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Effect of nickel with different sources of nitrogen on rice (*Oryza sativa* L.)

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Abstract
A field experiment consisting of 6 treatment combinations of two levels of Ni (@ 1 and 2 kg ha^{-1}) with two nitrogen sources and three replications was conducted under randomized block design at research plot of Udai Pratap (Autonomous) College, Varanasi (U.P.).The main objective of study was to find out the effect of Ni with different sources of nitrogen on growth and yield of rice (*Oryza sativa* L.).The experiment was laid out in a randomized block design (RBD) having 6 treatments and 3 replications. Treatments were T_0= control, T_1 = nitrogen through ammonium sulphate + Ni@ 1 kg ha^{-1}, T_2 = nitrogen through ammonium sulphate + Ni @ 2 kg ha^{-1}, T_3 = nitrogen through urea + Ni @ 1 kg ha^{-1}, T_4 = nitrogen through urea + Ni @ 2 kg ha^{-1} and T_5 = 50% nitrogen through Urea and 50% nitrogen through ammonium sulphate + Ni @ 2 kg ha^{-1}. The results revealed that the growth, yield, organic carbon and available N, P and K status of soil was significantly increased by application of Ni @ 1 and 2 kg ha^{-1} with different nitrogen sources (urea and ammonium sulphate) as compared to control. Similar results were also observed with nutrients (N, P and K) content and uptake by the rice.

Keywords: Nickel, nitrogen, urea, ammonium sulphate, rice

1. Introduction
Ni is the most recent candidate to be added in the list of essential nutrient for higher plant. Ni is considered as an essential element primarily because of its function as an irreplaceable component of urease which is responsible for the hydrolysis of urea N. Urea N acquired by plant is not available for plant N metabolism unless hydrolyzed to CO_2 and NH_3.Consequently, urea grown plants are highly sensitive to inadequate Ni supply (Gerendas and Sattelmacher, 1999a) [9]. Additionally, seed treatment together with Ni fertilization of soybean might improve the efficiency of biological nitrogen fixation (BNF), boosting grain dry matter yield and N content (Lavres *et al*., 2016) [13]. Among the nitrogenous fertilizer sources, urea is most popular than other nitrogenous fertilizer like, ammonium sulphate, ammonium nitrate etc. However, urea N requires conversion of nitrogen into inorganic form it is hydrolyzed by urease enzyme before its utilization by plant roots. (Gerendas *et al*., 1998) [8] found that in plants supplied with urea and Ni, the growth was impaired at the lower levels of Ni, whereas, in plants supplied with NH_4NO_3 and Ni, growth was not affected by micronutrient.

2. Materials and Methods
The field experiment was conducted in the *kharif* season of 2016 at research plot of UdaiPratap (Autonomous) College, Varanasi (U.P.). The soil (0-15 cm) of the experimental plot was of alluvial origin, sandy loam in texture, having electrical conductivity (EC) of 0.51 dS m^{-1}, pH 7.62 with 0.61% organic carbon (OC). The soil was low in available N (131.2 kg ha^{-1}), available P (14.2 kg ha^{-1}), and available K (182.3 kg ha^{-1}). The experiment was laid out in a randomized block design (RBD) having 6 treatments and 3 replications. Treatments were T_0= control, T_1 = nitrogen through ammonium sulphate + Ni@ 1 kg ha^{-1}, T_2 = nitrogen through ammonium sulphate + Ni @ 2 kg ha^{-1}, T_3 = nitrogen through urea + Ni@ 1 kg ha^{-1}, T_4 = nitrogen through urea + Ni @ 2 kg ha^{-1} and T_5 = 50% nitrogen through Urea and 50% nitrogen through ammonium sulphate + Ni@ 2 kg ha^{-1}. The crop was fertilized with recommended dose of 120 kg N, 60 kg of P_2O_5 and 60 kg of K_2O ha^{-1}. Half dose of N and full doses of P_2O_5 and K_2O were applied as basal application. The remaining N was applied at tillering and panicle initiation stages. Ni was applied in the form of $NiSO_4$ as basal application. The crop was irrigated as per recommended schedule and harvested at maturity. Growth and yield attributes were recorded.

