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Effect of nickel and *Azospirillum* on growth and yield of maize grown on loamy sand soil

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Abstract
The microplot experiment was conducted at the Micronutrient Research Project (ICAR) experimental site, B. A. College of Agriculture, Anand Agricultural University, Anand (Gujarat) during *kharif* 2015 to study the "Effect of Nickel and *Azospirillum* on Growth and Yield of *Kharif* Maize Grown on Loamy Sand Soil". The experiments were laid out in a Factorial Completely Randomized Design (FCRD), main study comprising of ten treatment combinations with five levels each of Ni (0, 2.5, 5, 10 and 20 mg Ni kg^{-1}) and *Azospirillum lipoferum* (ASA-1) with two levels (0 and 10 mL kg^{-1} seed). The soil used for the experiment was low in available N, medium in available P_20_5 and K_20 and low in NH_4^+ N and NO_3^- N content. The Ni status was 0.40 mg Ni kg^{-1} soil and alkaline (pH 7.86) in reaction. The observations on plant height (at 30 DAS and harvest), seed index, grain yield, stover yield and total yield were recorded. The nickel @ 2.5 mg kg^{-1} soil registered significantly the highest plant height at harvest stage, while its effect at 30 DAS was non-significant. The grain, stover and total yield were significantly improved due to nickel levels, wherein 5.0 mg Ni kg^{-1} soil and 10 mg Ni kg^{-1} soil registered maximum yield of grain and stover, respectively. The grain yield was on par with 2.5 mg Ni kg^{-1} soil, while stover and total yields were on par with 5 and 20 mg Ni kg^{-1} soil.

Keywords: nickel, *Azospirillum,* height, yield

1. Introduction

Nickel was suspected of possessing a metabolic role in plants when discovered as a constituent of plant ash in the early 20th Century. The discovery that Ni is a component of the plant urease in 1975 (Dixon *et al.*1975) [3]. Prompted a renewed interest in the role of Ni in plant life. Apart from urease, nickel is also essential for the functions of several other enzymes like hydrogenase and methyl reductase. It is also needed for grain filling, seed viability, and iron absorption and urea and ureide metabolism (To avoid the toxic levels of N-fixation products in legumes). It is a well-known phenomenon that low concentrations of Ni are necessary in N-metabolism and the germination of plants, such as cereals and cowpeas (Krogemeier *et al.* 1991; Gerendas *et al.* 1999) [6, 7]. Nickel may also be required for symbiotic nitrogen fixation by legumes (Gerendas and Sattelmacher 1997) [5]. It also influences nitrogen uptake and transport in plants. The discovery of nickel deficiencies in plants has underscored the need to understand the role of it in plants. It was found that nickel plays a major role in primary plant metabolism, especially regarding nitrogen usage. These discoveries highlight the importance of nickel in plant nutrition and provide insight into other roles of nickel in plants; thus ultimately enabling better plant yields (Bai *et al.* 2006) [1]. Bio-fertilizers included different types of microorganisms (Chen *et al.* 2009) [2] that could converse nutrients from unavailable form to available form during a biological process and resulted into develop root system and increase seed germination rate. *Azospirillum* is a Gram negative, motile and produces beta hydroxyl granules. Since 1970's, *Azospirillum* strains have been isolated and used as bio fertilizers. Members of the genus *Azospirillum* fix nitrogen under micro paedophilic conditions and are frequently associated with root rhizosphere of a large number of agriculturally important crops. It increases the yield which is mainly attributed to improved root development due to the production of growth promoting substances and consequently increased rates of water and mineral uptake. Nitrogen is one of the most primary nutrient among non-metal elements which requires in large quantity for the plant growth and nutrition. It is the most distributed element in nature. It occurs in atmosphere, lithosphere and hydrosphere. The soil accounts for very small amount of lithospheric nitrogen occurs in soil mainly in the form of nitrate (NO_3^-) and ammonium (NH_4^+) ions.

