Egyptian Journal of Chemistry

http://ejchem.journals.ekb.eg/

An Attempt to Use Moringa Products as A Natural Nutrients Source for Lettuce Organically Production

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Abstract

Lettuce is an important leafy vegetable crop, which contains many essential elements and vitamins for human health. The field experiments were conducted at the experimental station of the National Research Centre, Nobaria, Beheira Governorate, (Egypt) during the cultivation seasons of 2020/2021 and 2021/2022 to evaluate lettuce productivity (cv. Balady) using moringa seed cake as natural nutrients source comparing with other organic fertilizer (vermicompost) and chemical fertilizer (Ammonium sulfate) as well as a foliar application at two concentrations (5 and 10 g/L) of moringa leaf extract compared to untreated control. The obtained results showed positive effects for soil fertilizer application of moringa seed cake treatment on vegetative characters, i.e., fresh weight (g/plant) and leaf neck width (cm) as well as chemical contents, i.e., dry matter (%) and nitrate content (mg/kg). Moringa seed cake treatment recorded the same value as Ammonium sulfate treatment on their effects on plant height, leaf width and N, P and K content. The foliar application of moringa leaf extract at a higher rate (10g/L) ranked first followed by the rate of 5g/L for improving the vegetative growth characteristics of the lettuce plant and its chemical contents. Concerning the interaction treatments between soil additions and foliar applications of moringa leaf extract, the highest values of fresh weight, plant height, leaf length, leaf width and leaf neck width leaf dry matter, chlorophyll content and macronutrients (NPK) as well as the lowest value of nitrate content were resulted from fertilized lettuce with moringa seed cake and foliar spraying with a higher rate (10g/L) of moringa leaf extract.

Keywords: Lettuce, ammonium sulfate, nitrate, moringa leaf extract, moringa seed cake, quality

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1. Introduction

Lettuce (Lactuca sativa L.) belongs to the family Compositae, which is the most popular salad crop in the world including Egypt. Lettuce is an important leafy vegetable crop, contains many essential elements and vitamins for human health. In addition, lettuce contains low calories, so be suitable for diet protocol [1]. This crop is increasingly gaining high levels of economic importance both in the generation of income and provision of nutritional value. In Egypt, about 9655 feddan (4200 m^2) is cultivated by lettuce and the total yield was 92530 tons with an average yield of 9.584 tons/fed. (Ministry of Agriculture, Land reclamation, Agricultural statics, second part, 2020/2021).

Fertilizer plays a vital role in the proper growth and development of lettuce. Chemical fertilizers increase the growth and yield but the excessive application of chemical fertilizers in crop production cause health hazards, and create problem for the environment including the pollution of soil, air and water [2, 3]. Moreover, the overuse of mineral fertilizers is causing environmental pollution due to the excessive accumulation and leaching of harmful elements into the ground water [4]. Leafy vegetables particularly lettuce may accumulate nitrate when the supply of nitrogen is high [2, 5, 6, 7, 8]. However, today, organic farming and the use of fertilizers according to the crop needs in agriculture can cause these problems to be alleviated.

Generally, compost as organic fertilizer improved soil physicochemical properties such as the formation and stability of soil aggregates and nutrient availability, resistance against compaction and reduced soil bulk density [9, 10, 11, 12, 13, 14] indicated that application compost gave the highest vegetative growth and yield of lettuce as compared to the other treatments. Moreira et al. (2014) [15]

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Receive Date: 27 October 2022, **Revise Date:** 27 November 2022, **Accept Date:** 04 December 2022

First Publish Date: 04 December 2022

DOI: 10.21608/EJCHEM.2022.171286.7126

recommend the use of organic compost as a source of organic matter, as it showed the best result for plant diameter, plant height, fresh and dry root and shoot weights of lettuce. Moringa seed cake is rich in protein content, about 60% and as a powder contains all the essential amino acids; phenylalanine, valine, threonine, tryptophan, isoleucine, methionine, leucine, and lysine [16]. Additionally, cysteine (or sulfur-containing amino acids), tyrosine (or aromatic amino acids), histidine, and arginine [17]. Moringa seed cakes have been shown to increase the mineral content of soil and increase the yield of maize crops compared to the untreated control [18]. Organic fertilizers derived from moringa seed processed with the proper procedure can increase the soil aeration and richness of indigenous invertebrates, specialized endangered soil species, beneficial arthropods, earthworms, symbioses, and microbes [19].

