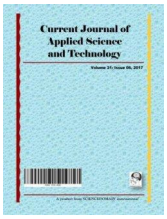

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Effect of Integrated Natural Mineral Compound and Farm-yard Manure Soil Fertilizer on Wheat Crop Yield versus Chemical Fertilizer

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Authors' contributions

This work was carried out in collaboration between all authors. Author AAEM designed the study, performed the statistical analysis, wrote the protocol and first draft of the manuscript. Authors MAAR and YMI managed the analyses of the study and the experimental side of the work. Author YMI managed the literature organization. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The great challenge is how to create and secure natural component derived from natural elements that can be used as mineral fertilizer sources and have a superior "residual effect" compared with the chemical fertilizers in agricultural systems. Also, to attain high productivity with lower costs relative to chemical (control) treatment, to upgrade and maintain the soil productivity and to improve the nutrient reserve in soil.
Methods: The production of the natural mineral soil fertilizer is fundamentally depending on the special mixture. It includes phosphate, feldspars, dolomite, gypsum, sulphur and ores of manganese, copper and iron, pyrite, sphalerite, magnetite and rare earth elements bearing minerals, as well as some clay minerals and other micronutrients. The experiment was done at clay-loamy soil on two treatments; 1- chemical fertilizer (Control), and 2- integrated farmyard nutrient

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(FYN) with Natural Minerals Compound (NMC) for growing wheat crop. Measurements was done on two steps during two seasons of wheat cultivation

Results: The growth parameters after ten weeks of sowing show greater results under treatment with the integrated farmyard manure and Natural Mineral Compound related to the control one. The growth parameters include: plant height, number of branches, number of leaves, leaf and total leaves area, crown diameter, stem diameter, internode length and root (length and width). At harvest time, the results indicate an increase of 32% of wheat grain yield compared to the control treatment.

Conclusion: The integrated NMC and FYN are more economically attractive; they have reasonable price and can reduce the costs of wheat production by 25% compared to the control treatment. This application will give safe products for users, increase benefits (e.g. higher productivity, lower production cost) and reduce the impacts on the environment.

Keywords: Natural compound; ore minerals; rocks; feddan; control; benefits.

1. INTRODUCTION

One of the most challenges of the developed countries is to maximize the crops production per limited cultivated areas. Although, the continuous production of crops requires a supply of plant with the available nutrients to enhance the crop growth from one hand and on the other hand the nutrient removed from the soil. Human diets depend on wheat, rice and maize by more than 60% via consumption directly or feed of livestock or by production [1]. As a result of demand on food increases, crop production must be intensively increased, and the necessity of application of fertilizer will be also maximized. Consequently, the impact factors of the application of chemical fertilizer on the environment will increase hazards on bio-organisms [2]. Therefore, the specialists have to create methods to increase food productivity via increasing the crop yield. Moreover, natural minerals compounds can be applied as natural soil improvement materials in agricultural systems. For instance, dolomite rocks contain calcium and magnesium elements can be used for reducing salinity effect [3]. Magnetite may play an important role in cation uptake capacity and has a positive effect on the immobile plant nutrient uptake [4]. Therefore, the magnetic field could be a substitution of chemical additives, which can reduce toxins in raw materials and these raise food safety. Also, magnetite plays a significant role in cation uptake and have a positive effect on immobile plant nutrient [5,6]. Natural elements compound, among elements, contains sulfur, which has favourable properties such as cheapness, ability to oxidation and acid production, ability to act as a fungicide that enhances the productivity and quality of the crops. Therefore, sulfur element is increasing, becoming popular in the field of crops [7,8].

The application of Natural Minerals Fertilizer is of great values to nutrient recycling. This means it plays roles in replacement the nutrient removed by crop yield and also to secure the food production at a high level and to maintain the soil potentiality [9]. Low Ca and Mg are serious limitations to crop production in sandy soils as demonstrated by Chen [10]. The application of iron for eggplant at the time of cultivation resulted in the higher values of nitrogen, phosphorus, potassium and Fe compared with no iron addition [11,12,13]. The beneficial role of silicon for plant growing and crops development is evidenced [14,15,16]. Zinc as a micro-nutrient is very essential for living organisms due to its effective catalytic, structural and regularity roles [17,18,19].

