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Response of Wheat Plants Grown on Alluvial and Sandy Soils to some Beneficial Elements.

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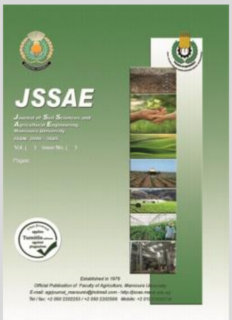

ABSTRACT

A pots experiment was executed aim to evaluate the influence of Co, Ni, Fe, Mo and B at different rates(0.0, 2.5, 5.0 and 10.0 mg L^{-1})with different application methods(foliar application and soil addition)on the performance of wheat plants grown on alluvial and sandy soils.Plant performance at periods of 30 and 60 days from sowing expressed in plant height, fresh and dry weights and N, P, K content in straw as well as the nutrient status of grains (N, P, K) and other characteristics at harvest stage *i.e.*, spike length and weight and No. of tillers $plant^{-1}$ were evaluated. The superior beneficial element was Ni compared to other studied elements, while Mo came in the second-order followed by Co then Fe and lately B. All studied elements, except B, caused improve plant performance which was enhanced as the added rate of these elements increased (either with foliar or soil additions).Regarding plants received B either with foliar or soil additions, the values of all studied traits significantly increased with increasing B rate from 0.0 mg L^{-1} to 2.5 and 5.0 mg L^{-1} and then significantly decrease at 10.0 mg L^{-1} due to appearing B toxicity. Foliar application method was most effective than soil addition method. Performance of plants grown on alluvial soil was better than that of plants grown on sandy soil. Generally, it can be concluded that Ni may have a vital role in N fixation more than other studied elements and this was reflected on wheat plant growth.

Keywords: Integrated fertilization, beneficial elements, B toxicity, wheat plants.

INTRODUCTION

A plant nutrient is an essential chemical element for higher plant growth and reproduction. The essential element is a term often used to identify a plant nutrient. The term nutrient implies essentiality, so it is redundant to call these elements essential nutrients (Barker and Pilbeam, 2015). Commonly, for an element to be a nutrient, it must fit certain criteria. The principal criterion is that the element must be required for a plant to complete its life cycle (Fageria, 2016).The second criterion is that no other element substitutes fully for the element being considered as a nutrient (Mishra *et al.*, 2020). The third criterion is that all plants require the element. All the elements that have been identified as plant nutrients (Tiwari *et al*., 2020), however, do not fully meet these criteria, so, some debate occurs regarding the standards for classifying an element as a plant nutrient.

Beneficial elements are not essential for plants, but when supplied they help promote their growth and development since they can stimulate mechanisms of resistance to biotic and abiotic stress factors, promote the use of other nutrients, and compensate or remedy the toxic effects of other elements (Barker, 2009). Beneficial elements can trigger response mechanisms in plants against environmental events *e.g.*, heavy metal toxicity, drought, low temperatures, and salt-affected soils, pest insects or pathogens (Broadley *et al.*, 2012).

On wheat plants, Gad and Kandil (2011) found that increasing cobalt concentration in plant media up to 15.0 mg L^{-1} possessed a promotive influence on seeds chemical constituents, while Rawashdeh and Sala (2015) found that wheat plants received 333.0 g Fe ha^{-1} produced the highest plant performance and grain yield compared to untreated plants. Beside, Kareem *et al.*, (2017) reported that application of molybdenum improved the performance of wheat plants under both well-watered and drought conditions On the other hand, Kumar *et al.*, (2018) showed a significant increase in performance of barley plants and grain yield with application of 10 mg Ni kg^{-1} soil. Also, Saleem *et al.*, (2020) found that foliar application of B at rate of 1.5% produced maximum biological yield (9.85 t ha^{-1}) and grain yield (4.72 t ha^{-1}) of wheat plants compared to all other studied B levels *i.e.*, 0.0, 0.5, 1.0, 2.0, 2.5, 3.0, 3.5 and 4%.

Wheat is the main winter cereal crop in all the world, where the properties of its kernel make it the leading cereal for human food (El-Ghamry *et al.*, 2016 and Salim and Raza, 2020). In Egypt, there is an urgent need for maximization of wheat crop production due to the local production isn't sufficient to equal the annual requirements (Kasim *et al.*, 2020). Moreover, total wheat consumption drastically increases due to overall population growth of about 2.5 % per year according to Economic Affairs Annual Report, (2017).

Therefore, the objective of this study is to evaluate the influence of some nutrients *i.e.*, Co, Ni, Fe, Mo and B on the performance of wheat plants grown on alluvial and

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sandy soils because of the importance of wheat as a strategic crop in Egypt as well as assess elements application methods and find out the best-added rate of these beneficial elements.

MATERIALS AND METHODS

1.Experimental site.

A pots trial was implemented at the Farm of Agricultural Faculty, Mansoura University, Egypt during growing season of 2019/20.

2.Soil sampling.

Two surface soil samples (0-25 cm) were collected, the 1st was from the experimental site to represent alluvial soil, while the 2nd sample was collected from Kalapshoo Village, Belqas District, Dakahlia Governorate, Egypt to represent the sandy soil. Both soils were analyzed according to Sparks *et al.,* (2020) and Dane and Topp (2020), where their characteristics are presented in Table1.

Table 1. Characteristics of both studied soils.

Soil type	Particle size distribution (%)				Texture class	FC	WP	SP	OM	$CaCO_3$	Available soil nutrients			EC, dSm^{-1}	pH^*
	C. Sand	F. Sand	Silt	Clay		(%)					N (mg kg^{-1})	P	K		
First soil (Alluvial)	1.89	22.0	26.6	49.51	Clay	35	17.50	70	1.20	2.29	45.95	7.10	210.1	3.25	7.92
Second soil (sandy)	4.2	86.3	2.7	6.8	Sand	15	7.5	30	0.30	1.00	25.5	4.2	105.6	1.10	7.81

*** pH (1:2.5 soil suspension).**

FC: Field capacity; WP: Wilting point; SP: Saturation and OM: Organic matter.

3.Experimental setup.

Pots experiment was carried out to assess the effect of some beneficial elements as main factor *i.e.,* Co (in form of cobalt sulphate), Ni (in form of nickel sulphate), Fe (in form of Fe-EDTA 12%Fe), Mo (in form of ammonium molybdate) and B (in form of calcium borate) with different application methods as sub main factor (foliar application and soil addition) at different rates (0.0, 2.5, 5.0 and 10.0 mg L^{-1}) as sub-sub main factor on the performance of wheat plants grown on alluvial and sandy soils.

The execution of the trail was done in a split-split-plot design with three replicates. Therefore, total number of pots under both studied soils separately was 120 as follows; 5 "beneficial elements" ×2 "application methods" × 4 "rates"× 3 "replicates ".

Plastic pots (30 cm diameter and 35 cm depth) were filled by air-dry soils equaled to 10 kg oven dry soil of both tested soils (alluvial and sandy).

Wheat grains (***Triticum aestivum* L. Cv Sods 14**) were obtained from Ministry of Agri. and Land Rec (MALR), where thirty grains were sown in each pot on November 16th then thinning process to 20 plants pot^{-1} was done after 20 days from sowing.

Three weeks before sowing, all pots found in the experimental site received organic fertilizer in a single application at rate of 40.0 g pot^{-1} then mixed and irrigated after adding as well as all pots received calcium superphosphate (6.6%P) at a rate of 1.0 g pot^{-1} for both studied soils.

