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IMPACT OF COMPOST AND METHODS OF POTASIUM HUMATE APPLICATION ON WHEAT

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ABSTRACT: *Two field experiments were carried out at the farm of EL-Gemmiza, Agric. Res. Station, Agric. Res. Centre. in two successive winter seasons of 2012/2013 and 2013/2014. The main targets of these experiments were to study the soil application of compost and evaluation of some methods of K-humate addition on wheat productivity as well as some nutrient contents and nitrogen use efficiency (NUE). Split plot design with three replicates was used.The main plots were assigned for two rates of compost soil application (0 and 20 m^3/fed) while, the sub plots were occupied by four methods of K-humate addition i.e. without addition, grain coating or soaking in 1% k-humate foliar spraying or soil application both at 1 or 2 L fed^{-1}. The obtained results revealed the following important topics. 1-The application of compost significantly increased the wheat grain and straw yields and their contents of N,P,K and grain protein as well as NUE. 2-The addition of K-humate generally had enhancing effects on wheat productivity and improved its nutrient contents and NUE. The highest values were recorded by soil addition of K-humate at 2L fed^{-1} followed by its spray at a rate of 1L fed^{-1}. Meanwhile, the treatments of grain coating and soaking achieved the least increments compared with the control treatment. 3- The addition of both compost and K-humate simultaneously gave the highest increments of all the yield and nutritive characters and NUE in comparison with their additions singly. In this concern, the soil application of 20 m^3 compost together with 2 L fed^{-1} K-humate had the superior impact. In brief, the productivity of wheat yield and its nutritive values as well as NUE can be improved through the soil application of compost and K-humate at levels of 20 m^3 and 2 L fed^{-1}, respectively in a dual treatment.*

Key words: *compost, K-humate, wheat, grain, straw, NUE*

INTRODUCTION

Wheat (Triticum aestivum L.) enjoys a privileged position amongst food grain crops in the world in general and particularly in Egypt where it serves as a staple food for the majority of the population. In Egypt, wheat yield per feddan is far below the inherent potential of the existing promising cultivars. As a result, wheat cultivated area reached, in year 2008, about 1.2 million hectare, produced only about 7.9 million ton (FAO, 2008). Such production does not meet the actual consumption and the rapid increase in the population demands. Among the various determining factors, soil fertility status is of prime importance. Hence, under the prevailing condition, restoration and maintenance of soil fertility is a basic and critical problem. This can be accomplished by adding organic materials and humic substances. Compost has a high nutritional value, with high concentrations of N, P and K and very low concentrations of heavy metals and other toxic substances (Youssf, 2011 and EL-Sayed, 2012). It also improves soil physical characteristics (soil structure, aggregate stability, soil infiltration rate as well as water holding capacity) and soil chemical properties particularly decreasing its pH value and thus increasing the availability of soil nutrients for the plants (Sarwar, 2005 and Sarwar *et al.,* 2007). As a result of all previous processes, various yield components were positively affected and reflected on both grain and straw yields (Sarwar, 2005). Organic manure also increased the wheat productivity by 105 to 128 %, relative to the control (Youssef, 2011; EL-Sayed, 2012 and Youssef *et al.,* 2013).

Humic substances have positive impacts on the soil structure and plant growth. They can directly or indirectly affect the physiological processes of plant growth by promoting the uptake of both macro-and micronutrients and affecting the biochemical substances, carring nutrients and growth regulators , increasing the microorganisms population and acting as hormone like substances (Verlinden *et al.,* 2009). Humic substances also enhanced the water retention, the ability rate of leaves for photosynthesis process, the seed filling intensity, the drought resistance of plants and the chelating agent through active groups of macronutrients and forming organo-metalic complexes which are considered as a storehouse and more mobile or available to be taken up by plant and in turn reflected positively on development yield of seed and straw and their attributes (Rafla, 2012). Soil addition of K-humate also increases the soil organic matter content, soil available water and EC value; however, pH value declines (Rafla, 2012). Humic substances as foliar sprays can also promote greater root and shoot growth, root branching, leaf chlorophyll content as well as rates of nutrients uptake, photosynthesis and respiration. Yet, Habashy and Aly (2005) observed that wheat grain soaking in K-humate solution had a superior effect on germination characteristics and emergence.