Organic fertilizers are derived from three main sources. The first source is animal. Animal sourced urea is suitable for application to organic agriculture, while pure synthetic forms of urea are not [20]. Also, sewage sludge use in organic agricultural operations has been extremely limited and rare due to toxic metal accumulation, among other factors [21,22]. The second is plant source as cover crops are also grown to enrich the soil as a green manure through nitrogen fixation from the atmosphere as well as phosphorus through nutrient mobilization content of soils [23]. While, the third is mineral source which is naturally mined powdered limestone, mined rock phosphate and sodium nitrate are energetically intensive to harvest and are approved for application in organic agriculture in minimal amounts [10].

Organic fertilizers have been known to improve the biodiversity [24,25] and may prove a large depository for excess carbon dioxide [26,27,28]. According to Mendes et al. [29] the application of organic fertilizer can enhance (i) the soil

biological activity, which improves nutrient mobilization from organic sources and decomposition of toxic substances, the colonization of mycorrhizae, which improves P supply and increase the content of organic matter in soil, (ii) to improve the efficiency exchange of nutrients, increasing soil water retention and promoting the soil aggregates (iii) to act as buffer for the soil against acidity, alkalinity, salinity, pesticides and toxic heavy metals. Integration of organic fertilizer and balanced mineral fertilizer application sustain crop yield via improvement of soil fertility and nutrient uptake efficiency [30] and (iv) to improve the organic carbon sequester and maintain the increase of organic content in soil and hence increase the crop production [31].

Many authors paid attention to the relationships between the upper and underground diversity [32,33]. To preserve and increase crop production, soil is one of an important source of benefits [34,35]. Soil moisture, soil organic carbon and soil nitrogen are essential after microbial diversity, while the soil microbes play an effective role in recycling of elements. Many bacteria have the potentiality to soluble k-bearing minerals (for ex.; K-feldspars, illite, clay minerals, kaolinite and mica) [36,37,38]. They are present in all soils and can dissolve silicate minerals [13].

The objective of the application of integrated Natural Mineral Compound Soil and farmyard manure are (i) to upgrade and maintain the soil productivity, (ii) to improve the nutrient reserve for plants in the soil, (iii) to minimize the nutrient loss to the environment via improving the efficiency of nutrient uses [39}. In general, the impact of uses of both organic and (NMC) can maintain the soil fertility and keep the nutrient supply to maximize the yield of wheat crop per the given area. They increase the soil chemical, physical and biological properties as well as the nutrient availability, enhance the soil organic matter-content and contribute to environment protection through reduction of N and P losses and carbon sequestration in the organic matter of soil [40,9].

The study concerns with the safe application of geological raw materials in industry of natural fertilizer as agricultural soil for planting. Wheat crop is the plant material subjected to the experiment during two cultivating seasons 2015/2016 and 2016/2017. This study concerns with the response of wheat plant to the integrated farmyard manure and Natural Minerals Compound Soil application as natural fertilizers in comparison with the water-soluble chemical fertilizers. Since, vegetative growth parameters of plants, yield and crop quality are the main points subjected to investigation in this respect.

2. MATERIALS AND METHODS

Two experiments were conducted during the two success growing seasons for wheat crop experiment amongst 2015 -2016 and 2016-2017 to study the effect of the combination of both farmyard manure and Natural Minerals Compound as soil application on vegetative growth and yield versus water-soluble chemical fertilizer (control).

Microorganisms play a significant role in regulating the dynamics of organic matter and Natural Minerals Compound decomposition and the availability of plant nutrients such as N, P, S and other elements. It is well-recognized that microbial inoculants constitute an important component of integrated nutrient management and sustainable agriculture [29]. Also, to degrade the chemical structure of the given Natural Mineral Compound, the microorganisms are necessarily added to facilitate crystal structure and to enhance the absorption of the mineral nutrient by the plant roots.