All beneficial elements were purchased from El-Gamhoria Company, Egypt then their solutions with investigated rates were prepared, where the addition (either foliar or soil) was executed after thinning immediately. Foliar application and soil addition of the studied beneficial elements were done at periods of 21, 28, and 35 days from sowing. The normal agricultural practices as well as mineral fertilization and irrigation process were done for the wheat production according to MALR. Ammonium nitrate (33.5 %N) was applied in one dose at 20 days from sowing after thinning process at rate of 100 kg N fed^{-1} for wheat cultivated in pots contains alluvial soil and 130 kg N fed^{-1} for wheat cultivated in pots contains sandy soil. Potassium sulfate (48 % K_2O) was applied for both soils at rate of 50 kg fed^{-1} with N-fertilizer dose. The irrigation process was done using Nile River, as the wheat plants required. Harvest process was done on 11th of March.

4.Measurements traits.

At periods of 30 and 60 days from sowing.

Random samples of five wheat plants were taken from each pot to determine the following criteria.

- Plant height (cm).
- Leaves fresh and dry weights (g $plant^{-1}$).
- Total N, P and K in wheat straw were determined using Kjeldahl method, spectrophotomitrically and flam photometer, respectively by completely wet digested according to Walinga *et al*., (2013), where the oven-dried wheat leaves were ground and then were digested by a mixture of and perchloric and sulfuric acids (1:1) (Peterburgski,1968).

At harvest stage (115 days from sowing).

Random samples of five wheat plants were taken from each pot to determine the following traits.

- Spike length (cm).
- Spike Weight (g).
- No. of tillers $plant^{-1}$.
- N, P and K contents (%) of wheat grains was determined as formerly mentioned in wheat straw at periods of 30 and 60 days.

5. Statistical analysis.

It was executed according to Gomez and Gomez,(1984).

RESULTS AND DISCUSSION

1. Performance at periods of 30 and 60 days from sowing.

Data of Tables from 2 to 9 show the impact of the beneficial elements *i.e.,* Co, Ni, Fe, Mo and B applied with different application methods (foliar application and soil addition) at different rates (0.0, 2.5, 5.0 and 10.0 mg L^{-1}) on the performance of wheat plants grown on alluvial soil (Tables 2,3,4,5) and sandy soil (Tables 6,7,8,9) during growing season of 2019/20.

Alluvial soil condition.

Individual effect

All studied beneficial elements significantly affected plant performance at periods of 30 and 60 days from sowing expressed in plant height (cm), fresh and dry weights (g plant^{-1}) (Table 2), contents of N, P, K in straw (%) (Table 3), where the highest values of these traits were recorded when wheat plants were treated with Ni element, while the values of plants treated with Mo came in the second-order followed by the values of plants treated with Co then the values of plants treated with Fe and lately the values of plants treated with B.

Also, Tables 2 and 3 illustrate that application of all studied beneficial elements as foliar application was most effective than as soil addition.

The same Tables indicate that the values of all aforementioned traits increased as the added rate of the studied beneficial elements increased.

Table 2. Individual effect of investigated treatments on growth parameters of wheat plants at periods of 30 and 60 days from sowing under alluvial soil condition during growing season of 2019/20.

Treatments	Plant height, cm		Fresh weight, g plant^{-1}		Dry weight, g plant^{-1}	
	30 days	60 days	30 days	60 days	30 days	60 days
Beneficial elements						
Cobalt (Co)	26.12c	37.46c	12.40c	15.51c	3.09c	6.71c
Nickel (Ni)	29.18a	41.79a	14.12a	17.07a	3.77a	8.11a
Iron (Fe)	24.42d	35.38d	11.43d	14.92d	2.77d	6.18d
Molybdenum (Mo)	27.50b	39.75b	13.32b	16.31b	3.41b	7.41b
Boron (B)	22.63e	32.62e	10.62e	14.36e	2.46e	5.62e
LSD at 5%	0.12	0.12	0.08	0.13	0.03	0.07
Addition methods						
Foliar	26.19a	37.71a	12.51a	15.70a	3.14a	6.88a
Soil	25.74b	37.09b	12.25b	15.57b	3.05b	6.74b
LSD at 5%	0.15	0.11	0.06	0.08	0.01	0.02
Application rates						
0.0 mg L^{-1}	22.02c	32.13c	10.19c	14.06c	2.38c	5.43c
2.5 mg L^{-1}	26.81b	38.55b	12.79b	15.94b	3.24b	7.09b
5.0 mg L^{-1}	27.50a	39.49a	13.29a	16.28a	3.38a	7.35a
10.0 mg L^{-1}	27.53a	39.43a	13.24a	16.27a	3.38a	7.36a
LSD at 5%	0.18	0.23	0.09	0.12	0.03	0.05

Table 3. Individual effect of investigated treatments on chemical constituents in straw of wheat plants at periods of 30 and 60 days from sowing under alluvial soil condition during growing season of 2019/20.

Treatments	N, %		P,%		K, %	
	30 days	60 days	30 days	60 days	30 days	60 days
Beneficial elements						
Cobalt (Co)	1.80c	2.42c	0.244c	0.288c	1.99c	2.14c
Nickel (Ni)	2.09a	2.87a	0.280a	0.338a	2.36a	2.66a
Iron (Fe)	1.52d	2.23d	0.225d	0.255d	1.82d	1.85d
Molybdenum (Mo)	1.94b	2.62b	0.262b	0.310b	2.17b	2.48b
Boron (B)	1.30e	2.08e	0.205e	0.217e	1.65e	1.47e
LSD at 5%	0.01	0.06	0.002	0.003	0.02	0.09
Addition methods						
Foliar	1.76a	2.48a	0.245a	0.285a	2.02a	2.15a
Soil	1.70b	2.41b	0.241b	0.278b	1.98b	2.09b
LSD at 5%	0.02	0.05	0.001	0.001	0.02	0.04
Application rates						
0.0 mg L^{-1}	1.29c	1.97c	0.202c	0.209d	1.59c	1.41c
2.5 mg L^{-1}	1.82b	2.52b	0.251b	0.298c	2.08b	2.25b
5.0 mg L^{-1}	1.90a	2.63a	0.261a	0.311a	2.16a	2.42a
10.0 mg L^{-1}	1.91a	2.66a	0.259a	0.308b	2.16a	2.41a
LSD at 5%	0.02	0.06	0.002	0.002	0.03	0.06

Interaction effect

Interaction effect among investigated treatments on growth parameters *i.e.,* plant height (cm), fresh and dry weights (g plant^{-1}) (Table 4) and chemical constituents in straw of wheat plants *i.e.,* N, P, K (%) (Table 5) at periods of 30 and 60 days from sowing was significant.

The highest values of all aforementioned traits were recorded when plants were treated with Ni element as foliar application at rate of 10 mg L^{-1}.

Under all studied beneficial elements, except B element, the highest values of above-mentioned traits were recorded when plants were treated with beneficial element as foliar application at rate of 10 mg L^{-1}, while the lowest values were realized with untreated plants.

Regarding B element, the highest values were recorded when plants were treated with B element as foliar application at rate of 5.0 mg L^{-1}, while the lowest values were realized when plants were treated with B element as either foliar or soil application at rate of 10.0 mg L^{-1}. On other words, the values of all studied traits for plants received B either with foliar or soil additions significantly increased with increasing B rate from 0.0 mg L^{-1} to 2.5 and 5.0 mg L^{-1} and then significantly decrease at 10.0 mg L^{-1} due to appearing B toxicity.

The superiority of Ni compared to other studied elements may be due to it has a vital role in N fixation more than other studied elements and this is reflected on wheat plant growth and nutrient status *e.g.,* N, P and K. Ni is a nutrient required for plants' metabolism because of its role as a structural component of urease and hydrogenase, which in turn perform nitrogen metabolism in many plant species as well as Ni is a functional constituent of eight enzymes as mentioned by Ragsdale, (2009). The findings are in accordance with those of Singh and Rao (2008) who reported that Ni should be used as an additional micronutrient to improve the performance of pulse crops that are dependent on biologically fixed N. Beside, Lavres *et al.*,(2016) who found that treating soybean seed with Ni Improved biological N fixation and urease activity. Also, Kumar *et al., (*2018) suggested that Ni addition positively affected growth and nutrient status of barley plants. Uruç-Parlak, (2016) also reported that the increase in growth parameters and chemical constitutes of wheat plants was due to the vital role of Ni in enhancing the physiological processes, to overcome the urgent need for nutrients.