Therefore, the main targets of the current investigation are increasing the grain and straw yields of wheat and improving their qualities through the addition of compost and K-humate singly or in combination. Evaluation of different methods of K-humate application was also taken into consideration as a sake of selecting the best method which achieve the highest yield with better quality.

MATERIALS AND METHODS

Two field experiments were conducted at the experimental farm of EL-Gemmiza, Agric. Res. Station, Agric. Res. Center, EL-Gharbiah governorate, Egypt during the two successive winter seasons of 2012/2013 and 2013/2014 .The physical and chemical properties of the soils under investigation are presented in Table 1 (a and b) were determined according to the standard methods reported by Hesse (1971).

Each experiment included fourteen treatments which were the combinations of two compost treatments and seven treatments of potassium humate. Chemical composition of the compost used is carried according to Jackson (1958) and presented in Table (2).

Table (1): Mechanical and chemical characteristics of the soils under investigation

a) Physical analysis

Seasons	$CaCO_3$ (%)	OM (%)	Particle size distribution(%)				Texture class
			Course Sand	Fine Sand	Silt	Clay	
1st	1.85	2.01	2.00	13.30	44.70	40.00	Clay Loam
2nd	1.92	2.11	2.21	13.99	46.10	37.7	Clay loam

b) Chemicale analysis

Seasons	pH (1:2.5) Soil :Water Suspension	EC_e (dSm^{-1}) Soil paste extract	Soluble ions in soil paste extract ($m.eL^{-1}$)								Available nutrients($\mu g\ g^{-1}$)		
			Cations				Anions						
			Na^+	K^+	Ca^{2+}	Mg^{2+}	CO_3^-	HCO_3^-	Cl^-	SO_4^{2-}	N	P	K
1st	7.9	2.2	7.19	2.63	7.25	6.04	-	9.30	9.6	4.21	73	9.6	439
2nd	7.8	2.1	9.56	1.44	5.2	4.8	-	9.6	7.57	3.83	71	9.0	419

Table (2): Chemical composition of the tested compost :

Seasons	N (%)	Organic Carbon (%)	C/N	pH (1:5)	EC (1:10)	P (%)
1st	0.7	16	23/1	6.69	7.3	0.07
2nd	0.8	17	21/1	6.72	8.9	0.05

The layout of each experiment was split plot design with three replicates. Each replicate was divided into two main plots. The first was fertilized with 20m^3 compost fed^{-1} while, the other one was non composted. Each main plot was randomly subdivided into seven sub plots representing the different treatments of K- humate in a liquid form (10% K_2O) as the following:-

I Without the addition of K-humate (control).

II Grain coating with 1% K-humate solution in the presence of adhesive agent (Triton B).

III Grain soaking with 1% K-humate solution for 24 hours.

IV Foliar spraying with 1 L K-humate fed^{-1}.

V Foliar spraying with 2 L K-humate fed^{-1}.

VI K-humate sprayed on the soil surface at a rate of 1L fed^{-1}.

VII K-humate sprayed on the soil surface at a rate of 2L fed^{-1}.

Treatments of grain coating and soaking were performed directly before planting, while, the above mentioned rates of foliar spraying were used per 200 L water and then sprayed on wheat plants at 35 days old. On the other hand , treatments of soil addition were added per 200 L water and sprayed on the soil surface beside the raws of grains after planting and directly before irrigation. Basic applications of N, P and K were applied to all plots i.e.,75 kg N, 15 kg P_2O_5 and 24 kg K_2O fed^{-1} in the forms of urea (46%N), single superphosphate (15% P_2O_5) and potassium sulphate (48%K_2O), respectively. The other usual agronomic processes of wheat plants were practiced.

