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The growth and yield response of Pui (*Basella alba*) at different levels of Nickel under various moisture conditions

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Abstract— A pot experiment was conducted at the Dept. of Soil, Water and Environment, University of Dhaka, Bangladesh to examine the effects of Ni on growth and yield of Pui *(Basella alba)* under 40%, 70% and 100% field capacity (F.C.) moisture content of soil. The soil collected from Bhaluka, Mymensingh (Chandra series), had the following general characteristics; pH 6.0, Electrical Conductivity (E.C.) 134µS cm^{-1}, organic matter 2.20%, organic carbon 1.27%, total N, P, K 0.024%, 0.07% and 0.05% respectively. The total Ni concentration was 20 ppm and the texture was silty loam. Three Ni levels were maintained by treating the experimental soils with 0, 50 and 100 mg Ni/kg soil. Roots and shoots of pui were collected after 45 days of sowing. A significant impact of nickel was observed on growth and yield of pui at various moisture content of soil. The concentration of nickel increased with increasing nickel treatment in pui roots and shoots.The length of roots and shoots, the fresh and dry matter production decreased with increasing nickel levels for pui. The results showed that nickel influenced the growth and yield of pui at various moisture conditions.

Index Terms— Cation Exchange, Field Capacity, Growth, Moisture, Nickel, Treatment, Yield.

1 INTRODUCTION

The trace element in soil are very important from aspects of both soil and environmental quality. Excessive or meager levels of these elements can cause toxicities or deficiencies in plants, ultimately, in animals and humans, which feed upon them. So the natural presence of these materials is of primary interest for human health, animals, plants as well as aquatic environment. Now-a-days, the presence of potentially toxic trace elements in soil is of intense public concern on both global and regional scale.

Nickel (Ni) is an essential element for activation of urease in higher plants. The effects of Ni as an essential micronutrient on growth and chlorophyll content of wheat plants grew in nutrient solutions supplied either with ammonium nitrate or urea as two different nitrogen (N) sources were investigated [1]. Ni is a component of the enzyme urease [2], which is present in a wide range of plant species [3], led to renewed scientific interest and research concerning the role of Ni in higher plants.

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Nickel plays numerous roles in the biology of microorganisms and plants, though they were not recognized until the 1970s [4]. In fact urease (an enzyme which assists in the hydrolysis of urea) contains nickel. The NiFe-hydrogenases contain nickel in addition to iron-sulfur clusters. Such [NiFe]-hydrogenases characteristically oxidise H_2. A nickel-tetrapyrrole coenzyme, F430, is present in the methyl coenzyme M reductase which powers methanogenic archaea. One of the carbon monoxide dehydrogenase enzymes consists of an Fe-Ni-S cluster. Other nickel-containing enzymes include a class of superoxide dismutase and a glyoxalase [5].

The soil chemistry of nickel is based on its divalent ion (Ni^{2+}). Nickel (II) is the most stable state over a wide range of different pH and redox conditions found in surface soils. Under acidic and reducing conditions, the sulphides of nickel (II) are most likely to control its concentration in the soil solution. As the alkalinity of soil increases, so nickel(II) is more likely to form sulphate, phosphate, carbonate and hydroxy complexes if the bulk solution chemistry permits [6].

The most important factor determining the distribution of nickel between soil particles and the solution phase is pH, while factors such as the clay content and the amount of hydrous iron and manganese oxides in the soil are also important [7]. The mobility of nickel in soils increases as the pH and the cation exchange capacity (CEC) decreases. Binding of nickel to the organic fraction of soil can be important, for example, in the release of nickel from soil amended with sewage sludge [8]. There appears to be general agreement among researchers that soil pH is a critical parameter in determining the availability of nickel for plant uptake [9].

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Phytotoxic concentrations of nickel occurred at leaf contents in the range 10–100 mg kg–1, dependent on plant species [10]. Although the transport and storage of nickel within plants is metabolically controlled, this metal is mobile in plants and is likely to be accumulated in both leaves and seeds [11].

The soil-to-plant concentration factor (CF) 1 for nickel is based on a literature review of nickel uptake by the garden vegetables of interest. Although dependence on soil pH for nickel plant uptake has been widely reported, this was only weakly supported by analysis of the studies reviewed [12]. It should be noted, however, that the available data set is limited and that a better correlation might be found as knowledge of the concentration of nickel in various types of vegetable and under different soil conditions increases.