While superiority of Mo compared to Co, Fe and B may be also due to its role in N fixation in addition to its essential role in protein synthesis and N metabolism in plants (Naqib and Jahan, 2017). During symbiotic N fixation, Mo acts as a cofactor for nitrogenase enzymes to catalyze the redox reaction to convert elemental N into ammonium (NH_4^+) ions (Darnajoux *et al.,* 2017). Also, it is required for the synthesis and activity of the enzyme nitrate reductase (Abbasifar *et al.,* 2020). Our results are in harmony with those of Kareem *et al.,* (2017) who found that Mo improved the performance of wheat under well watered and drought conditions. On the contrary, the present results disagree with those found by Imran *et al.,* (2019) who illustrated that Mo application hadn't a significant effect on the mineral elements contents in the winter wheat leaves.

As for Co element, its superiority compared to Fe and B may be attributed to its role in N fixation as mentioned by El- Sherpiny *et al.,* (2021) in addition to its critical role in the overall growth process of plants as mentioned by Gad *et al.,* (2019) as well as its role in the production of ethylene by plants as mentioned by Akeel and Jahan (2020).

Generally, cobalt application gave more vigorous plant growth as a visual score and the best chemical content in wheat leaves compared to the application of Fe and B and this may be due to the effective role of Coin increasing and stimulating wheat plant growth in different physiological stages. The data go in the same line with data found by Gad and Kandil (2011) and Atiia *et al.,* (2016)

Regarding Fe element, its superiority compared to B may be attributed to its critical role in metabolic processes *e.g.,* DNA synthesis, respiration and photosynthesis in addition to its vital role in the synthesis of chlorophyll which is important for the maintenance of chloroplast structure and function (Rout and Sahoo, 2015 and El Hadidi *et al.,* 2020). Our results in agreement with those of Ghafari and Razmjoo (2013) who confirmed that different forms iron (Nano-iron oxidase, iron chelate and iron sulphate) possessed positive effect on wheat plant performance.

Concerning B element, it is known that the range of deficiency and toxicity level is narrow. So, plants received B significantly increased with increasing B rate from 0.0 mg L^{-1} to 2.5 and 5.0 mg L^{-1} and then significantly decrease at 10.0 mg L^{-1} due to appearing B toxicity as mentioned by El-Sherpiny, (2016) who found that increasing b level from zero to 1, 2 and 3 mg L^{-1} in irrigation water negatively affected barley fresh and dry weights and general performance under sandy and alluvial conditions. On the other hand , it is known also that B possesses an essential role in a diverse range of plant functions *e.g.,* pollination, seed set, movement of sugar or energy into growing parts of plants, cell wall formation and stability and maintenance of structural and functional integrity of biological membranes(El Hadidi *et al.,* 2020). El-Ghamry *et al.,* (2016) reported that B application to wheat plants positively affected.

Table 4. Interaction effect among investigated treatments on growth parameters of wheat plants at periods of 30 and 60 days from sowing under alluvial soil condition during growing season of 2019/20.

Treatments			Plant height, cm		Fresh weight, g $plant^{-1}$		Dry weight, g $plant^{-1}$	
			30 days	60days	30 days	60days	30 days	60days
Co	Foliar	0.0 mg L^{-1}	22.07	32.17	10.19	14.05	2.39	5.44
		2.5 mg L^{-1}	26.97	38.73	12.89	15.88	3.22	6.97
		5.0 mg L^{-1}	27.93	40.00	13.70	16.08	3.45	7.23
		10.0 mg L^{-1}	28.17	40.57	13.74	16.32	3.53f	7.49
	Soil	0.0 mg L^{-1}	22.00	32.07	10.21	14.03	2.37	5.45
		2.5 mg L^{-1}	27.13	37.97	12.46	15.70	3.20	6.89
		5.0 mg L^{-1}	27.07	38.80	12.92	15.98	3.24	7.09
		10.0 mg L^{-1}	27.60	39.37	13.10	16.07	3.33	7.13
Ni	Foliar	0.0 mg L^{-1}	22.03	32.10	10.21	14.06	2.39	5.43
		2.5 mg L^{-1}	31.07	44.43	15.00	17.81b	4.21	8.79
		5.0 mg L^{-1}	32.20	45.70	15.76	18.18	4.29	9.09
		10.0 mg L^{-1}	32.47	45.80	16.21	18.71	4.36	9.48
	Soil	0.0 mg L^{-1}	21.97	32.27	10.22	14.05	2.37	5.43
		2.5 mg L^{-1}	30.57	44.13	14.65	17.62	4.03	8.67
		5.0 mg L^{-1}	31.20	44.87	15.28	18.07	4.22	8.94
		10.0 mg L^{-1}	31.90	45.03	15.64	18.08	4.26	9.02
Fe	Foliar	0.0 mg L^{-1}	22.10	32.07	10.18	14.06	2.37	5.43
		2.5 mg L^{-1}	24.90	35.67	11.56	14.99	2.76	6.23
		5.0 mg L^{-1}	25.77	37.20	12.11	15.30	3.07	6.53
		10.0 mg L^{-1}	26.10	37.67	12.27	15.65	3.13	6.74
	Soil	0.0 mg L^{-1}	22.07	32.27	10.16	14.01	2.38	5.43
		2.5 mg L^{-1}	24.17	35.07	11.49	14.90	2.74	6.17
		5.0 mg L^{-1}	24.90	36.10	11.78	15.19	2.84	6.44
		10.0 mg L^{-1}	25.37	36.97	11.93	15.28	2.87	6.44
Mo	Foliar	0.0 mg L^{-1}	21.97	32.10	10.17	14.09	2.37	5.43
		2.5 mg L^{-1}	28.80	41.90	14.20	16.61	3.60	7.78
		5.0 mg L^{-1}	29.80	43.00	14.54	17.37d	3.80	8.28
		10.0 mg L^{-1}	30.37	43.57	14.65	17.37d	4.01	8.51
	Soil	0.0 mg L^{-1}	21.97	32.03	10.15	14.10	2.37	5.41
		2.5 mg L^{-1}	28.17	41.03	13.81	16.52	3.60	7.60
		5.0 mg L^{-1}	29.30	41.97	14.50	17.09	3.70	8.02
		10.0 mg L^{-1}	29.60	42.37	14.51	17.32	3.79	8.26
B	Foliar	0.0 mg L^{-1}	22.13	32.20	10.22	14.06	2.40	5.43
		2.5 mg L^{-1}	23.50	33.90	11.08	14.76	2.62	5.98
		5.0 mg L^{-1}	23.77	34.37	11.36	14.86	2.67	6.00
		10.0 mg L^{-1}	21.77	31.07	10.13	13.89	2.25	5.23
	Soil	0.0 mg L^{-1}	21.93	32.00	10.19	14.06	2.39	5.44
		2.5 mg L^{-1}	22.80	32.67	10.72	14.62	2.49	5.77
		5.0 mg L^{-1}	23.10	32.87	10.95	14.69	2.53	5.82
		10.0 mg L^{-1}	22.00	31.90	10.27	13.98	2.32	5.31
LSD at 5%			0.59	0.74	0.29	0.38	0.08	0.17

Table 5. Interaction effect among investigated treatments on chemical constituents in straw of wheat plants at periods of 30 and 60 days from sowing under alluvial soil condition during growing season of 2019/20.

