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Response of Wheat (*Triticum aestivum L.*) to Organic Manure and Manganese Levels Applications in Two Different Soil Orders

Bakhan Hamarasul Qadir*
Shuela Mohammed Sheikh-Abdullah

Natural Resources Department, College of Agricultural Engineering Sciences, University of Sulaimani

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ABSTRACT

This study conducted to investigate the effect of organic manure and different levels of Mn on the wheat growth and yield at two different soil orders (Mollisols and Vertisol) in Sulaimani-Kurdistan Region of Iraq. Pot experiments was conducted during (November 12th, 2021 to May 10th, 2022), two rate of organic manure (0 and 2) % of (sheep manure) and five different levels of Mn (0,5,10,15 and 20) mg Kg-1 as MnSO4.H2O were used to the soil. The experiment was carried out using a factorial complete randomized design (CRD) in Triplicate. Growth characters, reproductive, and total dry matter were evaluated. The result showed that application organic manure and Mn were affected on the growth characters of wheat, except plant height (cm) and flag leaf area (cm2). While all reproductive characters were significantly affected with the fertilizer application. Total dry matter increased with application of organic manure and Mn levels in both soil orders. In Vertisol, total dry matter superior (40.813 %) from the most other application levels.

INTRODUCTION

One of the most significant crops of all cereals consumed by people for human nourishment worldwide is wheat, which is grown in calcareous soil in arid and semi-arid regions as well as in the Kurdistan Region of Iraq (Rasul *et al*., 2018). Wheat (Triticum aestivum L.) is an extensively adapted crop, is grown in temperate, irrigated, dry, and cold climates (Acevedo *et al*., 2002), with a variety of abiotic factors (Hyles *et al*., 2020). According to (Bakhtiari *et al*., 2015) wheat yield is affected by a variety of factors including environment, cultivar, agronomic approaches, diseases, pests, and weed infestation. Nutrient management is one of the most important of these aspects. Micronutrients play a variety of roles in plants, including acting as cofactors in enzyme systems and participating in redox reactions. Most importantly, micronutrients are engaged in critical physiological activities like photosynthesis and respiration (Mengel *et al*., 2001), and their deficiency can obstruct these vital physiological processes, limiting yield gains (Farooq *et al*.,

* *Corresponding author: E-mail*: bakhan.qader@univsul.edu.iq

2012). Manganese (Mn) is a vital element for plant growth and development, as it promotes metabolic components inside different plant cell compartments (Alejandro *et al*., 2020). It can fulfill diverse work acts as an activator and co-factor of an abundance of metalloenzymes in plants. Mn is important in a wide range of enzyme-catalyzed reactions, including redox reactions, phosphorylation, decarboxylation, and so on, because of its ability to quickly change oxidation state in organic systems, and hydrolysis (Andresen *et al*., 2018).

Iraqi soils show varying degrees of development based on the dominating local circumstances, mostly climatic and geological. Five soil orders which Aridisols, Mollisols, Entisols, Vertisols and Inceptisols were found in Iraq based on the results of morphological, physical, and chemical soil attributes (Muhaimeed *et al*., 2014). Aridisols, Mollisols and Vertisols are the most common soil orders in Kurdistan region (Khoshnaw and Esmail, 2020).

Due to the calcareous character of the soils, high pH, poor organic matter, salt stress, persistent drought, high bicarbonate content in irrigation water, and an imbalance in the application of NPK fertilizers, micronutrient deficiency is widespread in most Asian countries (Narimani *et al*., 2010). The deficiency of manganese (Mn) is a serious problem reducing crop yields on calcareous and sandy soils throughout the world (Long *et al*., 2021).

For this reason, **this study aims:** to investigate the effects of adding organic manure and different levels of manganese on the wheat growth and yield characteristics in two different soil orders (Mollisols and Vertisols).

MATERIALS AND METHODS

The study area

This study was conducted on two different soil orders around the region of Sulaimani; the sampling sites were located in New Halabja (Mollisol) (35˚ 20´ 40″ N; 45˚ 38´ 20″ E), and Bakrajo (Vertisol) (35˚ 32´ 19″ N; 45˚ 21´ 52″ E), soil orders was determined by morphological, physical, and chemical soil parameters (Abdulla, 2015).

