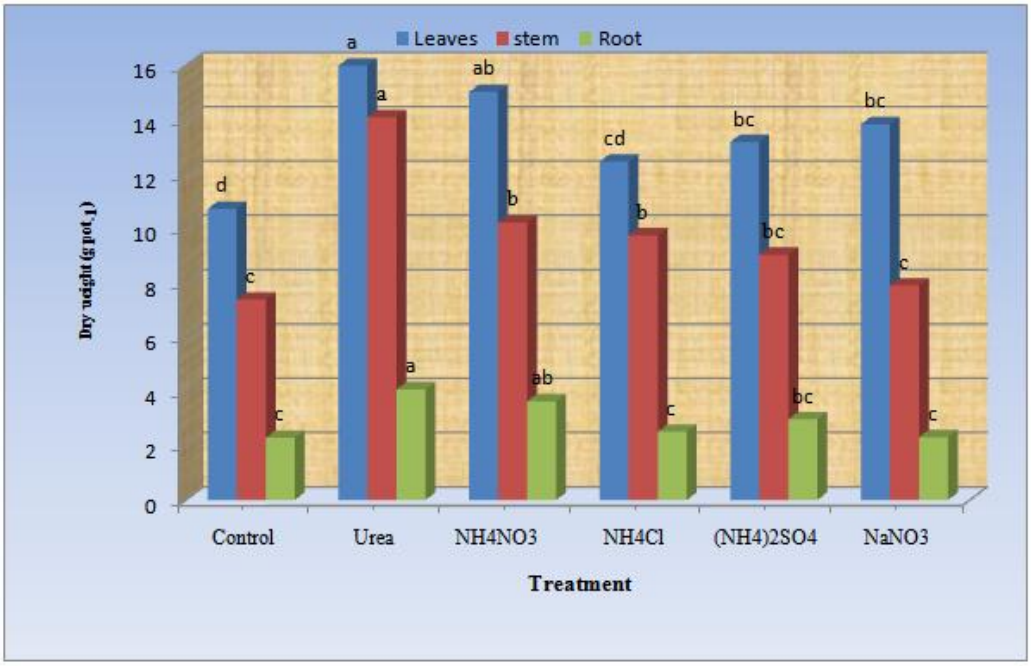

Figure 4 Dry weights of leaves stem and root as affected by applying N from different inorganic fertilizers. Bars having the same letter(s) are not significantly different at $p \leq 0.05$ among treatments.

The highest plant height of Indian spinach was observed with applying nitrogen from $NaNO_3$ at 30 DAS and from urea at 45 and 60 DAS whereas plant height was the lowest at control treatment at all stages of growth. The plant height with nitrogen from NH_4Cl, $(NH_4)_2SO_4$ and $NaNO_3$ was significantly higher than that with control but lower than that with urea at 45 and 60 days after sowing. The height of a plant depends on plant vigour and growth habit. Indian spinach is a vigorous growing plant and nitrogen had a significant effect on the length of vines. In accordance with the present study, the positive role of nitrogen in enhancing plant height was reported by Wahocho et al. [20] who showed that application of N at 140 kg ha^{-1} increased plant height and other growth characters significantly. Rop et al. [11] also reported that application of 90 kg N ha^{-1} from urea enhanced stem length of Indian spinach at 4 weeks after transplantation. The result of the present study was also in conformity with Bharad et al. [21].

Application of nitrogen from urea and NH_4NO_3 resulted in significantly increase in fresh and dry weight of leaves, stem and root compared to the control (no nitrogen fertilizers). This may be due to the fact that through increased photosynthetic activity, there was accumulation of carbohydrates in leaves, thus increasing their weight. Nitrogen forms an integral part of chlorophyll and hence is directly involved in dry matter accumulation through photosynthesis. Nitrogen leads to an increase in the carbohydrate accumulation in the plants thus enhancing leaf fresh weight [19]. Mirdad [10] reported that supplying nitrogen in urea form gave higher significant mean values of all studied vegetative growth characters of spinach, with only one exception of dry matter content, comparing with ammonium sulfate form, which gave lower mean values of these characters in two growing seasons. Elia et al. [22] reported that the presence of both NO_3-N and NH_4-N improved growth indices; but the best result was obtained with nitrate form only which stimulated more growth of spinach plants. In this concern, Bassioni [23] reported that different sources of nitrogen; i.e. ammonium sulfate, calcium nitrate and urea, had no effects on yield of spinach.

IV. Conclusion

The results obtained in the present study indicated that applying nitrogen from various inorganic fertilizers significantly affected the number of leaves $plant^{-1}$, plant height, fresh and dry weight of leaves, stem and root of Indian spinach. On the basis of the results it is suggested generally that urea had the potentials to be recommended as suitable nitrogen source for growth and yield characters of Indian spinach comparing with other sources of nitrogen.

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