Treatments			N, %		P,%		K, %	
			30 days	60days	30 days	60days	30 days	60days
Co	Foliar	0.0 mg L^{-1}	1.29	1.97	0.202	0.209	1.60	1.37
		2.5 mg L^{-1}	1.93	2.48	0.252	0.309	2.07	2.28
		5.0 mg L^{-1}	2.02	2.66	0.265	0.320	2.13	2.54
		10.0 mg L^{-1}	2.06	2.68	0.266	0.328	2.22	2.57
	Soil	0.0 mg L^{-1}	1.27	1.96	0.202	0.208	1.60	1.38
		2.5 mg L^{-1}	1.87	2.45	0.247	0.301	2.05	2.20
		5.0 mg L^{-1}	1.96	2.54	0.256	0.315	2.13	2.37
		10.0 mg L^{-1}	1.98	2.64	0.260	0.315	2.12	2.45
Ni	Foliar	0.0 mg L^{-1}	1.29	1.97	0.202	0.209	1.58	1.36
		2.5 mg L^{-1}	2.32	3.11	0.305	0.378	2.57	2.99
		5.0 mg L^{-1}	2.41	3.23	0.310	0.383	2.6	3.17
		10.0 mg L^{-1}	2.42	3.29	0.314	0.391	2.75	3.24
	Soil	0.0 mg L^{-1}	1.30	1.97	0.202	0.209	1.59	1.37
		2.5 mg L^{-1}	2.29	3.00	0.297	0.370	2.51	2.95
		5.0 mg L^{-1}	2.32	3.18	0.305	0.380	2.60	3.07
		10.0 mg L^{-1}	2.37	3.19	0.307	0.381	2.62	3.15
Fe	Foliar	0.0 mg L^{-1}	1.31	1.96	0.202	0.209	1.60	1.36
		2.5 mg L^{-1}	1.49	2.25	0.225	0.256	1.83	1.88
		5.0 mg L^{-1}	1.68	2.34	0.241	0.286	1.94	2.09
		10.0 mg L^{-1}	1.86	2.44	0.245	0.293	2.02	2.18
	Soil	0.0 mg L^{-1}	1.29	1.97	0.202	0.208	1.58	1.37
		2.5 mg L^{-1}	1.45	2.24	0.223	0.254	1.82	1.84
		5.0 mg L^{-1}	1.52	2.31	0.228	0.266	1.90	2.01
		10.0 mg L^{-1}	1.58	2.34	0.234	0.267	1.90	2.07
Mo	Foliar	0.0 mg L^{-1}	1.30	1.98	0.202	0.208	1.60	1.36
		2.5 mg L^{-1}	2.12	2.77	0.273	0.333f	2.28	2.71
		5.0 mg L^{-1}	2.20	2.92	0.292	0.356	2.43	2.86
		10.0 mg L^{-1}	2.23	2.94	0.296	0.364	2.46	2.93
	Soil	0.0 mg L^{-1}	1.29	1.96	0.202	0.207	1.57	1.80
		2.5 mg L^{-1}	2.10	2.73	0.271d	0.332	2.26	2.64
		5.0 mg L^{-1}	2.14	2.78	0.281	0.339	2.35	2.76
		10.0 mg L^{-1}	2.17	2.92	0.282	0.344	2.41	2.80
B	Foliar	0.0 mg L^{-1}	1.29	1.97	0.202	0.209	1.59	1.37
		2.5 mg L^{-1}	1.37	2.14	0.211	0.230	1.73	1.66
		5.0 mg L^{-1}	1.41	2.20	0.217	0.240	1.76n	1.75
		10.0 mg L^{-1}	1.18	2.27	0.192	0.198	1.56	1.31
	Soil	0.0 mg L^{-1}	1.27	1.97	0.202	0.209	1.59	1.37
		2.5 mg L^{-1}	1.30	2.06	0.205	0.221	1.70	1.40
		5.0 mg L^{-1}	1.34	2.10	0.212	0.225	1.72	1.54
		10.0 mg L^{-1}	1.24	1.94	0.197	0.202	1.57	1.36
LSD at 5%			0.07	0.19	0.006	0.007	0.08	0.20

Also, it can be noticed that application of all studied beneficial elements as foliar application was most effective than as soil addition and this may be attributed to the high efficiency of foliar application method compared to soil addition method, where the foliar application method could reduce the lag time between application and uptake by the wheat plants (Ghazi *et al.*, 2021).

Sandy soil condition.

Individual effect

Under sandy condition, all studied beneficial elements *i.e.*, Ni, Mo, Co, Fe and B significantly affected plant height (cm), fresh and dry weights (g $plant^{-1}$) (Table 6) and N, P, K contents in straw (%) (Table 7) at periods of 30 and 60 days from sowing, where the superior treatment was Ni element followed by Mo, Co, Fe and B elements ,respectively. Also, the same Tables illustrate that application of all studied beneficial elements as foliar application was most effective than as soil addition as well as the values of all aforementioned traits increased as the added rate of the studied beneficial elements increased.

Generally, it can be noticed that the trend under alluvial conditions looked just like that under the alluvial condition but the performance of wheat plants grown on alluvial soil was better than that of plants grown on sandy soil and this attributed to the low content of nutrients and O.M in sandy soil compared to alluvial soil which has a high content of nutrients and O.M (Table 1). Similar results were investigated by El- Sherpiny, (2016).

Interaction effect

Concerning interaction effect, growth parameters *i.e.,* plant height (cm), fresh and dry weights (g $plant^{-1}$) (Table 8) and chemical constituents in straw of wheat plants *i.e.,* N, P, K (%) (Table 9) at periods of 30 and 60 days from sowing significantly affected due to the combination among studied treatments, where the highest values of all aforementioned traits were recorded when plants were treated with Ni element as foliar application at rate of 10 mg L^{-1}.

On the other hand, under all studied beneficial elements, except B element, the highest values of above-mentioned traits were recorded when plants were treated with beneficial element as foliar application at rate of 10 mg L^{-1}, while the lowest values were realized with untreated plants.

Table 6. Individual effect of investigated treatments on growth parameters of wheat plants at periods of 30 and 60 days from sowing under sandy soil condition during growing season of 2019/20.

Treatments	Plant height, cm		Fresh weight, g plant^{-1}		Dry weight, g plant^{-1}	
	30 days	60 days	30 days	60 days	30 days	60 days
Beneficial elements						
Cobalt (Co)	25.07c	36.14c	10.85c	13.94c	2.72c	6.03c
Nickel (Ni)	28.24a	40.32a	12.59a	15.11a	3.31a	7.16a
Iron (Fe)	23.62d	34.15d	10.06d	13.33d	2.43d	5.48d
Molybdenum (Mo)	26.57b	38.36b	11.81b	14.54b	3.00b	6.62b
Boron (B)	21.87e	31.45e	9.22e	12.71e	2.12e	4.99e
LSD at 5%	0.11	0.14	0.04	0.10	0.03	0.08
Addition methods						
Foliar	25.29a	36.33a	11.02a	14.00a	2.75a	6.12a
Soil	24.86b	35.84b	10.79b	13.84b	2.68b	6.00b
LSD at 5%	0.11	0.13	0.04	0.04	0.01	0.04
Application rates						
0.0 mg L^{-1}	21.42c	31.01c	9.15c	12.61c	2.06c	4.90c
2.5 mg L^{-1}	25.82b	37.15b	11.24b	14.16b	2.85b	6.27b
5.0 mg L^{-1}	26.53a	38.14a	11.63a	14.45a	2.97a	6.53a
10.0 mg L^{-1}	26.52a	38.04a	11.62a	14.47a	2.98a	6.54a
LSD at 5%	0.17	0.27	0.05	0.10	0.02	0.05

Table 7. Individual effect of investigated treatments on chemical constituents in straw of wheat plants at periods of 30 and 60 days from sowing under sandy soil condition during growing season of 2019/20.