2.1 Soil and plant analysis

Soil samples were collected at 0-15cm depth after harvest of the crop and analyzed by standard method of analysis. Soil reaction (pH) was determined using soil: water suspension (1:2.5) with the help of glass electrode digital pH meter (Jackson, 1973) [11], EC by TDS meter (Chopra and Kanwar, 1991) [4], Organic Carbon by Walkley and Black's rapid titration method (Walkley and Black, 1934) [20], available P_2O_5 (Olsen's *et al.*, 1954) [15], available K_2O by neutral normal ammonium acetate extraction method (Jackson, 1973) [11], available N by alkaline permanganate method (Subbiah and Asija, 1956)[19] and available Ni by A.A.S. method using DTPA extract (Laurent and Sylvie, 1996) [12]. Plant samples were dried at 70^0C for 12 hours. 0.5 gram ground plant sample was digested in sulphuric acid and perchloric acid with the ratio of 9:1 and digested samples were used to determine the content of nitrogen by micro Kjeldahl's method, phosphorusby spectrophotometer, potassium by flame-photometer and nickel by AAS method.

3. Results and Discussion

The growth parameters (plant height and number of tillers) were significantly increased by the application of nitrogen through ammonium sulphate and urea with nickel @1and 2kg ha^{-1} as compared to and control (table 1). Maximum plant height and number of tillers were recorded with the treatment containing urea + Ni @ 2 kg ha^{-1}. The findings are in accordance with the results obtained by (Gheibi *et al.*, 2011) [10] who reported that both plant growth and leaf chlorophyll content of the urea fed plants increased significantly with the increase in nickel content up to a certain level. They further reported that the plants received urea plus nickel gave better response than those that received ammonium nitrate plus nickel. Increase in chlorophyll content due to nickel application is also documented by (Lavres *et al.*, 2016) [13]. (Dalton *et al.*, 1988) [6] stated that Ni enhances the urease activity in plants. Urease plays an essential role in mobilization of nitrogenous compounds in plants, a process that is especially important during seed germination and fruit formation when protein reserves are degraded into amino acids. Arginine, an abundant amino acid in plants when degraded, produces urea as a product and urease is needed for utilization. The increase in growth may also be due to increased chlorophyll content which ultimately increases the photosynthesis.

3.1 Yield

Application of nickel with different nitrogen sources significantly increased the grain and straw yield as compared to control (figure 1). The highest yield was recorded with nitrogen through urea+ Ni @ 2 kg ha^{-1} followed by 50% N through AS + 50% N through urea + Ni @ 2 kg ha^{-1} and minimum with control. Increase in yield parameters of different crops due to Ni application were also reported by (Atta-Aly 1999) [1], (Rahman, 2005) [18], (Bai *et al.*, 2006) [2] and (Lopez, 2011) [14]. (Gerendas *et al.*, 1999 a) [9] observed that the supplementing growth medium with 0.04 µm Ni enhanced dry matter production of urea grown plants significantly. (Pederson *et al.*, 1985) [17] stated that protein synthesis was increased due to Ni application. Actually dry matter production is the result of various enzymatic activities. Of the seven Ni-dependent enzymes two have non-redox functions (urease and glyoxylase) and remaining five are involved in oxidation-reduction reactions (Brown, 2006) [3] and (Lavres *et al.* 2016) [13] also found increase in grain dry matter and aerial part dry matter yield by the application of Ni via seed treatment.

3.2 Nutrient content and uptake

Ni application @ 1and 2 kg ha^{-1} in combination of two sources of nitrogen *viz*, urea and ammonium sulphate registered significantly higher nutrients (N,P,K) content in grain and straw as compared to without nickel application. Maximum content were recorded with nitrogen @120 kg ha^{-1} through urea + Ni @ 2 kg ha^{-1} (T_4). Uptake of N, P and K by straw and grain followed similar trend as in case of their content (table 2). Similar results were also reported by (Dahdoh, 1995) [5], (Palacios, 1998) [16] and (Gad *et al.*, 2007) [7]. (Dahdoh *et al.*, 1995) [5] observed that the plant N content and uptake were increased by the addition of Ni. According to (Palacios *et al.*, 1998) [16], the nitrogen content in the plant increased significantly with increasing Ni treatments, showing a synergetic effect between Ni and N. A positive interaction between Ni and potassium (K) content and uptake was also found. (Gad *et al.*, 2007) [7] Also reported a significant promotive effect on nitrogen, phosphorus and potassium content as compared to control by the application of Ni.