Pot Experiment

The pot experiment was conducted at the green house in College of Agriculture engineering sciences / Sulaimani University. The experiment was carried out using a factorial complete randomized design (CRD) and in Triplicate during November 12th, 2021 and May 10th, 2022. Soil samples were taken in (30 cm) soil surface and passed through (4 mm) sieve. Each plastic pot was filled with 2.5 kg gravel and 7.5 kg air-dried soil on top of the gravel. Two different rates of organic Manure (Sheep Manure) (0 and 2) % were applied to the soil before 12 days of seeding. Wheat (Triticum aestivum L.) were planted in each pot at 5 cm depth. Five different rates of Mn (0, 5, 10, 15 and 20) mg Kg^{-1} were applied to the soils as $MnSO_4.H_2O$ (32.5%Mn) after germination. Each pot was fertilized with 225mg kg^{-1} of Nitrogen as urea (46%N) and 150 mg kg^{-1} of Phosphorus as Triple Super-Phosphate (47%P_2O_5) for all pots with seeding. Micronutrients were added in the rates 9,2 and 3 mg kg^{-1} Fe as ($FeSO_4.7H_2O$), Cu as ($CuSO_4$) and Zn as ($ZnSO_4$) respectively in liquid phase after germination. Seven plants were left in each pot after germination. The water content of the pots was adjusted to 75% of field capacity throughout the experimental period, depending of gravimetric method. At harvesting time, wheat shoots were harvested, measured some yield parameters, weighted, and dried at 65°C for 72 hr to determine the dry matter yields.

The soil samples were air dried and passed through a 2-mm sieve and stored in plastic bottles prior to physical and chemical analysis. Soil particle size distribution was determined by the pipette method according to (Black, 1965). Electrical conductivity (Ec) and pH were measured for the soil dilution extract with using the Ec-meter according to (Rhoades, 1996), and pH meter, as mentioned by (Ryan *et al*., 2001). Organic matter was determined by using the (Walkley and Black, 1934) method, as described by (Ryan *et al*., 2001). The total calcium carbonate equivalent was determined method as mentioned by (Loeppert and Suarez, 1996). Active calcium carbonate was determined according to (Kozhekov and Yakovleva, 1977). Cation Exchange Capacity (CEC) was determined by using an ion exchange process method with ammonium acetate (NH_4OAc) pH 8.2 as an extraction solution, according to (Ryan *et al*., 2001).

Some of the vegetative and reproductive criteria were measured, such as plant height (cm), number of tillers per plant, flag leaf area (cm^2), and leaf chlorophyll content (CCI). The flag leaf area was determined by (Leaf area (cm^2) = Maximum Length (cm) x Maximum Width of a Leaf x 0.75) suggested by (Quarrie and Jones, 1979). Chlorophyll content index (CCI) of the upper, middle, and lower leaves was measured by chlorophyll meter (CCM-200 plus, Opti-Sciences, USA). Spike length(cm), number of grains per spike, 1000-grain weight (g pot^{-1}), grain yield (g pot^{-1}), biological yield (g pot^{-1}), and harvest index% were measured.

Harvest index calculated according to the following equation proposed by (Sharma *et al*., 1987).

$$\left(\text{Harvest Index \%} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100\right)$$

STATISTICAL ANALYSIS: The analysis of variation (ANOVA) and Duncan multiple range tests (DMRT) at $p \leq 0.05$ was used to separate the means (Al-Rawi and Khalaf Allah, 1980). Data were analyzed using the statistical programs from Statistics and Graphics Guide (XLSTAT, 2019).

RESULTS AND DISCUSSIONS

Properties of studied soils

Table (1) shows physical and chemical properties of studied soil orders. the range of sand, silt, and clay were (54.1 and 65.5), (479.9 and 458.2), and (466.0 and 476.3) mg kg^{-1} soil for Mollisol and Vertisol, respectively. The studied soils were silty clay texture, which indicates that they ranged in texture from fine to moderate.

Results indicate that the pH was (7.49 and 7.79) in Mollisol and Vertisol, respectively. The pH of both soils was slightly alkaline, which was explained by the presence of some cations. Electrical conductivity (Ec) results for both soil orders (Mollisol and Vertisol) were (0.33 and 0.37 dS m^{-1}, respectively). These findings demonstrated that both soil orders were non-saline due to Ec values below 2 dS m^{-1} the limits recommended by (Schoeneberger *et al*., 2012). The finding of organic matter was also displayed in a Table (1). Organic matter contents vary between the studied soil orders ranged from (15.5 and 14.4) g kg^{-1}, for Mollisol and vertisol respectively. Relatively high value of organic matter in Mollisol may resulted from continuous addition of plant residual to the soil (Barthakur and Baruah, 1997). The most significant soil-forming process in Mollisol, according to (Staff, 1999), is melanization (darkening of the soil by organic matter additions). Vertisols typically have a very dark color and a level of organic matter that varies greatly (between 1 and 6 percent). Despite having lower organic matter content than Mollisols, Vertisols nonetheless contain a significant amount of organic matter (Ossman and Fayyadh, 2021).

