Original Research Article

Does Nickel Element Play A Role in Atmospheric Nitrogen Fixation?

ABSTRACT

Now, there is unprecedented interest in process of non-biological atmospheric nitrogen fixation for plants. So, an exploratory pot experiment was executed aiming at answering the question of does nickel element play a role in atmospheric nitrogen fixation. Under alluvial and sandy conditions, the effect of nickel element at different rates *i.e.,* 0.0, 2.5, 5.0 and 10.0 mg L^{-1} on the performance and chemical constituents in the straw of wheat plants after 14 days only from sowing were studied, where Ni was added as soil addition after 7 days from sowing in a single application.

The findings showed that all studied Ni rates significantly affected all studied parameters of wheat plants grown on both alluvial and sandy soils, where the highest values of fresh and dry weights as well as N, P, K content in straw (%) were recorded when wheat plants were treated with Ni at rate of 10.0 mg L^{-1}, while the lowest values of all aforementioned traits were recorded with wheat plants grown without Ni addition. Generally, it can be noticed that the values of all aforementioned traits increased as the rate of Ni increased.The same trend was found under both studied soils taking into consideration that the values of all aforementioned traits for plants grown on sandy soil were less than that for plants grown on alluvial soil.

Generally, from obtained results, it can be concluded that the nickel element may have a hidden role in N fixation and there is a need for other research in future to confirm this.

Key words: N fixation, alluvial soil, sandy soil, wheat plants.

INTRODUCTION

Even though there are many studies related to the increase of efficiency of non-biological and biological nitrogen fixation by supplying some beneficial elements, the actual evidence on plant treatment with nickel and its influence on the N fixation process (either non-biological fixation or biological fixation) are unclear and scarce. In fact, very little research works have been executed about the impact of Ni on the process of non-biological N-fixation. **Kumar *et al.,* (2018)** indicated a significant increase in growth performance of barley plants with the application of 10.0 mg Ni kg^{-1} soil over control treatment but they did not mention its ability to N-fixation.

Many papers indicated the toxicity of Ni for plants, where they stated that Ni led to induction of chlorosis, necrosis and wilting as well as inhibiting the plant growth. Also, Ni strongly affected metabolic reactions in higher plants and had the ability to free radicals which may cause oxidative stress (**Chen et *al.,* 2009; Ahmad and Ashraf, 2012 and Bhalerao *et al.,* 2015**).

Therefore, the purpose of the current work was to demonstrate that Ni supply to wheat plants as soil addition can increase the nitrogen fixation effectiveness under alluvial and sandy conditions by measurement of N content in wheat straw directly as well as indirectly by measurement of growth performance of wheat plants (*Triticum aestivum* L.) and content of straw from other nutrients.

MATERIALS AND METHODS

A work research was executed during the winter season of 2021/22 at the Farm of Agric. Fac., Mans. Univ., Egypt aiming at evaluating the role of nickel element in improving the growth performance and increasing the chemical constituents in straw of wheat plants grown on alluvial and sandy soils through a pot experiment continued 14 days only. Wheat grains (**Cv Giza168**) were obtained from Egyptian Ministry of Agri. and Soil Rec (MASR). Twenty-five of wheat grains were cultivated in each pot on 13th of November, where the plastic pots (30 cm diameter and 35 cm depth) were filled by air-dry alluvial and sandy soils equaled to 10.0 kg oven dry soil.

Soil sampling: Soil analyses of initial alluvial and sandy soils samples were done according to **Dane and Topp (2020) and Sparks *et al.,* (2020).** Alluvial soil possessed a clayey texture and contained 22.99 % of sand, 27.2% of silt and 49.81% of clay with pH value of 7.82 and soil EC value of 3.05 dSm^{-1} as well as its values of available N, P and K were 49.95 , 6.70 and 240.5 mg kg^{-1}, respectively. While, sandy soil possessed a sandy texture and contained 91.9 % of sand, 1.7% of silt and 6.4 % of clay with pH value of 7.80 and soil EC value of 0.95 dSm^{-1} as well as its values of available N, P and K were 22.5 , 3.2 and 100.6 mg kg^{-1}, respectively.

Preparation of aqueous solutions of nickel: Ni was used in form of nickel sulphate (purchased from El-Gamhoria Company, Egypt) and its solutions were prepared with different rates *i.e.,* 0.0, 2.5, 5.0 and 10.0 mg L^{-1}.

Experimental setup: This trial was carried out in randomized complete block design with three replicates to assess the effect of nickel element at different rates *i.e.,* 0.0, 2.5, 5.0

and 10.0 mg L^{-1} on the performance and chemical constituents in straw of wheat plants grown on alluvial and sandy soils at a period of 14 days only from sowing as exploratory trial, where Ni was added as soil addition after 7 days from sowing in a single application.