The complete chemical analyses of the applied Natural Minerals Compound are listed in Table 1. The compound comprises grinding mixture (-150 to -200 mesh) of rocks and minerals, e.g. phosphate (P_2O_5), K-feldspar ($KAlSi_3O_8$), dolomite $CaMg(CO_3)_2$, gypsum ($CaSO_4 \cdot 2H_2O$), sulphur (S), manganese (Mn), pyrite (FeS_2), sphalerite (ZnS), iron ore (Fe), cuppor ore (Cu), magnetite (Fe_3O_4) and rare earth elements and Ba, Sr, Zn, V, Cr and Rb-bearing minerals. The analyses were performed in Central Laboratories Sector of the Egyptian Mineral Resources Authority.

2.1 Experimental Work

2.1.1 Soil characteristics

This study was carried out at private fields at and applied on a clay-loamy soil. The particle size and characteristics of the applied soil is given in Tables 2 and 3. During two successive winter seasons 2015/2016 and 2016/2017, the study concerns with the effect of the integrated farmyard manure and natural minerals compound on wheat plant growth and yield of Giza 168 CV type.

Table 1. Complete chemical analyses of the Natural Minerals Compound (NMC)

Major oxides (wt.%)		Trace elements (ppm)			
Oxides	**Concentration**	**Element**	**Conc. in ppm**	**Element**	**Conc. in ppm**
SiO_2	36.2	V	36	La	<1.00
TiO_2	0.76	Cr	17.07	Yb	3.33
Al_2O_3	7.8	Co	<1.00	Hf	3.33
Fe_2O_3	4.9	Ni	15.43	Pb	18.33
MnO	0.72	Cu	2.33		
MgO	3.7	Zn	33.67		
CaO	13.5	Rb	52.67		
Na_2O	1.92	Sr	134.33		
K_2O	4.37	Ta	4.33		
P_2O_5	8.14	Y	20.67		
Cl	0.56	Nb	2.33		
SO_3	5.4	Mo	3.0		
LOI*	9.01	Sn	2.33		
Total	96.35	Ba	190.27		

** L.O.I = loss of ignition*

Table 2. Particle size distribution of the investigated soil

Depth (cm)	Coarse sands %	Fine sands %	Silt %	Clay %	$CaCO_3$%	Texture
0-30	1.50	27.25	29.00	42.25	2.28	Clay-loam
30-60	2.10	55.65	19.25	23.00	1.83	Clay

Table 3. Soil characteristics on the investigated soil

Depth	EC	Soluble ions in meq./ L.							
(cm)	Mmos/cm 25° C	$Co^{=}$	HOC_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
0-30	0.37	-	2.40	1.00	2.15	1.41	1.32	2.73	0.09
30-60	0.36	-	2.47	1.00	1.79	1.36	0.99	2.83	0.08

2.1.2 The experiment includes the following treatments

Control; The recommended dose constitutes 20 m^3 animal manure, 200 Kg super phosphate 15.5% P_2O_5, 50 Kg sulphur and 100 kg potassium sulphate 48% per Feddan (0.4 of Hectare). Natural elements compound; 2.5 T/Ha at the 1st season and 1250 Kg/Ha at the next seasons for the same area, also 20 m^3 farmyard nutrient per Feddan was added every cultivated season. All fertilizers were applied as one dose for preparing the soil and before seed sowing.

Complete randomized blocks design with 3 replicates was used. Each plot contains 9 rows, (10 m. long and 0.3 m. a part). Recommended doses of nitrogen fertilizer were applied to all experimental plots with recommended agronomic practices were followed.

2.2 Data Recorded

2.2.1 After ten weeks from planting date

One hundred guard wheat plants were taken randomly during plant growth from each plot. The measurements include plant height(cm.), number of branches, number of leaves, leaf area and total leaves area (Cm^2), crown diameter (mm.), branch diameter (mm.), inter-node length (cm.) and root (length and width in cm.).