Total calcium carbonate (T-$CaCO_3$) and active calcium carbonate (A-$CaCO_3$) were ranged between (255.0 and 343.0) g kg^{-1} were (25.4 and 36.1) g kg^{-1} at Mollisol and Vertisol respectively. This result indicates that both soil orders are considered to be calcareous soils (FAO, 2016). This variation may have been caused by the diverse parent material, leaching processes, and creation of each soil order, especially those that are connected to weathering processes and levels of soil development. Due to the influence of the parent material, which is calcareous, Vertisols have high total carbonate levels (Ossman and Fayyadh, 2021). The values of cation exchange capacity (CEC) for both soil orders are shown in Table (1). The values ranged between (33.84 and 39.44) $Cmol_c$ $kg^{-1,}$ for Mollisol and Vertisol, respectively. This difference may have been attributed to the well-saturated study soils with basic cations (Eswaran and Reich, 2005).

Table (1): Some selected physical and chemical properties for studied soils

Physical Properties				
Soil type	Particle Size Distribution (PSD) g Kg^{-1}			Texture Class
	Sand	Silt	Clay	
Mollisol	54.1	479.9	466.0	Silty Clay
Vertisol	65.5	458.2	476.3	Silty Clay

Chemical Properties							
	pH 1:1 Soil: water	Ec dS m^{-1} 1:1 Soil: water	Organic Matter g Kg^{-1}	Calcium Carbonate g Kg^{-1}		CEC $Cmol_c$ kg^{-1}	DTPA-Mn mg Kg^{-1}
				Total	Active		
Mollisol	7.49	0.33	15.5	255.0	25.4	33.84	4.32
Vertisol	7.79	0.37	14.4	343.0	36.1	39.44	3.70

Influence Application of Organic Manure and Mn Individually and Combination on Vegetative Growth Characters

Table (2) indicates the influence application of organic manure and Mn on vegetative growth characters of wheat at ($P \leq 0.05$). Results show that plant height and flag leaf area were not response to the fertilizer application in both soil orders, while the number of tillers per plant and leaf chlorophyll content were significantly affected with organic manure and different levels of Mn application. The highest number of tillers per plant was (2.443), recorded with applied of (2% organic manure+20 mg Mn Kg^{-1}), whereas the minimum value was (1.553) recorded with applied (0% organic manure with 10 mg Mn Kg^{-1}) at Vertisol. The maximum value of leaf chlorophyll content before flowering in wheat was (36.843 CCI) recorded with applied (0% organic manure+15 mg Mn Kg^{-1}) in Vertisol. While the minimum value of chlorophyll was (27.610 CCI) obtained with applied level (2% organic manure with 10 mg Mn Kg^{-1}) at Mollisol release some of nutrient from the decomposition of organic manure in the soil, cause to increase growth characters. This result in agreement with result conducted by (Zeidan, 2007) who found that the application of organic manure had an effect on growth characters of wheat. (Zain et al., 2015) concluded that application of micronutrient effect on and have positive relationship with growth criteria of wheat.

Effect Application of Organic manure and Mn Individually and Combination on Reproductive Growth Characters

Data in Table (3) shows the effect of application organic manure and Mn on quantitative yield characteristics of wheat. It is clear that organic manure and Mn application have the significant different in all yield characteristics at ($P \leq 0.05$). The highest value of (Spike length, No. of grains per Spike, Grain yield, and Harvest Index) were (11.610 cm), (46.330), (35.693) and (40.140) observed with applied (0% organic manure+20 mg Mn Kg^{-1}), (0% organic manure+15 mg Mn Kg^{-1}), (2% organic manure+20 mg Mn Kg^{-1}), and (2% organic manure+20 mg Mn Kg^{-1}), respectively at Vertisol, whereas the lowest values (10.610 cm), (34.887), (21.123), and (29.180) obtained with applied (2% organic manure + 0 mg Mn Kg^{-1}), (0% organic manure +10 mg Mn Kg^{-1}), (2% organic manure +15 mg Mn Kg^{-1}) and (2% organic manre+20 mg Mn Kg^{-1}), respectively of Mollisol.