Nitrogen is known to be a very mobile element circulated among the atmosphere, the soil and living organisms. Nitrogen occurs in both organic and inorganic forms in plants. The inorganic form of combined nitrogen generally contributes only a small fraction of the total nitrogen. Nitrate, the most important inorganic form is mainly taken up by the plants and it is assimilated by reduction to ammonia, followed by incorporation into organic forms. Most of the organic nitrogen of plants is present in proteins. However, in addition to its function in proteins, nitrogen plays a part in other processes like chlorophyll pigments, hormones, respiration-energy carrier (ATP) etc. Maize is one of the major cereal crops grown in India. Maize (*Zea mays* L.) is grown for both grain and fodder purpose. In India it ranks fifth in total area and third in productivity. Maize has high potential and hence called as 'queen of cereal' but due to lack of proper information on fertilizer management, it gives poor yield. Considering the significance of N in agriculture, importance of bio-fertilizer to reduce the chemical load through fixation of atmospheric N and role of Ni to increase N use efficiency besides as an essential element, present study entitled "Effect of Nickel and *Azospirillum* on growth and Yield of Maize Grown on Loamy Sand Soil" was proposed with following objectives.

2. Materials and Method

The study entitled, "Effect of Nickel and *Azospirillum* on growth and yield of maize grown on loamy sand soil" was undertaken by conducting a micro-plot experiment in the net house of Micronutrient Research Project (ICAR), Anand Agricultural University, Anand (Gujarat) during kharif season of the year 2015. The soil used for the experiment was alkaline in reaction with low in available N and medium in available P_20_5 and K_20. The Ni status was 0.40 mg Ni kg^{-1} soil. Five levels of Ni (0, 2.5, 5, 10 and 20 mg kg^{-1} soil) and two levels of *Azospirillum lepoferum* (ASA-1) (0 and 10 mL kg^{-1} seed) were kept for the study. Incubation study, Ni levels was kept same as main study. The experiment was laid out in Factorial Completely Randomized Design with three repetitions. The observations on yield and yield attributes, contents of Ni and N as well their uptake and soil properties before and after harvest of the maize crop were determined. The salient findings are summarized as under. The bold, homogenous, pest and disease free seeds of maize variety GAYMH-1 were selected for the sowing purpose. The N application as per recommended dose (100 kg N ha^{-1}) was supplied in the form of urea and DAP. First split of N was applied as a basal dose in form of urea and DAP, second split was applied by top dressing of urea at knee high stage and third split was applied by top dressing of urea at tasselling stage. Total quantity of P_2O_5 of recommended dose (60 kg P_2O_5 ha^{-1}) was applied in the form of DAP as a basal dose. The seeds of maize were sown in micro plots keeping spacing of 60 x 20 cm. After germination, thinning was done after seven days of crop growth and uniform plant population was maintained. The ancillary observation of plant height was taken in accordance with the crop growth in micro plots and were allowed to grow up to maturity. The common agronomical and plant protection measures were taken from time to time. Irrigations were given as and when required. Plants were harvested after attaining maturity. First the above ground portion i.e. shoots were harvested and fresh weight of shoots was recorded immediately after harvesting. The grains were removed by hand thrashing and yield was recorded on micro plot basis. The seed index of grain was recorded.

3. Result and Discussion

3.1. Plant height

Data presented in table 1 show the effect of Ni and *Azospirillum* applications on plant height of maize at 30 DAS and harvest.

The data revealed that the effect of Ni and *Azospirillum* application on plant height at 30 DAS was non-significant, while at harvest the changes in plant height were significant due to different levels of Ni application. The significantly highest plant height (212.8 cm) was found under Ni application at 2.5 mg kg^{-1} soil and the improvement was to the tune of 7 per cent over control at harvest. There was a decrease in plant height with increasing Ni application after 2.5 mg Ni kg^{-1} soil. The plant height was not significantly affected by *Azospirillum* application. Interaction effect of Ni and *Azospirillum* applications at 30 DAS and at harvest was also found non-significant. Similar trends in growth of plants with the application of Ni have been observed by Gerendas *et al*. (1997) [5] in rice and Gautam and Pandey (2008) [4] in lentil. As Ni is closely associated with N-urea assimilation, growth promotion in plants fertilized with Ni can also be attributed to enhanced N-urea assimilation (Krogmeier *et al*. 1991; Gerendas and Sattelmacher 1997) [5, 7].