The moringa leaf extract is considered a natural plant growth regulator where it is a source of amino acids, 365.4 mg/g leaves; proline, 35.2 mg/g leaves; total sugars, 325.8 mg/g leaves; total phenol, 4.5 mg/g leaves; total flavonoid, 8.19 mg/g leaves and ascorbic acid, 8.10 mg/g leaves as well as hormones: IAA, 0.62 mg/100g; GA, 6.09 mg/100g and cytokinin, 2.491 mg/100 g [20], making to putting it as a potential natural growth stimulant, as mentioned by [21, 22]. Foliar application of moringa leaf extract is low-cost and environmentally friendly. These extracts have been used as natural sources of growth promoters for many plants [22, 23, 24, 25, 26, 27, 28 29, 30, 31]. Thus, this work aimed to investigate the effect of different moringa products as natural nutrients source compared to other organic and chemical fertilizers as well as foliar application with different concentrations of moringa leaf extract on vegetative growth, fresh and dry weight, root system, nitrate content and yield of lettuce plants (cv. Balady) grown under sandy soil conditions.

2. Materials and Methods:

Lettuce plants as a model of leafy vegetables were treated with moringa products as a natural source of nutrients: seed cake (soil application) and leaf extract (foliar application), and compared to other fertilizer sources: Ammonium sulfate (mineral fertilizer) and vermicompost (organic fertilizer).The field experiments were conducted at the experimental station of the National Research Centre, Nobaria, Beheira Governorate (Egypt) during the cultivation seasons of 2020/2021 and 2021/2022. The mechanical and chemical properties of the experimental soil are presented in Table (1).

The current research is aiming to evaluate lettuce productivity (cv. Balady) under different amendments of moringa products as natural nutrient sources compared to other organic and chemical fertilizers. All soil fertilizer applications were added at the rate of 100 kg N/feddan (4200 m^2). The seed cake of moringa (3.8% N) as organic fertilizer was incorporated into the soil before transplanting (soil application) and compared to other soil fertilizer applications: vermicompost (organic fertilizer) and Ammonium sulfate (mineral fertilizer). Vermicompost (2.33% N) was incorporated in the soil before transplanting, also. Meanwhile, the amount of Ammonium sulfate (100 kg N/feddan) was divided into three equal amounts and applied top-dressing each 15 days intervals after 20 days from lettuce transplanting. The physical and chemical properties of moringa seed cake and vermicompost are shown in Table (2).

The leaf extract of moringa as a source of nutrients was added by the foliar application at two rates (5g/L and 10g/L) three times with two weeks intervals starting after two weeks from transplanting compared to untreated control during the two cultivated seasons. The effects of different soil fertilizers (three) and foliar applications (three) and their interactions on plant growth, yield, and product quality of lettuce were evaluated.

Table 1: Mechanical and chemical properties of the experimental soil.

Physical analysis		Chemical analysis			
		Cations (meq/l)		Anions (meq/l)	
		Ca^{++}	8.7	CO_3^{--}	Zero
Sand	84.2%	Mg^{++}	4.0	HCO_3^-	0.52
Silt	11.8%	Na^+	2.3	Cl^-	11.48
Clay	4.1 %	K^+	1.0	SO_4^{--}	4.0
Texture class: Loamy sand					
Soil pH	7.7	Available N		0.78%	
E.C (dS/m)	1.6	Available P		0.32%	
Organic matter	3.54 %	Available K		0.46%	

Table 2: Physical and chemical properties of moringa seed cake and vermicompost.