Treatments	N, %		P,%		K, %	
	30 days	60 days	30 days	60 days	30 days	60 days
Beneficial elements						
Cobalt (Co)	1.76c	2.15c	0.230c	0.273c	1.79c	1.90c
Nickel (Ni)	2.05a	2.54a	0.266a	0.319a	2.08a	2.37a
Iron (Fe)	1.49d	1.99d	0.212d	0.241d	1.63d	1.65d
Molybdenum (Mo)	1.90b	2.32b	0.248b	0.295b	1.94b	2.15b
Boron (B)	1.27e	1.81e	0.194e	0.205e	1.47e	1.31e
LSD at 5%	0.03	0.02	0.002	0.003	0.02	0.02
Addition methods						
Foliar	1.72a	2.18a	0.232a	0.270a	1.80a	1.91a
Soil	1.67b	2.14b	0.228b	0.263b	1.76b	1.84b
LSD at 5%	0.01	0.01	0.002	0.003	0.01	0.01
Application rates						
0.0 mg L^{-1}	1.25d	1.75d	0.190d	0.198d	1.44d	1.22d
2.5 mg L^{-1}	1.79c	2.24c	0.238c	0.283c	1.85c	2.00c
5.0 mg L^{-1}	1.86b	2.33a	0.246a	0.293a	1.92a	2.15b
10.0 mg L^{-1}	1.88a	2.32a	0.246a	0.293a	1.92a	2.13a
LSD at 5%	0.01	0.02	0.002	0.003	0.01	0.01

Table 8. Interaction effect among investigated treatments on growth parameters of wheat plants at periods of 30 and 60 days from sowing under sandy soil condition during growing season of 2019/20.

Treatments			Plant height, cm		Fresh weight, g plant^{-1}		Dry weight, g plant^{-1}	
			30 days	60days	30 days	60days	30 days	60days
Co	Foliar	0.0 mg L^{-1}	21.40	30.97	9.15	12.63	2.06	4.90
		2.5 mg L^{-1}	25.90	37.20	11.14	14.20	2.85	6.22
		5.0 mg L^{-1}	26.87	38.50	11.83	14.62	3.03	6.57
		10.0 mg L^{-1}	27.17	39.07	11.95	14.68	3.12	6.76
	Soil	0.0 mg L^{-1}	21.21	31.03	9.11	12.61	2.06	4.88
		2.5 mg L^{-1}	25.50	36.70	10.93	14.03	2.81	6.16
		5.0 mg L^{-1}	26.13	37.47	11.25	14.27	2.92	6.34
		10.0 mg L^{-1}	26.40	38.20	11.46	14.48	2.95	6.42
Ni	Foliar	0.0 mg L^{-1}	21.63	31.13	9.22	12.57	2.05	4.87
		2.5 mg L^{-1}	29.97	42.77	13.53	15.75	3.66	7.80
		5.0 mg L^{-1}	31.00	44.30	13.94	16.06	3.80	8.04
		10.0 mg L^{-1}	31.40	43.93	14.12	16.43	3.89	8.17
	Soil	0.0 mg L^{-1}	21.43	30.90	9.12	12.62	2.04	4.90
		2.5 mg L^{-1}	29.60	42.60	13.33	15.59	3.57	7.68
		5.0 mg L^{-1}	30.20	43.40	13.63	15.84	3.70	7.86
		10.0 mg L^{-1}	30.67	43.53	13.85	16.00	3.77	7.99
Fe	Foliar	0.0 mg L^{-1}	21.60	31.13	9.19	12.63	2.07	4.89
		2.5 mg L^{-1}	23.90	34.40r	10.13	13.38	2.44	5.22
		5.0 mg L^{-1}	24.77	35.77	10.58	13.78	2.65	5.87
		10.0 mg L^{-1}	25.20	36.40	10.85	13.97	2.72	6.03
	Soil	0.0 mg L^{-1}	21.53	31.10	9.10	12.58	2.07	4.90
		2.5 mg L^{-1}	23.40	33.77	9.92	13.20	2.40	5.47
		5.0 mg L^{-1}	24.07	35.00	10.23	13.44	2.51	5.70
		10.0 mg L^{-1}	24.50	35.60	10.44	13.64	2.56	5.76
Mo	Foliar	0.0 mg L^{-1}	21.20	30.93	9.15	12.66	2.07	4.91
		2.5 mg L^{-1}	28.03	40.27	12.36	14.95f	3.24	7.00
		5.0 mg L^{-1}	28.80	41.40	13.00	15.36	3.36	7.34
		10.0 mg L^{-1}	29.27	41.93	13.21	15.54	3.52	7.61
	Soil	0.0 mg L^{-1}	21.30	31.07	9.17	12.62	2.06	4.90
		2.5 mg L^{-1}	27.37	39.63	12.22	14.87	3.16	6.86
		5.0 mg L^{-1}	28.20	40.60	12.62	15.12	3.27	7.09
		10.0 mg L^{-1}	28.40	41.07	12.74	15.21	3.33	7.24
B	Foliar	0.0 mg L^{-1}	21.23	30.93	9.14	12.59	2.06	4.91
		2.5 mg L^{-1}	22.57	32.53	9.56	12.93	2.26	5.25
		5.0 mg L^{-1}	22.90	33.07	9.77	13.13	2.31	5.33
		10.0 mg L^{-1}	21.00	30.00	8.66	12.30	1.92	4.63
	Soil	0.0 mg L^{-1}	21.63	30.90	9.12	12.61	2.05	4.89
		2.5 mg L^{-1}	22.00	31.60	9.24	12.71	2.15	5.03
		5.0 mg L^{-1}	22.40	31.90	9.43	12.89	2.18	5.10
		10.0 mg L^{-1}	21.20	30.67	8.86	12.48	2.00	4.75
LSD at 5%			0.55	0.86	0.15	0.32	0.06	0.16

Table 9. Interaction effect among investigated treatments on chemical constituents in straw of wheat plants at periods of 30 and 60 days from sowing under sandy soil condition during growing season of 2019/20.

Treatments			N, %		P,%		K, %	
			30 days	60days	30 days	60days	30 days	60days
Co	Foliar	0.0 mg L^{-1}	1.26	1.76	0.191	0.198	1.44	1.22
		2.5 mg L^{-1}	1.88	2.23	0.238	0.292	1.85	2.05
		5.0 mg L^{-1}	1.97	2.35	0.251	0.303	1.94	2.25
		10.0 mg L^{-1}	2.02	2.37	0.254	0.314	2.00	2.27
	Soil	0.0 mg L^{-1}	1.25	1.74	0.190	0.198	1.43	1.22
		2.5 mg L^{-1}	1.87	2.19	0.234	0.285	1.83	1.96
		5.0 mg L^{-1}	1.92	2.25	0.240	0.295	1.90	2.10
		10.0 mg L^{-1}	1.93k	2.32	0.246	0.298	1.91	2.15
Ni	Foliar	0.0 mg L^{-1}	1.25	1.75	0.191	0.198	1.44	1.21
		2.5 mg L^{-1}	2.28	2.75	0.286	0.357	2.27	2.64
		5.0 mg L^{-1}	2.36	2.89	0.296	0.356	2.34	2.83
		10.0 mg L^{-1}	2.39	2.91	0.300	0.374	2.37	2.88
	Soil	0.0 mg L^{-1}	1.26	1.75	0.190	0.196	1.44	1.23t
		2.5 mg L^{-1}	2.25	2.68	0.281	0.349	2.22	2.63
		5.0 mg L^{-1}	2.29	2.81	0.289	0.360	2.28	2.72
		10.0 mg L^{-1}	2.34	2.82	0.294	0.364	2.32	2.79
Fe	Foliar	0.0 mg L^{-1}	1.25	1.74	0.191	0.197	1.44	1.22
		2.5 mg L^{-1}	1.46	2.01	0.213	0.242	1.63	1.68
		5.0 mg L^{-1}	1.65	2.11n	0.226	0.267	1.75	1.88
		10.0 mg L^{-1}	1.83	2.16	0.232	0.277	1.80	1.93
	Soil	0.0 mg L^{-1}	1.26	1.76	0.190	0.198	1.43	1.23
		2.5 mg L^{-1}	1.43	2.00	0.209	0.238	1.61	1.64
		5.0 mg L^{-1}	1.50	2.08	0.216	0.252	1.68	1.81
		10.0 mg L^{-1}	1.55	2.09	0.222	0.254	1.70	1.85
Mo	Foliar	0.0 mg L^{-1}	1.25	1.74	0.187	0.199	1.45	1.23
		2.5 mg L^{-1}	2.07	2.43	0.261	0.319	2.05	2.38
		5.0 mg L^{-1}	2.14	2.55	0.273	0.334	2.15	2.56
		10.0 mg L^{-1}	2.23	2.60	0.280	0.345	2.20	2.59
	Soil	0.0 mg L^{-1}	1.24	1.76	0.191	0.197	1.44	1.23
		2.5 mg L^{-1}	2.04	2.42	0.259	0.317	2.04	2.34
		5.0 mg L^{-1}	2.09	2.47	0.266	0.321	2.09	2.44
		10.0 mg L^{-1}	2.12	2.56	0.268	0.326	2.11	2.46
B	Foliar	0.0 mg L^{-1}	1.24	1.74	0.190	0.197	1.45	1.21
		2.5 mg L^{-1}	1.34	1.91	0.202	0.220	1.52	1.48
		5.0 mg L^{-1}	1.39	1.94	0.206	0.227	1.56	1.55
		10.0 mg L^{-1}	1.16	1.69	0.180	0.185	1.38	1.15
	Soil	0.0 mg L^{-1}	1.25	1.75	0.191	0.198	1.44	1.23
		2.5 mg L^{-1}	1.28	1.84	0.194	0.209	1.50	1.25
		5.0 mg L^{-1}	1.32	1.89	0.200	0.212	1.51	1.39
		10.0 mg L^{-1}	1.21	1.72	0.186	0.190	1.40	1.20
LSD at 5%			0.04	0.05	0.008	0.009	0.03	0.05