3.2. Seed index

The data on seed index of maize grain as influenced by Ni and *Azospirillum* applications are presented in table 2. The seed index of maize grain increased up to 2.5 mg kg^{-1} soil, but it was not statistically significant. The result revealed that there was no significant effect of application of *Azospirillum* on test weight of maize grain. The interaction effect was also found to be non-significant.

3.3. Yield

The data on grain, stover and total yield of maize as influenced by Ni and *Azospirillum* applications are presented in table 2.

The results revealed that positive effect of Ni application was noticed on yield of different components of maize, which was graphically presented in Figure 4.2. The significantly higher grain yield (466 g $plot^{-1}$) was noticed due to application at 5.0 mg Ni kg^{-1} soil than rest of the levels, but it was at par with 2.5 mg Ni kg^{-1} soil (451 g $plot^{-1}$). In case of stover and total yield of maize, the significantly higher yields over control were reported due to 5.0, 10 and 20 mg Ni kg^{-1} soil. The higher stover and total yield were noticed with the application of 10 mg Ni kg^{-1} soil was 844 g $plot^{-1}$ and 1255 g $plot^{-1}$, respectively. Stover yield under 10 mg kg^{-1} (845 g $plot^{-1}$) was on par with Ni application at 20 mg kg^{-1} (807 g $plot^{-1}$) and 5 mg kg^{-1} soil (761 g $plot^{-1}$). In case of total yield, it was at par with Ni application at 5.0 mg kg^{-1} (1227 g $plot^{-1}$) and 20 mg kg^{-1} (1210 g $plot^{-1}$). The maximum per cent improvement in grain, stover and total yield of maize due to Ni application over control was 14.22, 25.97 and 16.31, respectively. The effect of *Azospirillum* application on grain, stover and total yield was found non-significant for all three components of maize yield. Similar results were found by Rabie *et al.* (1992) [10] in wheat. The first evidence of response to Ni application by field crop was demonstrated in 1945 in potato, wheat and beans. Later Narwal *et al.* (1991) [9] reported significant increases in corn shoot and root biomass at 10 mg Ni kg^{-1} soil application. Ramani *et al* (2006) [11] also reported beneficial effect of Ni application on growth and yield of spinach, wheat, maize and cluster bean at Anand. As reviewed by Mishra and Kar (1974) [8] and Welch (1981) [12], an optimum dose of Ni in any crop would enhance grain or economic yield by virtue of its role in N metabolism as well its significant function in several metabolic activities like iron acquisition and phytoalexin synthesis.

Table 1: Effect of Ni and *Azospirillum* applications on plant height at 30 DAS and at harvest of maize

Treatments	Plant height (cm)	
	30 DAS	Harvest
Ni levels (mg kg^{-1} soil)		
Ni_0	92.0	198.9
$Ni_{2.5}$	92.9	212.8
$Ni_{5.0}$	95.2	207.2
Ni_{10}	95.1	204.9
Ni_{20}	91.9	201.2
S. Em. ±	2.44	1.73
C.D. at 5%	NS	5.1
Azospirillum levels (mL kg^{-1} seed)		
Az_0	92.5	205.9
Az_{10}	93.5	204.1
S. Em. ±	1.54	1.09
C.D. at 5%	NS	NS
Interaction Ni x *Az*	NS	NS
C.V. (%)	6.4	2.1

Table 2: Effect of nickel and *Azospirillum* applications on yield of maize

Treatments	Yield (g $plot^{-1}$)			Seed index
	Grain	Stover	Total	
Ni levels (mg kg^{-1} Soil)				
Ni_0	409	670	1079	22.5
$Ni_{2.5}$	451	700	1151	24.4
$Ni_{5.0}$	466	761	1227	23.2
Ni_{10}	410	845	1255	23.1
Ni_{20}	403	807	1210	23.0
S. Em. ±	14.9	27.1	30.3	0.74
C.D. at 5%	44	79	89	NS
Azospirillum levels (mL kg^{-1} Seed)				
Az_0	435	758	1193	22.7
Az_{10}	421	755	1176	23.8
S. Em. ±	9.5	17.1	19.2	0.47
C.D. at 5%	NS	NS	NS	NS
Interaction Ni x *Az*	NS	NS	NS	NS
C.V. (%)	8.6	8.8	6.3	7.8

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