Properties	Moringa seed cake	Vermicompost
pH	5.8	7.3
Moisture content (%)	5.5	24
EC (dS/m)	1.4	1.6
Organic matter (%)	90.7	67
C/N ratio	7.08	18.01
Macronutrients (%)		
Total Nitrogen	3.8	2.33
Phosphorus	0.71	2.6
Potassium	0.8	0.4
Magnesium	0.30	0.44
Micronutrients (ppm)		
Zinc	20.8	378
Iron	13.5	27
Manganese	42	31

The experiment contained nine treatments as a combination between three soil fertilizers (Factor A) and three foliar applications (Factor B) as follows:
A: Soil fertilizer applications at of 100 kg N/feddan for all different three treatments:

1. Ammonium sulfate (Mineral fertilizer, 21% N).
2. Vermicompost (Organic fertilizer, 2.33% N).
3. Moringa seed cake (Natural fertilizer, 3.8% N).

B: Foliar applications:

1. Untreated control.
2. Moringa leaf extract (5g/L).
3. Moringa leaf extract (10g/L).

Lettuce seeds were sown in a nursery bed on the 4th and 6th of October in both seasons and then transplants of nearly 30 days were transplanted on the 4th and 6th of November in the permanent field on both sides of dripper lines at 30 cm between plants. A field experiment was laid out in a split-plot design with three replications where soil addition treatments were arranged in the main plots, while, foliar application treatments were randomly assigned in the subplots. The experimental unit area was 31.5 m^2, every plot consisted of three rows 15 m in length and 70 cm in width.

At the harvesting stage which after 70 days from transplanting, lettuce plants harvested, and 10 plants as the representative sample collected for evaluation of lettuce productivity and its quality during the two cultivated seasons.

Vegetative characters

Plant fresh weight (g/plant), plant height (cm), the number of leaves, leaf height and width, and leaf neck width (cm) were estimated.

Total Chlorophyll

Leaf total chlorophyll content (SPAD unit) values were determined by using portable Minolta Chlorophyll Meter (Model SPAD-501).

Chemical compositions

Nitrogen, phosphorus, and potassium contents (%) were determined according to the methods described by [32, 33, 34], respectively. Nitrate in the dry plant samples (mg/kg) was extracted by 2% acetic acid, determined according to [35].

Statistical Analysis:

Data collected were subjected to statistical analysis according to the standard methods recommended by [36], using the computer program (SAS).

3. Results

Vegetative characters:

Effect of soil fertilizer applications:

The obtained results showed positive effects for moringa seed cake treatment on fresh weight (g/plant) in the two seasons and leaf neck in the second season. Ammonium sulfate treatment ranked the first to increase the leaf length and leaf width of lettuce plants. Moringa seed cake treatment recorded the same value as Ammonium sulfate treatment on their effects on leaf width. The differences in plant height were not significant in the two seasons (Table, 3).

Effect of foliar applications:

It is evident from obtained results that the foliar application of moringa leaf extract improved all growth characteristics of the lettuce plant such as leaf fresh weight (g/plant), plant height, leaf length, leaf width, leaf neck width, and yield compared to untreated control during the two cultivated seasons (Table, 3). The foliar application at a higher rate (10g/L) of moringa leaf extract ranked the first followed by 5g/L of moringa leaf extract for improving vegetative growth characteristics of the lettuce plant and its yield. Similar results were stated by [37, 38] on lettuce, [22, 26, 31] on common beans and [24, 29, 39] on tomatoes.

Effect of the interaction:

Results show that the interaction treatments between soil addition and foliar application of moringa leaf extract improved all growth characteristics of lettuce plants such as leaf fresh weight, plant height, leaf length, leaf width, leaf neck width, and yield compared to untreated control during the two cultivated seasons (Table, 3). The treated plants with moringa seed cake and foliar application at a higher rate (10g/L) of moringa leaf extract ranked the first for improving vegetative growth characteristics of lettuce plant and its yield.