2 MATERIALS AND METHOD

The seeds of pui, used in the present investigation were collected from Bangladesh Agricultural Research Institute (BARI), the soil used for pot experiment was collected from Bhaluka upazila of Mymansingh district. Bhaluka Upazila in Mymensingh district was selected as an area with a rural setting representing a typical socio-economic activity. The population of more than 1000 persons per square kilometer presents a severe pressure to create jobs and livelihood. Incentive to commercial and small and medium scale industries is given by the government. This produces pollution of diverse character. Primary pollution is effluent from domestic refuge and sewage discharge. Secondary pollution comes from various commercial enterprises and small and medium scale industries. Dynamic population structure produces pollution potential of diverse nature with changing time frame.

The soil samples collected were air dried, ground and screened to pass through a 2.0 mm sieve and then mixed thoroughly to make it a composite sample. Dry roots, grasses and other substances were discarded from the sample and used for net house experiment. The soil collected from Bhaluka, Mymensingh (Chandra series), had the following general characteristics; pH 6.0, E.C 134 µS cm-1, moisture percentage 2.883, organic matter 2.20%, organic carbon 1.27%, total N, P, K, S, Ca and Mg 0.024, O.07, 0.05, 0.054, 2.6 and 2.5 % respectively; available N, P 0.017% and 4.67 ppm respectively. The total Ni content was 20 ppm and the texture was silty loam.

Three kg of air dried composite soil samples were taken in 4 kg plastic pot. Every pot was marked in accordance with the treatments. The moisture content of the soil was maintained at 40%, 70% and 100% of field capacity throughout the growing period by weighing the pots regularly. In the experiment three sources of fertilizer urea, TSP and MP (N, P and K) were added at a rate of 108 kg N/ha, 24 kg P2O5/ha, 40 kg K2O/ha.

In order to study the effect of nickel on the growth of pui, Ni was applied as NiSO4.H_2O at the rate of 0, 50 and 100 ppm. The basis of selecting these levels of treatments was the maximum permissible limit of Ni in soil is 50 ppm (kloke, 1980). Pui plant was harvested after 45 days of sowing. The plants were uprooted and the basal part of the harvested plants were washed with water to remove soil particles and algae. Then the fresh weight was taken and dried in the sun and finally oven-dried at 70◦C for three days, weighed and ground seperately and then stored properly for analysis.

Total nickel concentration of the plant samples were determined by atomic absorption spectrophotometer (AAS) method after digestion of the samples with perchloric acid-nitric acid.

The results of the experiment were statistically evaluated in the form of Analysis of Variance (ANOVA) using statistical procedure for social science, SPSS (version 17.0) packages.

3 RESULTS AND DISCUSSION

3.1 Effect of Ni on Length of Shoots and Roots of pui

Average length of shoot and root of Pui as affected by different levels of nickel are shown in and Table 3.1.1 and Fig. 3.1.1

Table 3.1.1: Length or height (cm) of Pui at various Ni-level

Ni- level	Root+ Shoot
Control	90
50ppm	76
100ppm	62

From Table 3.1.1 it is evident that increasing nickel level reduced the length of shoot and root of Pui. The highest length of shoot+ root of Pui was observed under control treatment.

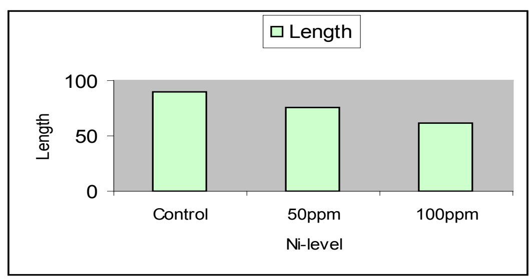

Fig. 3.1.1: Effect of Ni-levels on length or height (cm) of Pui

Average length of shoot and root of Pui as affected by different levels of moisture are shown in Table 3.1.2 and Fig. 3.1.2

Table 3.1.2: Length or height (cm) of Pui at various Moisture-

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level

Moisture- level	Root+ Shoot
40% F.C	76.40
70% F.C	88.20
100% F.C	66.50

From Table 3.1.2 it is evident that increasing moisture level increased the length of shoot and root of Pui upto 70% F.C.. The lowest length of shoot+ root of Pui was observed under 100% F.C.