Regarding B element, the highest values were recorded when plants were treated with B element as foliar application at rate of 5.0 mg L^{-1}, while the lowest values were realized when plants were treated with B element as either foliar or soil application at rate of 10.0 mg L^{-1}. On other words, the values of all studied traits for plants received B either with foliar or soil additions significantly increased with increasing B rate from 0.0 mg L^{-1} to 2.5 and 5.0 mg L^{-1} and then significantly decrease at 10.0 mg L^{-1} due to appearing B toxicity. The difference among the studied elements in the nutrition of wheat plants was discussed above. The obtained results were discussed above and agree with those of Ghafari and Razmjoo (2013); Uruç-Parlak, (2016) and Imran *et al.*, (2019).

1.Spike traits at period of 115 days from sowing.

Tables 10, 11, 12 and 13 illustrate the influence of the studied beneficial elements applied with different application methods and different rates on the spike physical traits and chemical constituents in grains of wheat plants grown on alluvial soil (Tables 10 and 11) and sandy soil (Tables 12 and 13) at period of 115 days from sowing.

Alluvial soil condition.

Individual effect

It is clear from data shown in Table 10 that physical and chemical traits of wheat plants *i.e.*, spike length (cm) and weight (g), No. of tillers plant^{-1} and nutrient status of grains (N, P, K,%) at harvest stage were significantly affected as a result of studied beneficial elements, where the sequence order of studied elements from the most effective to the less was as follows;

Ni element > Mo element > Co element > Fe element > B element.

Also, application of all studied beneficial elements as foliar application recorded values of spike length (cm) and weight (g), No. of tillers plant^{-1} and chemical content in grains (N, P, K,%) better than that under soil addition method.

Increasing growth parameters because of the increasing added rate of the studied elements was reflected on studied physical and chemical traits of wheat plants at the harvest stage, where the values of all aforementioned traits increased as the added rate of the studied beneficial elements increased.

Interaction effect

Table 11 shows the interaction effect among investigated treatments on physical and chemical traits of wheat plants *i.e.*, spike length (cm) and weight (g), No. of tillers plant^{-1} and nutrient status of grains (N, P, K, %) at harvest stage**,** where the trend of wheat performance at harvest stage looked exactly like the trend at periods of 30 and 60 days. In other words, the highest values of spike length (cm) and weight (g), No. of tillers plant^{-1} and nutrient status of grains (N, P, K, %) were recorded when plants were treated with Ni element as a foliar application at a rate of 10 mg L^{-1}.

Except for B element, the highest values of studied traits at the harvest stage for wheat plants treated with other studied beneficial elements were recorded when plants were treated with the beneficial elements as a foliar application at a rate of 10 mg L^{-1}, while the lowest values were realized with untreated plants.

Regarding B element, the data of the same Table indicate that the highest values of studied traits *i.e.,* spike length (cm) and weight (g), No. of tillers plant^{-1} and nutrient status of grains (N, P, K, %) at harvest stage were recorded when plants were treated with B element as foliar application at rate of 5.0 mg L^{-1}, while the lowest values were realized when plants were treated with B element as either foliar or soil application at rate of 10.0 mg L^{-1}. In other words, the values of all studied traits for plants received B either with foliar or soil additions significantly increased with increasing B rate from 0.0 mg L^{-1} to 2.5 and 5.0 mg L^{-1} and then significantly decrease at 10.0 mg L^{-1} due to appearing B toxicity.

Table 10. Individual effect of investigated treatments on spike physical traits and chemical constituents in grains of wheat plants at period of 115 days from sowing under alluvial soil condition during growing season of 2019/20.

Treatments	Physical traits			Chemical constituents in grains		
	Spike length, cm	Spike weight, g	No. of tillers plant^{-1}	N, %	P,%	K, %
Beneficial elements						
Cobalt (Co)	15.27c	3.08c	4.08a	1.77c	0.215c	1.90c
Nickel (Ni)	17.26a	3.61a	4.63a	2.29a	0.260a	2.39a
Iron (Fe)	14.51d	2.81d	3.67ab	1.56d	0.193d	1.70d
Molybdenum (Mo)	16.30b	3.40b	4.21a	2.03b	0.237b	2.12b
Boron (B)	13.73e	2.52e	3.04b	1.41e	0.160e	1.52e
LSD at 5%	0.08	0.03	0.96	0.03	0.002	0.08
Addition methods						
Foliar	15.51a	3.12a	3.98a	1.84a	0.216a	1.95a
Soil	15.31b	3.05b	3.87a	1.78b	0.210b	1.90b
LSD at 5%	0.06	0.01	*N.S	0.01	0.001	0.01
Application rates						
0.0 mg L^{-1}	13.48c	2.45c	2.87b	1.38c	0.153d	1.44c
2.5 mg L^{-1}	15.80b	3.19b	4.20a	1.88b	0.225c	2.02b
5.0 mg L^{-1}	16.20a	3.34a	4.40a	1.99a	0.238a	2.12a
10.0 mg L^{-1}	16.17a	3.35a	4.23a	2.00a	0.236b	2.12a
LSD at 5%	0.13	0.02	0.64	0.02	0.002	0.03

***N.S: Non-significant**

Table 11. Interaction effect among investigated treatments on on spike physical traits and chemical constituents in grains of wheat plants at period of 115 days from sowing under alluvial soil condition during growing season of 2019/20.