Chemical compositions:

Effect of soil fertilizer applications:

The obtained results showed positive effects of moringa seed cake treatment on dry matter (%) in the first season. Vermicompost ranked the first to increase dry matter in the second season and chlorophyll content (SPAD) in the first season (Table, 4). moringa seed cake treatment recorded the same value as Ammonium sulfate treatment on their effects on N in the second season, P in the first season, and K content in the two seasons (Table, 4). On the opposite, the highest nitrate content in lettuce heads was related to the application of Ammonium sulfate compared to both organically fertilized plants during the two growing seasons.

Effect of foliar applications:

It is evident from obtained results that the foliar application of moringa leaf extract improved leaf dry matter (%) and chlorophyll content (SPAD) and macronutrients (NPK) compared to untreated control (Table, 4). The foliar application at a higher rate

(10g/L) of moringa leaf extract ranked first followed by 5g/L of moringa leaf extract for improving the chemical composition of lettuce plants. The obtained data also showed that applying foliar spray on lettuce plants decreased nitrate content in lettuce heads compared to untreated control, especially in the first season. Almost, similar results were reported by [40] on rocket, [24, 29] on tomatoes and [20, 26, 31] on common beans which explained that the treated plants with moringa extract likely to have increased the content of leaves with N, P and K.

Table (3): Effect of soil fertilizer applications: Ammonium sulfate, Vermicompost and moringa seed cake and foliar applications of moringa leaf extract on vegetative growth of lettuce plant and its productivity in cultivated seasons of 2020/2021 and 2021/2022.

Treatments		Fresh weight (g/plant)		Plant height (cm)		Leaf length (cm)		Leaf width (cm)		Leaf neck width (cm)	
		20/21	21/22	20/21	21/22	20/21	21/22	20/21	21/22	20/21	21/22
Soil applications:											
Ammonium sulfate		1019b	1040b	38.2a	40.0a	32.9a	33.8a	15.5a	16.2a	1.74a	1.73b
Vermicompost		1024b	1020c	38.3a	39.4a	31.4ab	32.3b	14.3b	15.3b	1.73a	1.76ab
Moringa seed cake		1096a	1130a	38.0a	39.7a	31.2b	32.7b	15.5ab	16.0a	1.76a	1.83a
Foliar applications:											
Control		875c	936c	36.3c	38.9b	30.2c	32.0b	14.8b	15.7a	1.74a	1.70a
5g/L moringa		1141b	1069b	38.3b	39.4ab	31.7b	32.7ab	14.7b	15.8a	1.69a	1.80a
10g/L moringa		1262a	1183a	39.9a	40.8a	33.7a	34.1a	15.8a	16.1a	1.80a	1.82a
Interactions:											
Ammoniu m sulfat	Control	889e	961c	35.7c	39.3b	30.7b	32.3a	15.3a	16.3a	1.77a	1.67a
	5g/L moringa	1015c	1028c	39.3ab	40.0ab	34.0a	33.7a	14.7a	15.6a	1.57a	1.73a
	10g/L moringa	1154c	1130b	39.7ab	40.7a	34.0a	35.5a	16.5a	16.3a	1.90a	1.80a
Vermic mpost	Control	852f	909d	36.7bc	38.7c	30.7b	31.7a	14.0a	15.0a	1.73a	1.70a
	5g/L moringa	998d	999c	38.0b	39.0b	30.7b	32.0a	14.0a	15.3a	1.73a	1.80a
	10g/L moringa	1222b	1152b	40.3a	40.7a	33.0a	33.3a	14.8a	15.7a	1.73a	1.77a
Moring seed cake	Control	884e	939c	36.7bc	38.7	29.2b	32.0a	15.0a	15.7a	1.73a	1.73a
	5g/L moringa	1141c	1181b	37.7bc	39.3b	30.3b	32.3a	15.5a	16.0a	1.77a	1.87a
	10g/L moringa	1262a	1269a	39.7ab	41.0a	34.0a	33.7a	16.5a	16.3a	1.77a	1.90a

Means within each column and factor followed by the same letter are not significantly different at $P<5\%$.