Table 1: Effect of treatments on growth attributes of rice

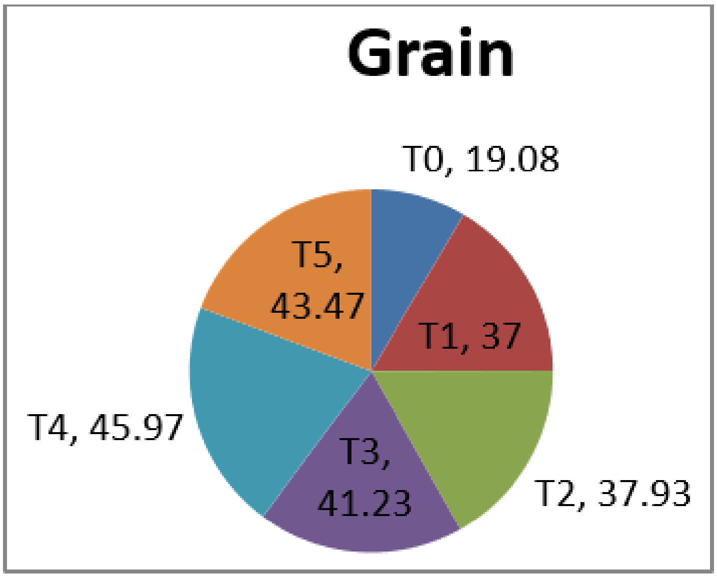
Treatment	30 DAT		45 DAT		60 DAT	
	Plant height (cm)	Tillers $plant^{-1}$	Plant height (cm)	Tillers $plant^{-1}$	Plant height (cm)	Tillers $plant^{-1}$
T_0	60.20	3.83	75.10	4.33	80.00	4.50
T_1	73.10	5.08	92.33	5.50	99.25	5.67
T_2	77.50	6.00	95.20	6.42	101.20	6.50
T_3	81.30	6.50	97.20	7.08	105.10	7.25
T_4	89.40	8.83	113.13	9.42	122.80	9.67
T_5	85.20	7.17	100.50	7.75	109.0	7.83
CD (P=0.05)	3.370	0.561	4.263	0.729	3.337	0.652

DAT = Days after transplanting

Table 2: Effect of treatments on N, P and K content and uptake by rice

Treatment	Nitrogen content (%)		Nitrogen uptake (kg ha^{-1})		Phosphorus content (%)		Phosphorus uptake (kg ha^{-1})		Potassium content (%)		Potassium uptake (kg ha^{-1})	
	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain
T_0	0.249	1.12	7.25	21.36	0.10	0.320	2.91	6.09	0.42	1.13	12.23	21.56
T_1	0.433	1.52	26.16	56.24	0.16	0.471	9.66	17.42	0.71	1.60	42.89	59.2
T_2	0.446	1.62	27.79	61.44	0.18	0.491	11.21	18.62	0.74	1.71	46.12	64.86
T_3	0.465	1.71	30.29	70.50	0.21	0.506	13.68	20.86	0.78	1.83	50.81	75.45

T_4	0.496	1.83	34.74	84.12	0.25	0.562	17.51	25.83	0.93	2.10	65.14	96.53
T_5	0.485	1.78	32.96	77.37	0.23	0.521	15.63	22.64	0.87	1.92	59.13	83.46
CD (P=0.05)	0.09	0.083	4.724	1.139	0.03	0.009	2.438	1.204	0.06	0.110	3.531	3.365



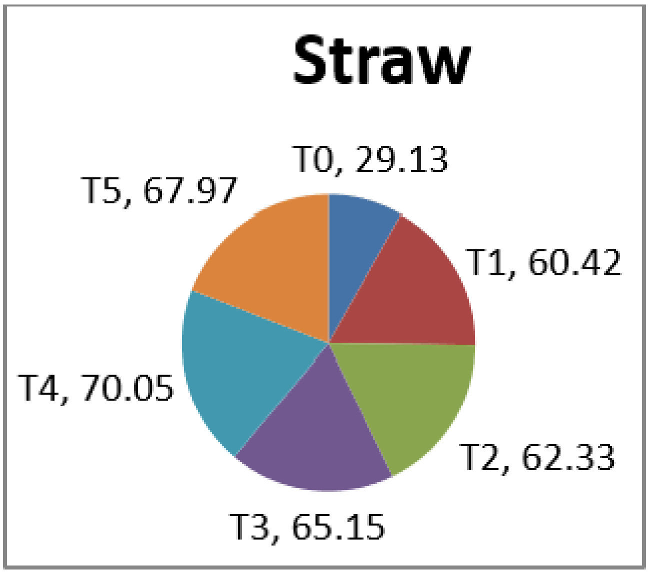


Fig 1: Effect of treatments on yield (q ha^{-1}) of rice

4. Conclusion

The present study thus concluded that the application of nickel with two sources of nitrogen *viz*; urea and ammonium sulphate significantly affected the growth, yield and nutrient uptake by rice. The application of nitrogen @ 120 kg ha^{-1} through urea + Ni @ 2 kg ha^{-1} was found to be the best treatment regarding growth, yield and nutrients (N, P, K) uptake.

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