In Mollisol, the maximum values of 1000-grain weight and biological yield were (58.500) and (91.367) recorded with applied (0% organic manure+10 mg Mn Kg^{-1}) and (2% organic manure+10 mg Mn Kg^{-1}), respectively. While the minimum values observed (41.233) with applied (0% organic manre+5 mg Mn Kg^{-1}) of Mollisol and (66.740) with applied (2% organic manure+10 mg Mn Kg^{-1}) at Vertisol. In general, the (spike length, number of grains per spike and biological yield) values increased in Vertisol compared to Mollisol. This may due to the low content of organic matter in Vertisol (Table 1), adding organic manure to the soil with low organic matter content more beneficial (Binder *et al*., 2002). Additionally, farm yard manure functions as a natural soil conditioner, improving the soil's qualities and, as a result, its production (El-Ghamry *et al*., 2009). These results are in a harmony with those obtained by (Koutroubas *et al*., 2016).

Table (2): Influence of application of organic manure (%) and Mn (mg Kg^{-1}) in individually and combined on the vegetative growth characters of wheat plant

Soil type	Organic manure levels (%)	Mn levels (mg Kg^{-1})	Plant height cm	No. of tiller/ plant	Flag leaf area cm^2	Leaf Chlorophyll content before flowering CCI
Mollisol	0%	0	82.000 a	2.113 abc	23.287 a	29.830 cde
		5	80.667 a	1.890 abc	22.917 a	34.597 abc
		10	84.000 a	2.000 abc	24.280 a	30.473 bcde
		15	84.333 a	2.003 abc	27.043 a	33.350 abcd
		20	81.667 a	1.890 abc	26.047 a	31.410 abcde
	2%	0	81.000 a	2.003 abc	22.153 a	27.973 de
		5	82.667 a	2.223 abc	23.343 a	30.407 bcde
		10	84.333 a	2.333 ab	23.043 a	27.610 e
		15	80.667 a	1.670 bc	23.077 a	31.360 abcde
		20	84.000 a	1.780 abc	22.657 a	28.687 de
Vertisol	0%	0	84.333 a	2.113 abc	21.783 a	36.417 a
		5	84.000 a	2.330 ab	24.403 a	35.620 ab
		10	85.000 a	1.553 c	23.637 a	36.750 a
		15	83.000 a	1.890 abc	25.143 a	36.843 a
		20	81.000 a	1.780 abc	25.663 a	34.830 abc
	2%	0	85.000 a	2.333 ab	21.190 a	31.853 abcde
		5	81.000 a	2.000 abc	24.483 a	32.327 abcde
		10	78.000 a	2.000 abc	26.967 a	32.417 abcde
		15	80.667 a	2.110 abc	23.087 a	33.573 abcd
		20	80.000 a	2.443 a	23.107 a	32.753 abcde

Means in a column that are followed by the same letter are not significantly different according to Duncan's multiple range tests at ($p \leq 0.05$).

Effect of Organic manure and Mn Application Levels on Wheat Dry matter

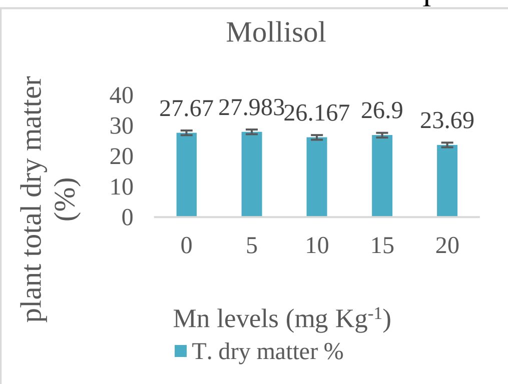
Figure (1,2,3 and 4) shows the effects of different levels of applied organic manure and Mn on total dry matter of wheat for two different soil orders. Application of different levels of Mn on the total wheat dry matter in Mollisol shows in Figure (1), the highest amount of wheat total dry matter was (27.983 %) achieved from applied 5mg Mn kg^{-1}, whereas the lowest total dry matter was (23.69 %) recorded from applied 20 mg Mn kg^{-1}. In Mollisol, application 2% organic manure combine with Mn levels, caused to increase total dry matter of wheat (figure 2). The maximum value of dry matter was (34.347 %) recorded from applied (20) mg Mn kg^{-1}, whereas the minimum mean value was (26.47 %) obtained from adding (0) mg Mn kg^{-1}. Figure (3) shows the effects of applied different levels of Mn on wheat dry matter in Vertisol, the values of wheat dry matter ranged between (24.977 and 29.417) %; the highest value was recorded in the treatment of application 20 g Mn Kg^{-1}, whereas the lowest value was obtained with application rate 20 mg Mn kg^{-1}. Application of organic manure at a 2% level with 15 mg Mn Kg^{-1} was associated with a significant increase in total wheat dry matter (figure 4), it was the highest value which significant with all other applied levels in Vertisol except (0% organic manure + (15 and 20) mg Mn Kg^{-1} and was significant with (0% organic manure + (10 and 20) mg Mn Kg^{-1} and (2% organic manure +0 mg Mn Kg^{-1}) of Mollisol. Also, the lowest value recorded with application of 2% organic manure with 20 mg Mn Kg^{-1}.