Table (4): Effect of soil fertilizer applications: Ammonium sulfate, vermicompost and moringa seed cake and foliar applications of moringa leaf extract on chemical contents of lettuce plant in cultivated seasons of 2020/2021 and 2021/2022.

Treatments		Dry matter (%)		Chlorophyll (SPAD)		N (%)		P (%)		K (%)		Nitrate (mg/kg)	
		20/21	21/22	20/21	21/22	20/21	21/22	20/21	21/22	20/21	21/22	20/21	21/22
Soil applications:													
Ammonium sulfate		4.92b	4.77b	53.2b	52.3a	3.34a	3.53a	0.60a	0.54a	4.02a	4.00a	1330a	1301a
Vermicompost		5.04b	5.07a	54.8a	52.2a	2.96c	3.20b	0.49b	0.50a	3.74b	3.88b	1264b	1236b
Moringa seed cake		5.17a	5.05a	53.2b	51.9a	3.23b	3.47a	0.61a	0.60a	3.92a	4.01a	1200b	1174c
Foliar applications:													
Control		4.96b	4.72b	49.1c	50.8c	3.07c	3.33b	0.54a	0.53a	3.77b	3.90b	1361a	1285a
5g/L moringa		5.08a	4.97ab	54.3b	52.6ab	3.19b	3.39b	0.56a	0.55a	3.90ab	3.97a	1227b	1192a
10g/L moringa		5.09a	5.19a	57.8a	53.1a	3.27a	3.48a	0.59a	0.55a	4.00a	4.02a	1206b	1233a
Interactions:													
Ammoniu m sulfat	Control	4.83d	4.46	48.3c	51.3a	3.24b	3.42a	0.57a	0.54a	3.89cd	3.93b	1432a	1352a
	5g/L moringa	4.96c	4.79e	53.7b	52.2a	3.35ab	3.54a	0.58a	0.55a	4.04ab	4.02a	1291b	1254b
	10g/L moringa	4.95cd	5.04c	57.7ab	53.3a	3.43a	3.62a	0.58a	0.53a	4.14a	4.06a	1268c	1297b
Vermic mpost	Control	5.12b	4.77e	49.3c	50.7a	2.91d	3.16a	0.47a	0.49a	3.62e	3.83c	1360b	1284b
	5g/L moringa	5.04b	5.10b	55.3b	53.3a	2.95d	3.15a	0.48a	0.50a	3.74d	3.87c	1226c	1191c
	10g/L moringa	5.04b	5.32a	59.7a	52.7a	3.05	3.30a	0.51a	0.50a	3.85cd	3.94b	1205c	1232b
Moring seed cake	Control	5.10b	4.93d	49.7c	50.3a	3.11c	3.40a	0.57a	0.57a	3.80d	3.94b	1292b	1220b
	5g/L moringa	5.16ab	5.02c	54.0b	52.0a	3.27b	3.48a	0.61a	0.61a	3.92bc	4.03a	1165d	1132c
	10g/L moringa	5.25a	5.20c	56.0b	53.3a	3.32b	3.53a	0.64a	0.62a	4.02b	4.05a	1144d	1171c

Means within each column and factor followed by the same letter are not significantly different at $P<5\%$.

Effect of the interaction:

The interaction effect between soil fertilizer applications and foliar application treatments significantly affected leaf dry matter (%) and chlorophyll content (SPAD) as well as macronutrients (NPK) compared to untreated control (Table, 4). The highest values of leaf dry matter (%), chlorophyll content (SPAD), and macronutrients (NPK) as well as the lowest value of nitrate content was resulted from fertilized lettuce plants with moringa seed cake (soil fertilizer application) and foliar spraying with higher rate (10g/L) of moringa leaf extract.