Treatments			Physical traits			Chemical constituents in grains		
			Spike length, cm	Spike weight, g	No. of tillers plant^{-1}	N, %	P,%	K, %
Co	Foliar	0.0 mg L^{-1}	13.50	2.45	3.00	1.39	0.153	1.44
		2.5 mg L^{-1}	15.60	3.16	4.33	1.84	0.229	1.95
		5.0 mg L^{-1}	16.10	3.41	4.67	1.98	0.244	2.16
		10.0 mg L^{-1}	16.40	3.49	4.67	2.01	0.242	2.19h
	Soil	0.0 mg L^{-1}	13.43	2.46	3.00	1.37	0.151	1.44
		2.5 mg L^{-1}	15.40	3.13	4.33	1.77	0.223	1.94
		5.0 mg L^{-1}	15.70	3.20	4.33	1.89	0.240	1.99
		10.0 mg L^{-1}	16.00	3.32j	4.33	1.94	0.242	2.11
Ni	Foliar	0.0 mg L^{-1}	13.53	2.46	2.67	1.38	0.154	1.42
		2.5 mg L^{-1}	18.27	3.86	5.00	2.51	0.289	2.65
		5.0 mg L^{-1}	18.80	4.09	5.33	2.67	0.301	2.78
		10.0 mg L^{-1}	18.87	4.18	5.67	2.72	0.307	2.86
	Soil	0.0 mg L^{-1}	13.43	2.44	3.00	1.38	0.153	1.45
		2.5 mg L^{-1}	18.10	3.86	5.00	2.46	0.281	2.49
		5.0 mg L^{-1}	18.47	3.92	5.00	2.60	0.296	2.69
		10.0 mg L^{-1}	18.60	4.07	5.33	2.60	0.296	2.76
Fe	Foliar	0.0 mg L^{-1}	13.50	2.44	2.67	1.38	0.152	1.42
		2.5 mg L^{-1}	14.60	2.84	4.00	1.56	0.198	1.75
		5.0 mg L^{-1}	14.90	2.99	4.00	1.70	0.218	1.84
		10.0 mg L^{-1}	15.30	3.07	4.33	1.73	0.221	1.90
	Soil	0.0 mg L^{-1}	13.27	2.45	2.67	1.40	0.152	1.44
		2.5 mg L^{-1}	14.50	2.79	3.67	1.52	0.193	1.69
		5.0 mg L^{-1}	15.03	2.95	4.00	1.55	0.200	1.76
		10.0 mg L^{-1}	15.00	2.96	4.00	1.65	0.207	1.79
Mo	Foliar	0.0 mg L^{-1}	13.43	2.45	3.00	1.38	0.153	1.44
		2.5 mg L^{-1}	16.87	3.66	4.33	2.16	0.255	2.26
		5.0 mg L^{-1}	17.60	3.81	4.67	2.36	0.274	2.38
		10.0 mg L^{-1}	17.77	3.81	5.00	2.41	0.278	2.49
	Soil	0.0 mg L^{-1}	13.60	2.45	3.00	1.38	0.153	1.44
		2.5 mg L^{-1}	16.67	3.53	4.33	2.06	0.251	2.23
		5.0 mg L^{-1}	17.20	3.72	4.67	2.20	0.262	2.33
		10.0 mg L^{-1}	17.23	3.78	4.67	2.27	0.271	2.36
B	Foliar	0.0 mg L^{-1}	13.50	2.45	2.67	1.39	0.153	1.46
		2.5 mg L^{-1}	14.20	2.60	3.67	1.48	0.170	1.66
		5.0 mg L^{-1}	14.30	2.70	3.67	1.49	0.183	1.68
		10.0 mg L^{-1}	13.20	2.40	2.33	1.30	0.148	1.35
	Soil	0.0 mg L^{-1}	13.60	2.45	3.00	1.39	0.153	1.45
		2.5 mg L^{-1}	13.80	2.53	3.33	1.44	0.159	1.56
		5.0 mg L^{-1}	13.90	2.59	3.67	1.47	0.167	1.60
		10.0 mg L^{-1}	13.33	2.42	2.00f	1.36	0.150	1.42
LSD at 5%			0.41	0.06	N.S	0.07	0.005	0.08

Sandy soil condition.

Individual effect

As shown in Table 12, the trend under sandy soil condition looked just like the trend under alluvial condition, but the values of spike length (cm) and weight (g), No. of tillers plant^{-1} and nutrient status of grains (N, P, K,%) for wheat plants grown on sandy soil were less than that of corresponding plants grown on alluvial soil.

Regarding, physical and chemical traits of wheat plants at harvest stage, the superior beneficial nutrients was Ni element followed by Mo element then Co element then Fe element and lately B element.

As mentioned with plants grown under alluvial condition, also the application of all studied beneficial elements as foliar application to plants grown under sandy condition recorded values of spike length (cm) and weight (g), No. of tillers plant^{-1} and chemical content in grains (N, P, K,%) better than that under soil addition method.

Increasing growth parameters because of the increasing added rate of the studied elements was reflected on studied physical and chemical traits of wheat plants grown on sandy soil at the harvest stage, where the values of all aforementioned traits increased as the added rate of the studied beneficial elements increased.

Interaction effect

Table 13 shows the interaction effect among investigated treatments on physical and chemical traits of wheat plants *i.e.,* spike length (cm) and weight (g), No. of tillers plant^{-1} and nutrient status of grains (N, P, K, %) of wheat plants grown on sandy soil at harvest stage**,** where the trend of wheat performance at harvest stage looked exactly like the trend at periods of 30 and 60 days. In other words, the highest values of spike length (cm) and weight (g), No. of tillers plant^{-1} and nutrient status of grains (N, P, K, %) were recorded when plants were treated with Ni element as a foliar application at a rate of 10 mg L^{-1} taking in consideration that plant performance under sandy soil was less than that under alluvial soil and this due to, as mentioned above, the poor fertility of sandy soil compared to alluvial soil

Table 12. Individual effect of investigated treatments on spike physical traits and chemical constituents in grains of wheat plants at period of 115 days from sowing under sandy soil condition during growing season of 2019/20.

Treatments	Physical traits			Chemical constituents in grains		
	Spike length, cm	Spike weight, g	No. of tillers plant^{-1}	N, %	P,%	K, %
Beneficial elements						
Cobalt (Co)	14.33c	2.76c	3.29bc	1.59c	0.204c	1.71c
Nickel (Ni)	16.69a	3.22a	3.96a	2.05a	0.247a	2.13a
Iron (Fe)	13.98c	2.51d	3.46b	1.39d	0.182d	1.54d
Molybdenum (Mo)	15.74b	3.02b	2.58d	1.80b	0.225b	1.89b
Boron (B)	13.23d	2.24e	2.96cd	1.25e	0.152e	1.35e
LSD at 5%	0.68	0.07	0.46	0.01	0.003	0.01
Addition methods						
Foliar	14.99a	2.79a	3.31a	1.64a	0.205a	1.75a
Soil	14.60b	2.71b	3.23a	1.59b	0.199b	1.70b
LSD at 5%	0.35	0.04	N.S	0.01	0.002	0.02
Application rates						
0.0 mg L^{-1}	12.99b	2.18c	3.23a	1.23c	0.145c	1.31c
2.5 mg L^{-1}	15.26a	2.86b	3.40a	1.68b	0.213b	1.80b
5.0 mg L^{-1}	15.32a	2.99a	3.07a	1.77a	0.226a	1.89a
10.0 mg L^{-1}	15.59a	2.97a	3.30a	1.78a	0.224a	1.89a
LSD at 5%	0.47	0.05	N.S	0.01	0.002	0.02

Table 13. Interaction effect among investigated treatments on spike physical traits and chemical constituents in grains of wheat plants at period of 115 days from sowing under sandy soil condition during growing season of 2019/20.