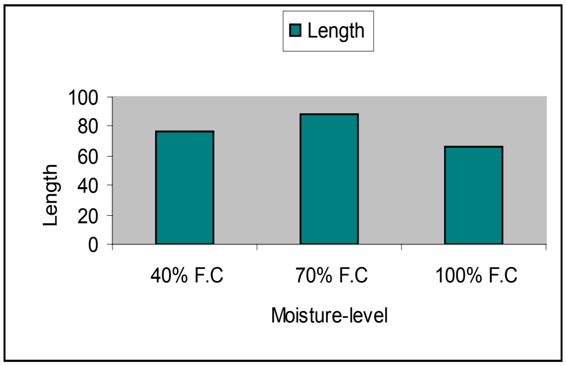

Fig. 3.1.2: Effect of Moisture-level on length or height (cm) of pui

3.2 Fresh Matter Production of Pui

Mean values of fresh weight of pui root at various Ni- levels under different moisture conditions are presented in Table 3.2.1 and Fig. 3.2.1

Table 3.2.1: Fresh weight (g/pot) of pui root at various Ni-level under different moisture condition

Moisture \ Ni- lev el	Control	50 ppm	100 ppm
40% F.C	11.46	11.88	3.0
70% F.C	12.45	3.90	4.81
100% F.C	10.23	3.12	1.57

Weight of pui root was highest at the control treatment of 70% field capacity (FC). The lowest weight was found at 100 ppm Ni-level of 100% field capacity (FC). Fifty ppm treatment did not suppress the production of pui root at 40% FC.

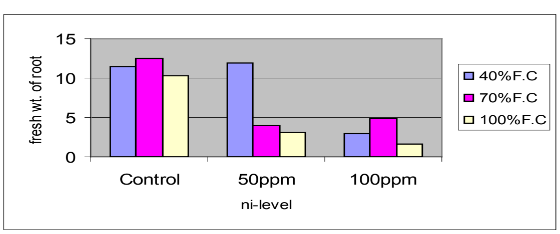

Fig. 3.2.1: Effect of nickel and moisture on fresh weight of pui root

The analysis of variance (ANOVA) of the data (Table 3.2.2) shown that the value of treatments (0.362>0.05) and block that means moisture (0.058>0.05) were higher than 0.05. So, their effects on fresh weight are not statistically significant

Table 3.2.2 : ANOVA for fresh matter production of pui root

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	125.792[a]	4	31.448	3.817	0.111
Intercept	432.917	1	432.917	52.543	0.002
treat	21.798	2	10.899	1.323	0.362
block	103.994	2	51.997	6.311	0.058
Error	32.957	4	8.239		
Total	591.667	9			
Corrected Total	158.749	8			

a. R Squared = 0.792 (Adjusted R Squared = 0.585)

Mean values of fresh weight of pui shoot at various Ni- levels under different moisture conditions are presented in Table 3.2.3and Fig. 3.2.2

Table 3.2.3: Fresh weight (g/pot) of pui shoot at various Ni-level under different moisture condition

Moisture \ Ni- level	Control	50 ppm	100 ppm
40% F.C	109.65	100.01	5.63
70% F.C	98.17	27.26	5.78
100% F.C	90.68	4.52	9.22

Weight of pui shoot was highest at the control treatment of 40% field capacity (FC). The lowest weight was found at 50 ppm Ni-level of 100% field capacity(FC). Fifty ppm treatment did not suppress the production of pui root at 40% FC.

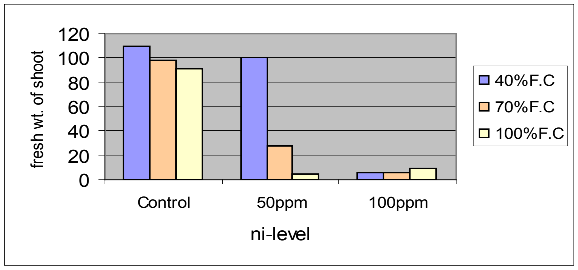

Fig. 3.2.2: Effect of nickel and moisture on fresh weight of pui shoot

The analysis of variance (ANOVA) of the data (Table 3.2.4) showed that the value of treatments (0.323>0.05) is higher than 0.05. So, their effects on fresh weight are not statistically significant. But the value of block (moisture) is lower than 0.05. Thus, the value is significant at 5% level. That's why, different level of moisture have significant effect on fresh matter production.

Table 3.2.4 : ANOVA for fresh matter production of pui shoot

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	15271.090[a]	4	3817.773	5.202	0.070
Intercept	22592.094	1	22592.094	30.782	0.005
treat	2231.034	2	1115.517	1.520	0.323
block	13040.056	2	6520.028	8.883	0.034
Error	2935.801	4	733.950		
Total	40798.986	9			
Corrected Total	18206.892	8			

a. R Squared =0 .839 (Adjusted R Squared = 0.678)

3.3 Dry Matter Production of Pui

Mean values of dry weight of pui root at various Ni- levels under different moisture conditions are presented in Table 3.3.1 and Fig. 3.3.1

Table 3.3.1: Dry matter production (g/pot) of pui root at various Ni-level under different moisture condition

Ni-level / Moisture	Control	50 ppm	100 ppm
40% F.C	1.36	1.3	0.41
70% F.C	1.58	1.08	0.28
100% F.C	1.34	0.57	0.24

Weight of pui root was highest at the control treatment of 70% field capacity (FC). The lowest weight was found at 100 ppm Ni-level of 100% field capacity (FC).