Measurements traits: Random samples of ten wheat plants were taken at a period of 14 days from sowing from each pot to measure the growth criteria *i.e.,* leaves fresh and dry weights (g $plant^{-1}$) and determine the total N, P and K in wheat straw at the same period by completely wet digested using Kjeldahl method, spectrophotomitrically and flam photometer, respectively according to **Walinga *et al*., (2013),** where the oven-dried wheat leaves were ground and then were digested depending on the method of **Peterburgski,(1968)** using a mixture of and perchloric and sulfuric acids (1:1).

Statistical analysis: It was done according to **Gomez and Gomez, (1984).**

RESULTS AND DISCUSSION

To understand the strategies of wheat plants response to application of nickel element, the obtained results will be presented in Figs and then discussed as shown below.

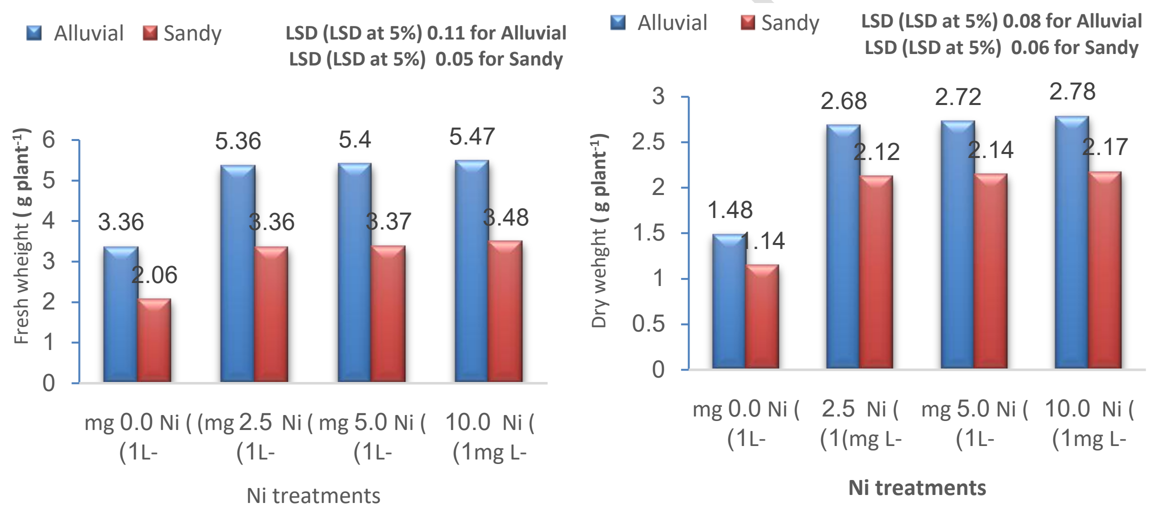

Fig1. Effect of different rates of Ni on growth criteria of wheat plants at period of 14 days from sowing under alluvial and sandy soils circumstances during growing season of 2019/20.