Treatments			Physical traits			Chemical constituents in grains		
			Spike length, cm	Spike weight, g	No. of tillers plant^{-1}	N, %	P,%	K, %
Co	Foliar	0.0 mg L^{-1}	13.00	2.17	2.00	1.23	0.145	1.31
		2.5 mg L^{-1}	15.10	2.82	3.33	1.64	0.217	1.77
		5.0 mg L^{-1}	15.60	3.29	3.33	1.80	0.231	1.91
		10.0 mg L^{-1}	15.87	3.07	3.67	1.83	0.234	1.94
	Soil	0.0 mg L^{-1}	13.03	2.17	3.00	1.23	0.145	1.32
		2.5 mg L^{-1}	14.77	2.77	3.33	1.57	0.211	1.75
		5.0 mg L^{-1}	11.87	2.86	3.33	1.67	0.225	1.79
		10.0 mg L^{-1}	15.40	2.94	4.33	1.75	0.229	1.87
Ni	Foliar	0.0 mg L^{-1}	13.10	2.15	4.67	1.23	0.145	1.28
		2.5 mg L^{-1}	17.67	3.51	4.67	2.26	0.273	2.37
		5.0 mg L^{-1}	18.20	3.62	4.00	2.37	0.288	2.50
		10.0 mg L^{-1}	18.27	3.71	4.33	2.43	0.294	2.55
	Soil	0.0 mg L^{-1}	12.97	2.17r	4.33	1.24	0.145	1.32
		2.5 mg L^{-1}	17.47	3.48	3.67	2.22	0.265	2.24
		5.0 mg L^{-1}	17.87	3.53	3.00	2.32	0.280	2.38
		10.0 mg L^{-1}	17.97	3.60	3.00	2.34	0.283	2.44
Fe	Foliar	0.0 mg L^{-1}	12.87	2.19	2.67	1.25	0.146	1.29
		2.5 mg L^{-1}	14.10	2.54	3.00	1.38	0.187	1.58
		5.0 mg L^{-1}	14.50	2.68	3.00	1.50	0.205	1.64
		10.0 mg L^{-1}	14.70	2.74	3.67	1.53	0.209	1.73
	Soil	0.0 mg L^{-1}	12.97	2.19r	4.00	1.21	0.146	1.32
		2.5 mg L^{-1}	14.00	2.51	4.00	1.37	0.181	1.51
		5.0 mg L^{-1}	14.30	2.59	3.67	1.41	0.189	1.60
		10.0 mg L^{-1}	14.37	2.62	3.67	1.47	0.196	1.63
Mo	Foliar	0.0 mg L^{-1}	13.00	2.19	4.00	1.25	0.145	1.32
		2.5 mg L^{-1}	16.30	3.24	2.67	1.91	0.244	2.02
		5.0 mg L^{-1}	17.00	3.39	2.67	2.11	0.260	2.14
		10.0 mg L^{-1}	17.17	3.46	1.33	2.15	0.262	2.20
	Soil	0.0 mg L^{-1}	12.97	2.16	2.00	1.22	0.146	1.30
		2.5 mg L^{-1}	16.17	3.15	2.33	1.86	0.239	1.99
		5.0 mg L^{-1}	16.60	3.29	1.00	1.95	0.248	2.04
		10.0 mg L^{-1}	16.70	3.32	4.67	1.99	0.258	2.09
B	Foliar	0.0 mg L^{-1}	13.07	2.20	2.67	1.25	0.144	1.32
		2.5 mg L^{-1}	13.70	2.32	3.67	1.30	0.162	1.46
		5.0 mg L^{-1}	13.80	2.43	3.6	1.32	0.174	1.49
		10.0 mg L^{-1}	12.70	2.12	2.33	1.14	0.139	1.18
	Soil	0.0 mg L^{-1}	12.93	2.21	3.00	1.23	0.147	1.33
		2.5 mg L^{-1}	13.30	2.22	3.33	1.26	0.151	1.38
		5.0 mg L^{-1}	13.50n	2.27	3.00	1.29	0.157	1.40
		10.0 mg L^{-1}	12.80	2.14s	2.00	1.21	0.142	1.26
LSD at 5%			1.49	0.16	N.S	0.04	0.007	0.07

Except for B element, the highest values of studied traits at the harvest stage for wheat plants treated with other studied beneficial elements were recorded when plants were treated with the beneficial elements as a foliar application at a rate of 10 mg L^{-1}, while the lowest values were realized with untreated plants.

Regarding B element, the data of the same Table indicate that the highest values of studied traits *i.e.,* spike length (cm) and weight (g), No. of tillers $plant^{-1}$ and nutrient status of grains (N, P, K, %) at harvest stage were recorded when plants were treated with B element as foliar application at rate of 5.0 mg L^{-1}, while the lowest values were realized when plants were treated with B element as either foliar or soil application at rate of 10.0 mg L^{-1}. In other words, the values of all studied traits for plants received B either with foliar or soil additions significantly increased with increasing B rate from 0.0 mg L^{-1} to 2.5 and 5.0 mg L^{-1} and then significantly decrease at 10.0 mg L^{-1} due to appearing B toxicity. The findings are in accordance with those of El-Ghamry *et al.,* (2016); Kumar *et al., (*2018); and Akeel and Jahan (2020).

CONCLUSION

Findings of the current paper and those obtained by others are enough to confirm that nickel, molybdenum, cobalt, iron and boron are beneficial elements for wheat plants at all studied rates except B at rate of 10 mg L^{-1}.

Beneficial elements application as foliar spraying on plants was most effective than their application as soil addition.

Nickel may be possess a vital role in non-biological N fixation with wheat plants grown on alluvial or sandy soil, where it can fix atmospheric N either on straw or soil surface.

Boron application to wheat plants at a low concentration (2.5 and 5.0 mg L^{-1}) is a beneficial, but the B toxicity start to appear at high rate (10 mg L^{-1}).

Generally, it can be concluded that Ni may have a vital role in N fixation more than other nutrients *i.e.,* molybdenum, cobalt, iron and boron and this is reflected on plant growth.

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إستجابة نبات القمح النامي على أراضي رسوبية ورملية لبعض العناصر المفيدة

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تم تنفيذ تجربة أصص تهدف إلى تقييم تأثير الكوبلت والنيكل والحديد والموليبدنيوم والبورون بمعدلات مختلفة (0.0، 2.5، 5.0 و10.0 مجم /لتر) باستخدام طرق إضافة مختلفة (الرش الورقي والإضافة الارضية) على أداء نباتات القمح النامي في التربة الرسوبية والرملية. تم تقييم أداء النبات عند فترتي30 و60 يومًا من الزراعة معبرًا عنه بارتفاع النبات، والأوزان الطازجة والجافة، ومحتوي النيتروجين والفوسفور والبوتاسيوم في القش وكذلك حالة العناصر الغذائية للحبوب (محتوي الحبوب من النيتروجين والفوسفور والبوتاسيوم) وغيرها من الخصائص عند الحصاد مثل طول ووزن السنبلة وعدد الافرع/ النبات. يمكن تلخيص النتائج الرئيسية للدراسة الحالية على النحو التالي: النيكل كان أكثر العناصر المفيدة تفوقا مقارنة بالعناصر الأخرى المدروسة، وجاء الموليبدنيوم في المرتبة الثانية متبوعًا بـ الكوبلت ثم الحديد ومؤخرًا البورون. باستثناء عنصر البورون، أدت جميع العناصر المدروسة إلى تحسين أداء النبات حيث ازداد التحسن كلما زاد معدل الإضافة لهذه العناصر سواء كانت طريقة الإضافة رش ورقي او أرضية. فيما يتعلق بالنباتات المعاملة بالبورون سواء كانت طريقة الإضافة رش ورقي او أرضية، زادت قيم جميع الصفات المدروسة زيادة معنوية مع زيادة معدل البورون من 0.0 مجم /لتر إلى 2.5 و5.0 مجم /لتر ثم حدث انخفاض معنوي عند معدل الاضافة 10.0 مجم /لتر بسبب ظهور سمية البورون. كانت طريقة الرش الورقي هي الأكثر فعالية عن طريقة الإضافة الارضية. كان أداء النبات النامي في التربة الرسوبية أفضل من أداء النبات النامي في التربة الرملية. بشكل عام، يمكن استنتاج أن النيكل قد يكون له دور حيوي في تثبيت النيتروجين أكثر من العناصر المدروسة الأخرى وهذا انعكس على نمو نبات القمح.