2.2.2 At harvest

Also, one hundred plants of wheat were taken randomly from each plot to record and measure: plant height (cm.), number of spire, root length (cm.), (stem, root and spire) dry matter percentage and weight of 10 kg wheat grains.

3. RESULTS AND DISCUSSION

The influence of the integrated farm yard manure and Natural Minerals Compound application on vegetative growth and yield of wheat plants during the two seasons will be evaluated as follows;

3.1 Vegetative Growth after Ten Weeks from Planting Date

The Natural Minerals Compound plus farmyard nutrient application on wheat plants Cv. Giza 168

can be illustrated using growth parameters. These parameters include; plant height, number of branches, number of leaves, leaf and total leaves area, crown diameter, stem diameter, inter-node length and root (length and width) are the parameters of growth rate and are applied in

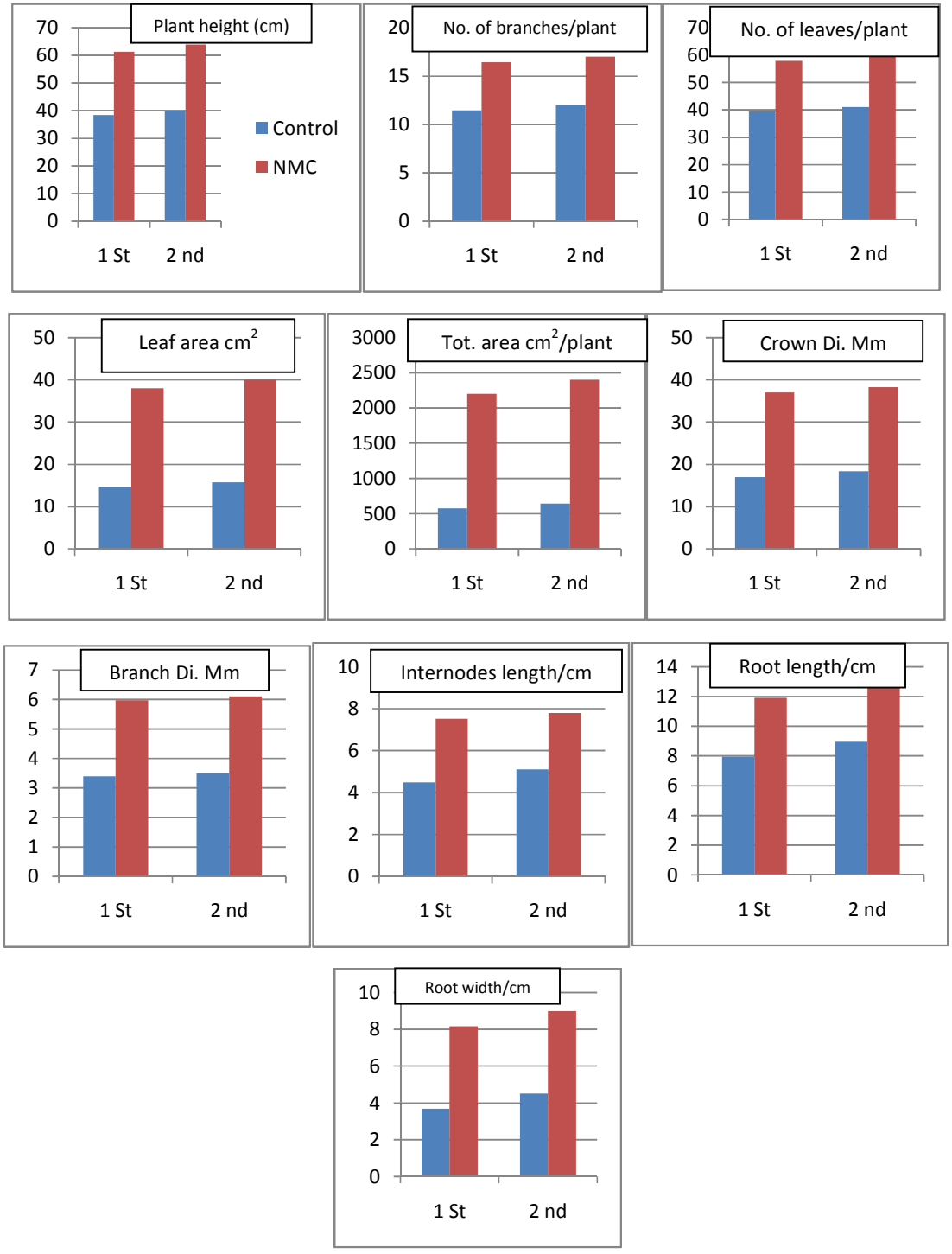

Fig. 1. Histogram presentation shows the effect of the integrated farmyard nutrient and Natural Minerals Compound (NMC) and soluble chemical fertilizer treatment (Control) on wheat vegetative growth after ten weeks from the planting date during the two experimental seasons