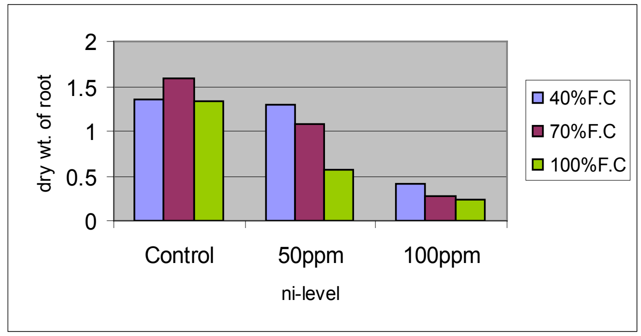

Figure 3.3.1: Effect of nickel and moisture on dry weight of pui root

The analysis of variance (ANOVA) of the data (Table 3.3.2) showed that the value of treatments (0.252>0.05) is higher than 0.05. So, their effects on dry weight are not statistically significant. But the value of block(moisture) is lower than 0.01. Thus, the value is significant at 1% level. That's why, different level of moisture have significant effect on dry matter production.

Table 3.3.2 : ANOVA for dry matter production of pui root

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.062[a]	4	0.516	12.388	0.016
Intercept	7.398	1	7.398	177.775	0.000
treat	0.165	2	0.083	1.986	0.252
block	1.897	2	0.948	22.790	0.007
Error	0.166	4	0.042		
Total	9.627	9			
Corrected Total	2.229	8			

a. R Squared = 0.925 (Adjusted R Squared =0 .851)

The average dry matter production (gm/pot) of pui shoot as affected by different levels of nickel are presented in Table 3.3.3 and Fig. 3.3.2

Table 3.3.3 : Dry matter production (g/pot) of pui shoot at various Ni-level under different moisture condition

Ni- level / Moisture	Control	50 ppm	100 ppm
40% F.C	4.98	5.34	0.43
70% F.C	6.14	1.79	3.54
100% F.C	9.62	0.73	0.65

Weight pui shoot and yield of pui were highest at the control treatment. Dry matter production was lowest at 100 ppm Ni treated plant.

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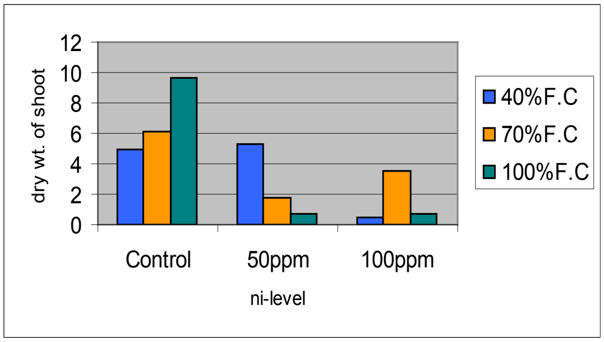

Fig. 3.3.2: Effect of nickel and moisture on dry weight of pui shoot

The analysis of variance (ANOVA) of the data (Table 3.3.4) showed that the value of treatments (0.994>0.05) and block that means moisture (0.142>0.05) were higher than 0.05. So, their effects on dry weight are not statistically significant.

Table 3.3.4 : ANOVA for dry matter production of pui shoot

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	48.561[a]	4	12.140	1.660	0.318
Intercept	122.619	1	122.619	16.765	0.015
treat	0.089	2	0.045	0.006	0.994
block	48.472	2	24.236	3.314	0.142
Error	29.256	4	7.314		
Total	200.436	9			
Corrected Total	77.817	8			

a. R Squared =0.624 (Adjusted R Squared = 0.248)

3.4 Nickel Content of Pui

Average nickel content of pui root as affected by different levels of Ni under various moisture conditions are shown in Table 3.4.1 and Fig. 3.4.1.

Table 3.4.1 : Nickel content (ppm) of pui root at various Ni-level under different moisture condition

Ni-level / Moisture	Control	50 ppm	100 ppm
40% F.C	10.66	32.50	58.40
70% F.C	12.05	38.02	65.05
100% F.C	13.00	38.50	68.20

Nickel application influenced the uptake of nickel by pui plants. its concentration increased significantly with increasing Ni concentration in soil compared with control. Its concentration was the highest at 100 ppm Ni treated plants and lowest was at control. Root accumulated more Ni at higher moisture contion.