4. Discussion

Crop residues can bring positive results on soil quality, soil organic matter and soil moisture retention, nutrient cycling promotion, and reducing soil loss, among other environmental and soil health benefits [41, 42]. Therefore, this investigation was carried out on sandy soil under a drip irrigation system to evaluate using moringa seed cake or compost as organic soil amendments compared to mineral fertilizer for sustainable agriculture in the lettuce plant. Fertilization by moringa seeds cake and vermin compost resulted in a significant maintaining growth and quality characteristics of lettuce plant compared to untreated control. This may be due to the contents of moringa seed cake, which is obtained after extracting the moringa oil from seeds by the method of cold pressing. It is rich in protein content of about 60% and contains all the essential amino acids; phenylalanine, valine, threonine, tryptophan, isoleucine, methionine, leucine, leucine, cysteine (or sulfur-containing amino acids), tyrosine (or aromatic amino acids), histidine and arginine [16, 17].

In addition, the moringa seed cake acts as a coagulant due to positively charged, water-soluble proteins, which bind with negatively charged particles (silt, clay, some minerals, bacteria, etc.) allowing soil regeneration and improving plant fertilization by releasing the nutrients into the soil in a form that plants can easily absorb, activating soil microorganisms and increasing microbes that can increase soil aeration, which will help the decomposition processes of organic matter which will promote higher plant growth within a short period of its application as compared to other organic matters from animal manure and plant compost that require long periods for decomposition and cautious use [16]. It is generally accepted that moringa seed cake increased the mineral content of the soil. This is reflected in improving lettuce quality and maintaining head size. These results are in the line with [18, 43].

The significant increase in the concentrations of N, P, and K in plant leaves may be due to the significant role of moringa leaf extract, which contains many nutrients and important compound as proteins (27.2%), sugars (38.6%), Ca (2%), K (0.013%), p (0.2%) in addition to reasonable quantities of vitamins like A, B1, B2, B3, C, and E. Also, contains hormone-like substances such as Zeatin [44, 45, 46, 47]. Abdalla (2013) [47] mentioned that the use of 2 and 3% of moringa leaf extract stimulates biomass production of the *Eruca* plant and stimulates photosynthesis pigments, total sugars, proteins, and plant phytohormones levels such as auxin, gibberellins, and cytokinins. The essential elements (N, P, K, Ca, Mn, and Fe) increased also. These results coincided with the results of the present investigation, whereas the spray of lettuce plants with moringa leaf extract increased yield components and quality characteristics as well as essential plant mineral content such as N, P, K, Fe, Zn, and Mn. The combination of moringa seed cake as soil application and MLE as foliar application led to improve vegetative growth of lettuce plants and their quality by reducing the nitrate level. According to [48], the complete chemical analyses of moringa leaves showed high essential nutrients and vitamins as presented in Table (5).

Correlation among studied characters

Knowledge of the degree and direction of correlation among different traits of lettuce plants is of great importance. The estimates of correlation coefficients among all studied traits are presented in Table (6).

For fresh weight, it showed a significant and highly significant positive correlation with plant height chlorophyll, respectively in both seasons, but it showed a significant negative correlation with P (%) in both season and nitrate content in the second season only. Whereas, plant height had significant or highly significant positive correlation with all traits. Moreover, leaf length showed a highly significant positive correlation with leaf width in both seasons and only a significant positive correlation with leaf neck width, dry matter, chlorophyll and nitrate in the second season.

Concerning leaf width, data showed a significant positive correlation with leaf neck width, N (%), P (%), and nitrate in both seasons, but it showed a significant negative correlation with the dry matter in the first season. Whereas, leaf neck width had a highly significant positive correlation with N, P, K, and nitrate in both seasons while it had a significant negative correlation only with the chlorophyll in the second season.