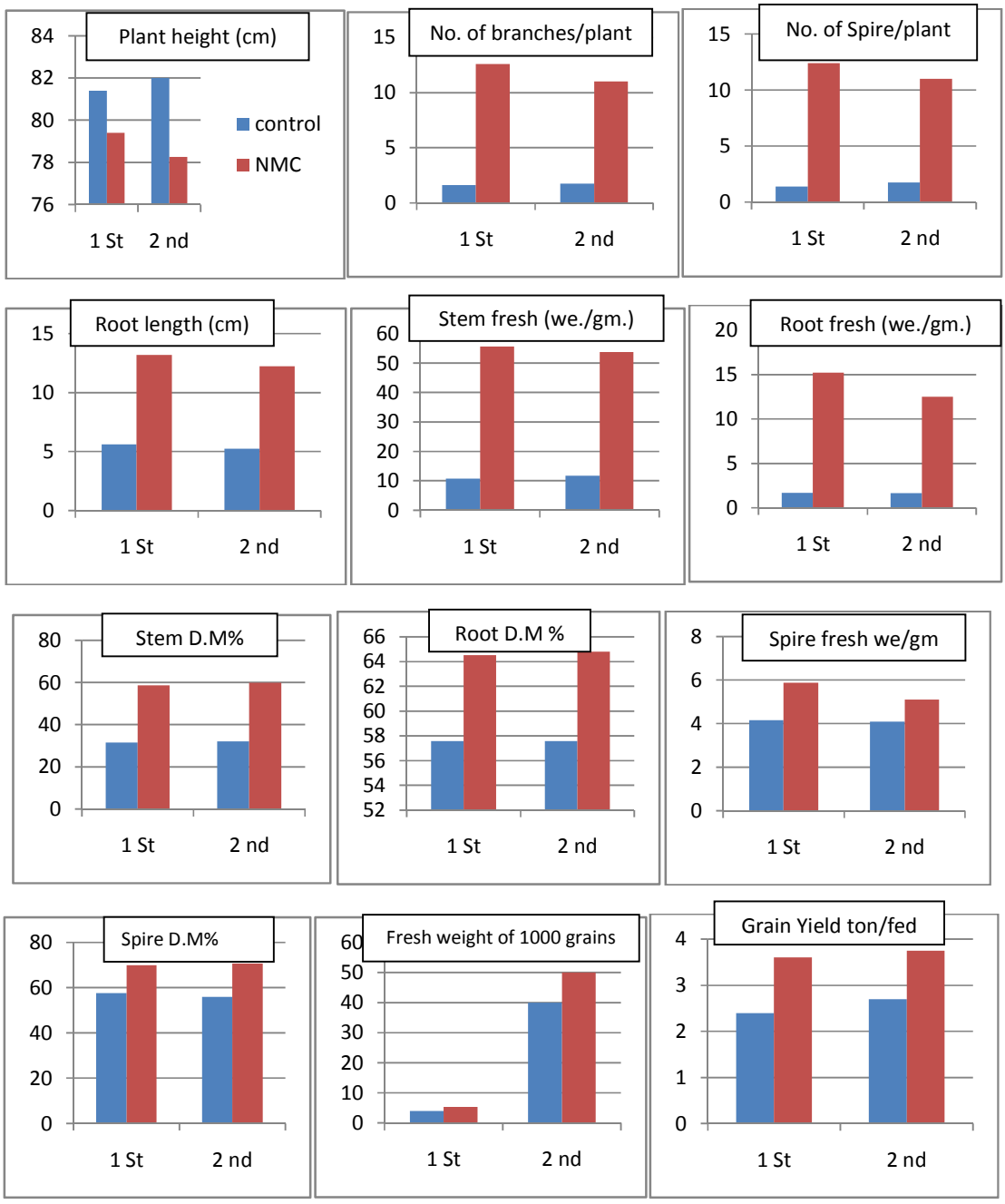

Fig. 2. Histograms show the effect of the integrated farmyard nutrient and Natural Minerals Compound (NMC) and soluble chemical fertilizer treatment (Control) on wheat vegetative growth and yield at harvest stage

the data collection. Data obtained are presented obviously show that integrated NMC plus FYN soil application as fertilizer significantly increased plant height, number of branches, number of leaves, leaf and total leaves area, crown in Table 4 and Fig. 1. The obtained data diameter, stem diameter, inter-node length and root area distribution of wheat plants when compared with the soluble-water chemical fertilizers during both seasons.

Table 4. Data summarize the effect of Natural Minerals Compound and control treatment on wheat vegetative growth after ten weeks from planting date

During the 1 st Season (2015/2016)										
Aspect treat.	**Plant height cm**	**No. Of branches / plant**	**No. of leaves / plant**	**Leaf area cm^2**	**Tot. area cm^2 / plant**	**Crown Di. Mm**	**Branche Di. Mm**	**Internodes length/ cm**	**Root length/ Cm**	**Root width/ cm**