In general, the outcome demonstrates that in both studied soils type the total dry matter increase with the application of organic manure and Mn in combination. This may be due to the interaction of nutrient content in organic manure with each other and with Mn levels. In fact, the high manure application rate enhanced aboveground dry matter, a characteristic that is extremely important for the development of grain production in cereal crops, especially in Mediterranean climates (Koutroubas *et al*., 2012).

Table (3): Influence application of organic manure (%) and Mn (mg Kg^{-1}) individually and combination on reproductive growth characters

Soil type	Organic manure levels (%)	Mn levels (mg Kg^{-1})	Spike length (cm)	No. of grains/ Spike	1000-grain weight (g pot^{-1})	Grain yield (g pot^{-1})	Biological yield (g pot^{-1})	Harvest Index (%)
Mollisol	0%	0	11.277 abc	39.607 ab	42.000 b	21.160 b	68.813 ab	30.523 ab
		5	11.200 abc	41.777 ab	41.233 b	24.103 ab	67.183 b	33.453 ab
		10	11.110 abc	34.887 b	58.500 a	24.027 ab	73.977 ab	32.563 ab
		15	11.323 abc	43.167 ab	46.600 ab	28.377 ab	82.903 ab	33.833 ab
		20	11.520 ab	39.997 ab	45.000 b	26.570 ab	72.083 ab	36.967 ab
	2%	0	10.610 c	38.997 ab	47.200 ab	27.323 ab	79.857 ab	33.257 ab
		5	10.713 bc	36.497 ab	53.933 ab	27.790 ab	84.907 ab	33.697 ab
		10	11.000 abc	36.833 ab	48.000 ab	29.493 ab	91.367 a	31.580 ab
		15	11.063 abc	41.833 ab	48.400 ab	21.123 b	73.133 ab	28.990 b
		20	11.257 abc	38.333 ab	45.500 b	21.667 ab	74.437 ab	29.180 b
Vertisol	0%	0	10.923 abc	43.777 ab	47.933 ab	24.213 ab	78.827 ab	29.327 b
		5	11.233 abc	43.277 ab	45.267 b	32.060 ab	83.933 ab	37.907 ab
		10	11.177 abc	41.663 ab	50.067 ab	21.207 b	66.740 b	31.650 ab
		15	11.357 abc	46.330 a	43.233 b	24.920 ab	77.560 ab	32.080 ab
		20	11.610 a	40.553 ab	48.233 ab	24.977 ab	74.797 ab	32.230 ab
	2%	0	11.233 abc	44.667 ab	47.280 ab	34.623 ab	87.607 ab	39.040 ab
		5	11.033 abc	39.273 ab	48.167 ab	26.700 ab	77.410 ab	34.467 ab
		10	11.243 abc	36.443 ab	42.000 b	22.360 ab	71.927 ab	30.317 ab
		15	11.310 abc	43.773 ab	45.100 b	30.390 ab	86.567 ab	35.017 ab
		20	10.867 abc	40.443 ab	49.500 ab	35.693 a	88.810 ab	40.140 a

Means in a column that are followed by the same letter are not significantly different according to Duncan's multiple range tests at ($p \leq 0.05$).