As for dry matter, positive significant correlation coefficient estimates were found with chlorophyll (SPAD), N (%), K (%), and nitrate in the second season while chlorophyll showed a highly significant negative correlation with P (%) in both seasons.

Concerning P (%), it showed a highly significant or significantly positive correlation with K (%), and nitrate but K (%) had a significant correlation only with nitrate in both seasons.

5. Conclusion

From the previous results of this investigation, it could be concluded that fertilized lettuce plants with moringa seed cake (soil fertilizer application) and foliar spraying with of higher rate (10g/L) of moringa leaf extract were the superior treatments for producing the best values of vegetative growth parameters, fresh and dry weight per plant organs, and yield of lettuce plants as well the lowest nitrate content. These treatments also maintained chlorophyll and total NPK contents and gave lettuce plants with good appearance and healthy plants.

6. Conflicts of interest

There are no conflicts to declare.

Table (5): Analysis of moringa leaves.

Carbohydrate, %	38.2
Protein, %	27.1
P, mg/kg	2040
K, mg/kg	13240
Mg, mg/kg	3681
S, mg/kg	8700
Ca, mg/kg	20030
Zn, mg/kg	46
Mn, mg/kg	10.5
Fe, mg/kg	282
B, mg/kg	4.1
Cu, mg/kg	5.9
Vitamin A (Beta Carotene), mg/kg	163
Vitamin B1(Thiamin), mg/kg	26.4
Vitamin B2 (Riboflavin), mg/kg	206
Vitamin B3 (Niacin), mg/kg	82
Vitamin B6 (Pyridoxine), mg/kg	33
Vitamin C (Ascorbic Acid), mg/kg	163.5
Vitamin E (Tocopherol), mg/kg	92.3

Table (6): Estimates of correlation coefficients among each pair of studied traits in lettuce plants.

		Fresh weight	Plant height	Leaf length	Leaf width	Leaf neck width	Dry matter	Chlorophyll SPAD	N (%)	P (%)	K (%)	Nitrate (mg/kg)
Fresh weight	20/21	1.000										
	21/22	1.000										
Plant height	20/21	0.503*	1.000									
	21/22	0.570*	1.000									
Leaf length	20/21	0.241	0.848**	1.000								
	21/22	0.135	0.815**	1.000								
Leaf width	20/21	-0.114	0.678*	0.850**	1.000							
	21/22	-0.142	0.584*	0.852**	1.000							
Leaf neck width	20/21	0.162	0.575*	0.324	0.450*	1.000						
	21/22	-.062	0.563*	0.627*	0.649*	1.000						
Dry matter	20/21	0.140	0.282	0.006	-0.001	0.646*	1.000					
	21/22	0.759*	0.869**	0.503*	0.329	0.307	1.000					
Chlorophyll (SPAD)	20/21	0.936**	0.542*	0.352	0.017	0.133	0.044	1.000				
	21/22	0.704**	0.682*	0.524*	0.325	-0.075	0.731*	1.000				
N (%)	20/21	0.302	0.881**	0.927**	0.672*	0.314	0.211	0.397	1.000			
	21/22	0.118	0.7017*	0.147	0.652*	0.370	0.652*	0.602	1.000			
P (%)	20/21	-0.104	0.455*	0.354	0.586*	0.844**	0.214	-0.002	0.229	1.000		
	21/22	-0.010	0.532*	0.591*	0.742*	0.891**	0.326	-0.016	0.271	1.000		
K (%)	20/21	0.211	0.497*	0.271	0.422*	0.909**	0.330	0.243	0.175	0.930**	1.000	
	21/22	0.570	0.568*	0.237	0.128	0.618*	0.609*	0.098	0.058	0.655*	1.000	
Nitrate (mg/kg)	20/21	-0.082	0.606*	0.370	0.733*	0.825**	0.034	0.034	0.464	0.960**	0.685*	1.000
	21/22	-0.212	0.751*	0.703*	0.763*	0.844**	0.589*	0.262	0.479	0.946**	0.702*	1.000

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