**Cont.	38.44 B	11.48 B	39.36 B	14.68 B	578.06 B	17.04 B	3.4 B	4.48 B	7.96 B	3.68 B
* NMC	61.32 A	16.43 A	57.88 A	38.06 A	2200.63 A	37.04 A	5.98 A	7.52 A	11.92 A	8.16 A
***L.S.D 0.05	2.487	1.183	2.53	2.405	128.5	1.151	0.484	1.045	0.111	0.509
The 2 nd Season (2016/2017)										
Aspect treat.	**Plant height cm**	**Nu. Of branches / plant**	**No. Of leaves / plant**	**Leaf area cm2**	**Tot. area Cm2/ plant**	**Crown Dia. Mm**	**Branche Di mm**	**Internodes length cm**	**Root length Cm**	**Root width cm**
**Cont.	40 B	12 B	41 B	15.7 B	643.7 B	18.4 B	3.5 B	5.1 B	9 B	4.5 B
* NMC	64 A	17 A	60 A	40 A	2400 A	38.3 A	6.1 A	7.8 A	13 A	9. A
***L.S.D 0.05	2.753	1.249	2.811	3.151	4.623	0.404	1.399	0.512	0.676	0.702

**NMC= Natural Minerals Compound treatment **Cont.= Chemical Fertilizer treatment ***LSD= Less Significant Difference at 0.05*

Table 5. Data show the effect of Natural Minerals Compound and control treatment on wheat vegetative growth and yield at harvest stage