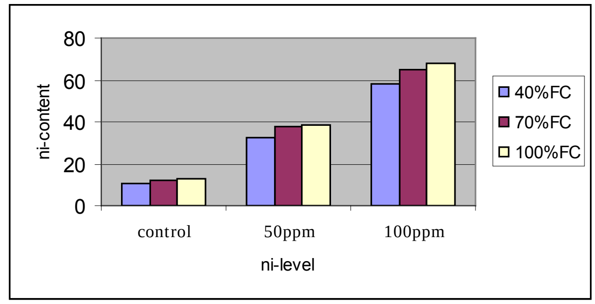

Fig. 3.4.1: Effect of nickel and moisture on Ni-cotent of pui root

The analysis of variance (ANOVA) of the data(Table 3.4.2) showed that the value of treatments (0.044<0.05) is lower than 0.05. So, their effects on Ni-content of pui root are statistically significant. The level of significance is 5%. Besides the value of block(moisture) is lower than 0.01. Thus, the value is significant at 1% level. That's why, different level of moisture have significant effect on Ni-content of pui root.

Table 3.4.2 : ANOVA for Ni-content of pui root

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4117.030[a]	4	1029.257	261.531	0.000
Intercept	12572.389	1	12572.389	3194.601	0.000
treat	59.323	2	29.662	7.537	0.044
block	4057.706	2	2028.853	515.525	0.000
Error	15.742	4	3.936		
Total	16705.161	9			
Corrected Total	4132.772	8			

a. R Squared = 0.996 (Adjusted R Squared =0.992)

Average nickel content of pui shoot as affected by different levels of Ni under various moisture conditions are shown in Table 3.4.3 and Fig. 3.4.2.

Table 3.4.3 : Nickel content (ppm) of pui shoot at various Ni-

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level under different moisture condition

Ni-level / Moisture	Control	50 ppm	100 ppm
40% F.C	9.6	30.00	68.50
70% F.C	10.00	40.02	45.40
100% F.C	10.50	54.80	86.20

Nickel application influenced the uptake of nickel by pui plants. its concentration increased significantly with increasing Ni concentration in soil compared with control. Its concentration was the highest at 100 ppm Ni treated plants and lowest was at control. shoot accumulated more Ni at higher moisture contion.

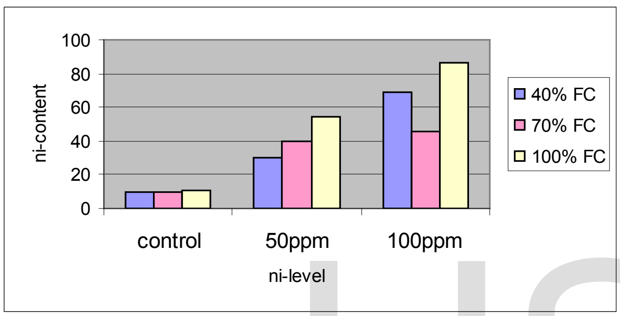

Fig. 3.4.2: Effect of nickel and moisture on Ni-cotent of pui shoot

The analysis of variance (ANOVA) of the data(Table 3.4.4) showed that the value of treatments (0.248>0.05) is higher than 0.05. So, their effects on Ni-content are not statistically significant. But the value of block (moisture) is lower than 0.05. Thus, the value is significant at 5% level. That's why, different level of moisture have significant effect on Ni-content of pui shoot.

Table 3.4.4 : ANOVA for Ni-content of pui shoot

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5414.252[a]	4	1353.563	9.461	0.026
Intercept	14004.356	1	14004.356	97.882	0.001
treat	576.590	2	288.295	2.015	0.248
block	4837.662	2	2418.831	16.906	0.011
Error	572.293	4	143.073		
Total	19990.900	9			
Corrected Total	5986.545	8			

a. R Squared = 0.904 (Adjusted R Squared = 0.809)

4 Conclusion

Nickel added at the rates of 0, 50 and 100 ppm affected the height, fresh matter production and dry matter production of pui significantly. Nickel application influenced the uptake of nickel by pui plants. Their content of nickel increased significantly with increasing Ni concentration in soil compared with control. Different levels of moisture also influenced the uptake of nickel. The content of nickel was higher at higher moisture level. Root accumulated more Ni at higher moisture content in case of pui plants.

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