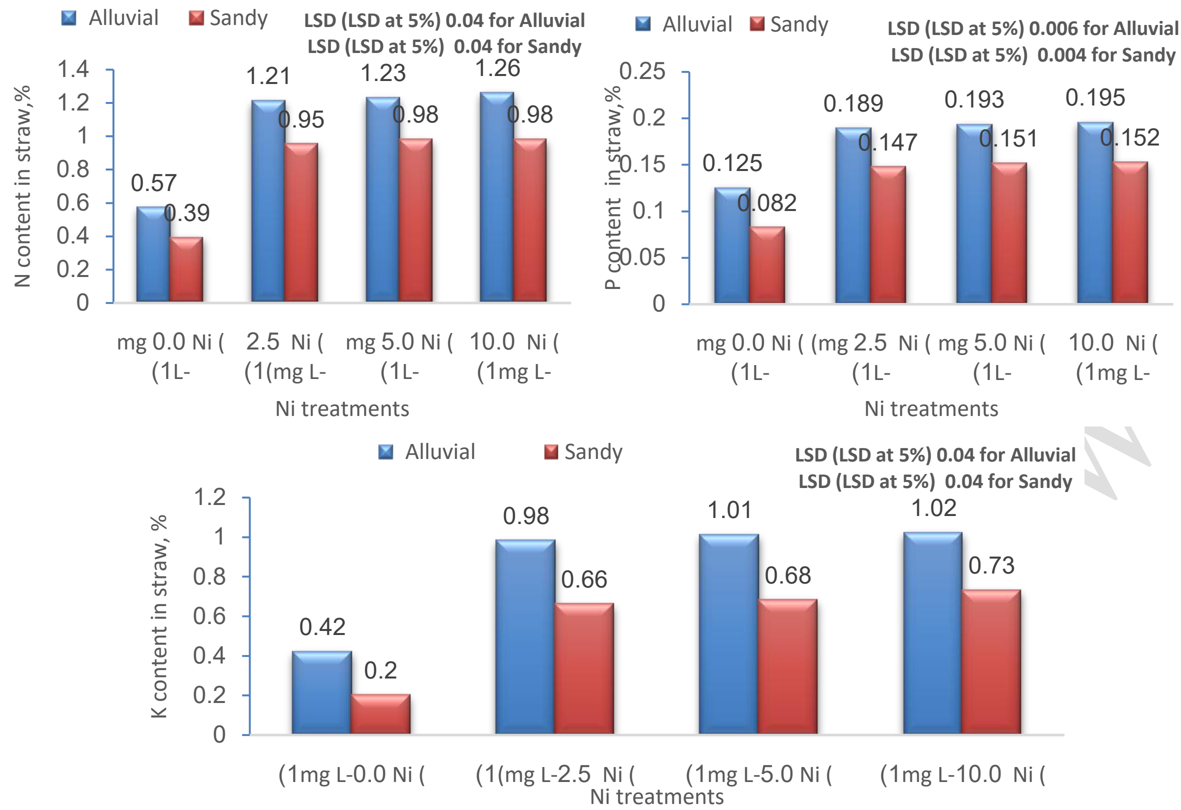

Fig 2. Effect of different rates of Ni on chemical constituents in straw of wheat plants at period of 14 days from sowing under alluvial and sandy soils circumstances during growing season of 2019/20.

Fig 1 shows the effect of various rates of nickel (0.0, 2.5, 5.0 and 10.0 mg Ni L^{-1}) on growth performance of wheat plants expressed in fresh and dry weights (g $plant^{-1}$) at period of 14 days from cultivation of the wheat grains under both alluvial and sandy conditions, while Fig 2 illustrates the effect of investigated treatments on chemical constituents in straw of wheat plants grown under the same conditions at the same period expressed in N, P and K content (%).

Figs 1 and 2 show that all studied Ni rates significantly affected all studied parameters of wheat plants grown on both alluvial and sandy soils, where the highest values of fresh and dry weights as well as N, P, K content in straw (%) were recorded when wheat plants were treated with Ni at rate of 10.0 mg L^{-1}, while the lowest values of all aforementioned traits were recorded with wheat plants grown without Ni addition. Generally, it can be noticed that the values of all aforementioned traits increased as the rate of Ni increased, where the sequence order of studied rates of Ni element from the most effective to the less was as follows;

$$10.0 \text{ mg Ni L}^{-1} > 5.0 \text{ mg Ni L}^{-1} > 2.5 \text{ mg Ni L}^{-1} > 0.0 \text{ mg Ni L}^{-1} \text{ (control)}.$$

It can be said that the superiority of Ni at different rates compared to control treatment (without Ni) may be due to having a vital role for Ni in non-biological N fixation and this is reflected on wheat plant growth performance (fresh and dry weights) and macronutrient status (N, P and K). Also, it can be noticed that the increase in fresh and dry weights and chemical constituents in the straw of wheat plants may be due to the vital role of the Ni element in enhancing the physiological processes at the start of wheat period life, to overcome the urgent need for nutrients. Moreover, Ni is a nutrient required for plants' metabolism as a result of its role as a structural component of hydrogenase and urease **(Weisany *et al.*, 2013),** which in turn perform nitrogen metabolism in many higher plant species. In addition, the Ni element is a functional constituent of 8 enzymes **(Ragsdale, 2009).** The same trend was found under both studied soils taking into consideration that the values of all aforementioned traits for plants grown on sandy soil were less than that for plants grown on alluvial soil and this may be attributed to the high fertility of alluvial soil as compared to sandy soil which has poor fertility **(El-Sherpiny, 2016).** On the other hand, the benefit of Ni element for the wheat plant may be attributed to its ability to shift the element from one element to another through fission or nuclear fusion through nuclear reactors. Our results are in harmony with those of **El-Ghamry *et al.*, (2021)** who proved that a living cell has the ability to transform elements from one element to another as well as they also reported that this action needs on living cells and this action they called it a cell reactor.

CONCLUSION

This study recommends soil addition of nickel element to wheat plants after one week from sowing at rate of 10.0 mg L^{-1} don't cause toxicity for plants, while the best rate for obtaining the best performance and nutrient status for wheat plants grown on alluvial and sandy soils was 2.5 mg L^{-1}.

Generally, it can be concluded that the nickel element may have a hidden role in atmospheric N fixation and there is a need for other research in future to confirm this. In other words, Ni is beneficial for wheat plants up to 10.0 mg Ni L^{-1} without toxicity.

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