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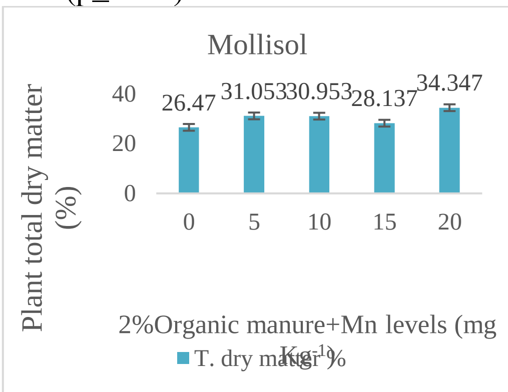

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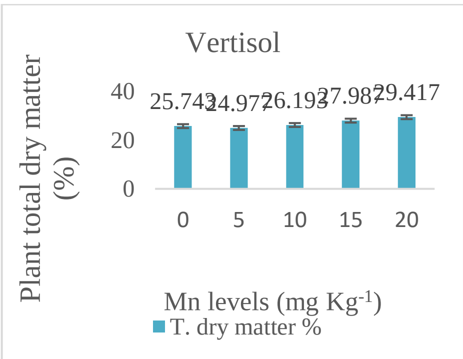

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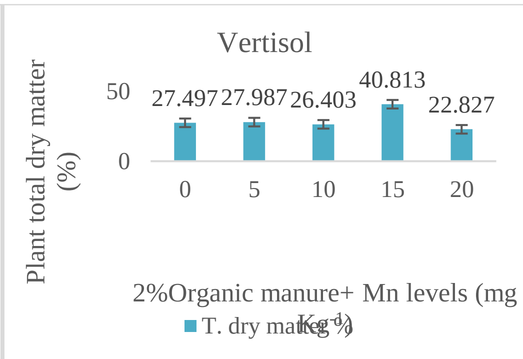

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Figure (1,2,3,4) Effect of different levels of organic manure (%) and Mn (mg Kg^{-1}) application on wheat total dry matter (%) in studied soils

CONCLUSION

We investigated wheat respond of organic manure and Mn application for two soil orders Mollisols, and Vertisols in the Sulaimani-Kurdistan Region of Iraq. Wheat growth and reproductive characters differed with fertilizers application and between the studied soil orders. Leaf chlorophyll content, number of tillers per plant and all reproductive characters in both soil orders were significantly affected with applied 2% of organic manure and different levels of Mn, while plant height and flag leaf area were not affected significantly by the application. As a result, the wheat planted in the Bakrajo (Vertisol) responded the strongest to application of organic manure and Mn fertilizer as $MnSO_4$. The highest total dry matter of wheat was observed with application of (2% organic manure and 15 mg Mn Kg^{-1}) in the Bakrajo (Vertisol). The highest total dry matter of wheat in the New Halabja (Mollisol) was observed with application rate of (2% organic manure and 20 mg Mn Kg^{-1}); this may due to improve soil physical and chemical properties with utilizing organic manure, then increase crop quality and wheat grain yield (Zeidan, 2007). Future studies could benefit for determine the critical level of Mn for wheat in the Sulaimani-Kurdistan region.

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استجابة القمح (Triticum aestivum L.) للتسميد العضوي ومستويات المنغنيز في رتبتين مختلفين للتربة

باخان حمه رسول قادر **شعلة محمد شيخ عبدالله**

قسم الموارد الطبيعية، كلية علوم الهندسة الزراعية، جامعة السليمانية

الكلمات المفتاحية:
السماد العضوي ، سماد المنغنيز ، نمو القمح ، تربة موليسول ، تربة فرتيسول.

الخلاصة

أجريت هذه الدراسة للتحقق من تأثير السماد العضوي ومستويات مختلفة من المنغنيز على نمو القمح والمحصول في رتبتين مختلفتين من التربة (موليسول و فرتيسول) في السليمانية - إقليم كردستان العراق. أجريت تجارب اصيص خلال المدة من 12 نوفمبر 2021 إلى 10 مايو 2022 بمستويين من السماد العضوي (روث الأغنام) (0 و 2٪) وخمسة مستويات مختلفة من المنغنيز(0، 5، 10، 15و 20 ملغم كـ($MnSO_4.H_2O$) لكل غم تربة. أجريت التجربة باستخدام التصميم العشوائي العاملي الكامل بثلاث تكرارات. تم تقييم خصائص النمو والتكاثر والمادة الجافة الكلية. أظهرت النتائج أن إضافة السماد العضوي والمنغنيز قد أثرت في صفات نمو القمح باستثناء ارتفاع النبات (سم) ومساحة ورقة العلم (سم^2). بينما تأثرت جميع الصفات الحاصل والانتاج معنويا باضافة السماد. زاد إجمالي المادة الجافة مع اضافة مستويات السماد العضوي والمنغنيز في كل من رتبتي التربة. في تربة فرتيسول ، تفوق إجمالي المادة الجافة (40.813٪) عن معظم مستويات الاخرى.