During the 1st season												
Aspect treat.	**Plant height (cm)**	**No. of Branches /Plant**	**No. of Spire /Plant**	**Root length (cm)**	**Stem fresh (we./gm.)**	**Root fresh (we./gm.)**	**Stem D. M %**	**Root D. M %**	**Spire fresh we/ gm.**	**Spire D. M %**	**Fresh weight of 1000 grains (gm)**	**Grain yield (Ton / fed.)**
**Cont.	81.4 A	1.6 B	1.4 B	5.6 B	10.79 B	1.7 B	31.52 B	57.58 B	4.16 B	57.7 B	4.01 B	2.4 B
* NMC	79.4 A	12.6 A	12.4 A	13.2 A	55.67 A	15.22 A	58.64 A	64.52 A	5.88 A	69.94 A	5.24 A	3.6 A
***LSD 0.05	4.562	2.912	2.912	3.887	23.84	3.855	8.777	2.673	1.088	9.38	0.561	0.314
The 2 nd Season												
Aspect treat.	**Plant height cm**	**No. of branches/ Plant**	**No\. of Spire/ Plant**	**Root length cm**	**Stem fresh we.gm.**	**Root fresh we.gm**	**Stem D. M %**	**Root D. M %**	**Spire fresh we. Gm.**	**Spire D . M %**	**Fresh weight of 1000 grains (gm)**	**Grain yield Ton / fed**
**Cont.	82 A	1.75 B	1.75 B	5.25 B	11.67 B	1.67 B	32.1 B	57.59 B	4.1 B	55.94 B	40.02 B	2.7 B
* NMC	78.25 A	11.0 A	11.0 A	12.25 A	53.75 A	12.5 A	59.9 A	64.8 A	5.1 A	70.73 A	50.0 A	3.75 A
***LSD 0.05	10.37	5.715	5.715	2.323	28.74	6.348	11.34	2.061	0	11.54	0.294	0.329

**NMC= Natural Minerals Compound treatment **Cont.= Chemical Fertilizer treatment ***LSD= Less Significant Difference at 0.05.*

Table 6. The comparison between the NMC and the chemical fertilizer (control) as input and output results

Crop	**Input**		**Output**		
	Control	**NMC**	**Control**	**NMC**	**Notes**
Wheat (per - Fedan = 0.4 Ha)	- 200 Kg super phosphate - 50 Kg sulpher - 100 kg K-sulphate - 400 Gr Fe EDTA - 400 Gr Zn EDTA - 200 GrMN EDTA - 200 Gr Borax	500 Kg NMC	18.1 Ardab (2700 Kg)	23.9 Ardab (3600 Kg)	32% extra

3.2 Vegetative Growth and Yield at Harvest Date

The observations show clearly that wheat plants were responded positively to Natural Minerals Compound and FYN application when compared with control treatment in both seasons as shown in Fig. 2. The data concern to plant height, number of spire, root length, (stem, root and spire) dry matter, weight of 100 seeds and total yield of seeds are given in Table 5 and represented in Fig. 2.

These experiments demonstrate that it is possible to apply a Natural Minerals Compound Soil derived from some geological raw materials with an integration of farmyard manure at the expense of the chemical fertilizers (control) as agriculture nutrient. The correlated productivity is summarized in Table 6. It clearly shows an increase of wheat grains yield by 33.3% and 30.7% for the first and second season respectively, per the same cultivated area. The average of wheat yield increase is 32% when the integrated farmyard nutrient and Natural Minerals applied as soil fertilizer versus the chemical fertilizer treatment.

4. CONCLUSIONS

The study revealed that, there are different growth parameters, i.e. plant height, number of branches, number of leaves, leaf and the total leaves area, crown diameter, stem diameter, inter-node length as well as root area distribution of wheat plants after ten weeks of seed planting date were positively affected by the application of Natural Minerals Compound soil in comparison with the application of chemical fertilizer.

The correlative study regarding plant height, the number of spire, root length, (stem root and spire) dry matter. The total yield of seeds at harvest date in an average of two seasons is generally greater values (32%) by the effective of an integrated farmyard and natural minerals compound as a fertilizer in comparison with soluble chemical fertilizers (control) in both cultivated seasons.

The experiment of the application of the integrated farmyard manure with NMC versus chemical fertilizer can upgrade the rate and ratio of nutrient for crop planting to increase yield per area. The integration of both organic and mineral fertilizer can sustain the production of wheat crop through the improvement of soil fertility and nutrient uptake efficiency. Also, the present application plays a significant role to avoids soil fertility degradation, to ensure sustainability of soil fertility and to maximize the wheat productivity per area (32% more the control treatment). The increase of wheat production per area is needed to sustain socio-economic ability to access food for human and feed livestock consumptions.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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