The wheat grains variety (Gemiza 9) at the rate of 60 kg fed^{-1} were drilled in rows of 15 cm apart within plots of 3 x 3.5 m on 25th and 21st November, at the 1st and 2nd seasons, respectively.

At harvesting, a sample of 20 plants from each plot was randomly chosen to calculate 1000 grain weight. Grain, straw and biological yields were recorded on plot basis, then, they were estimated as ton fed^{-1}. N, P and K percentages of both wheat grain and straw were determined in wet digested extract using the methods described by Chapman and Partt (1961). Values of N, P and K uptake in both grains and straw were also estimated as kg fed^{-1}. Crude protein in grains (kg fed^{-1}) was determined by multiplying the values of N-content in grains (kg fed^{-1}) by 5.7, according to (A.O.A.C., 2000). Nitrogen use efficiency was calculated as kg grain yield /kg of N added according to (Dobermann 2007). Combined analyses for the two growing seasons were statistically analyzed according to Gomez and Gomez (1984). The significant differences among the means of the two seasons were tested using the least significante difference (L.S.D) at the 5% level of significance.

RESULTS AND DISCUSSION

The present study aimed to improve the wheat productivity and raise the use efficiency of N-fertilization for wheat plants through the addition of compost and potassium humate. So, data attained herein included the influence of compost soil application and some methods of K-humate application and their possible combinations on wheat grain, straw and biological yields as well as their nutrient contents. Yet, protein content in grains and nitrogen use efficiency (NUE) were also taken into consideration.

1-Effect of compost application

Data obtained in Table (3) revealed that the application of compost caused significant increases for 1000 grain weight as well as grain, straw, and biological yields. In this concern, the relative increases compared to the control treatment (non composted) were 21.7, 19 and 20.1% for grain, straw and biological yields, respectively. These increases may be due to:

1- Soil application of compost increases the soil organic matter percentage that has been regarded a key factor determining soil fertility and productivity (Sarwar *et al.,* 2007).

2- The addition of compost improves the physical properties of the soil and decreases its pH value. As a result, the availability of soil nutrients for plants increased and various yield components were positively affected and ultimately these components contributed twards increasing of grain and straw yields (Sarwar, 2005).

3- Compost supports the plants with macro- and micronutrients needed for their growth. Additionally, Table (3) also refer that contents of N, P and K (kg fed^{-1}) in both wheat grain and straw were also significantly increased with the soil addition of compost .In comparison with the control treatment, the relative increases of N- content in both grain and straw were 37.2 & 41.4%. The corresponding increments in P and k contents were 32.2 & 28.4% and 26.7& 40.7 %,respectively . Grain protein content was also increased as a result of compost soil application by 37.3% compared with the non composted treatment. The enhancing impacts of compost on N, P and K contents could be explained as the following:

1- Mineralization of compost and slow release of minerals in available forms due to effects of several organic acids produced during compost decomposition (Sofidkoohi *et al.,* 2012).

2- Compost application decreases N-losses caused by volatilization, leaching and denitrification by binding to nutrients and releasing with the passage of time (Sofidkoohi *et al.,* 2012). Compost also increases both soil microbial biomass and soil enzymatic activities which release P and other nutrients from the organic materials.

Yet, the promoting impact of compost on protein content of grains is mainly attributed to the good supply and positive effect of N-uptake by wheat which encourages greater uptake of the other available macronutrients. These results are in harmony with those reported by Youssef (2011) and EL-Sayed (2012).

2- Effect of application methods of potassium humate:

Data attained in Table (4) represent the values of wheat 1000-grain weight, straw and biological yields as well as their nutrients contents beside protein content in grains as affected by different methods of K-humate application. It is obvious that all previous characteristics were positively affected with the addition of K-humate in different methods. In this context, soil application of K-humate at the level of 2 L fed^{-1} achieved the highest values followed by its foliar spraying at the level of 1 L fed^{-1}. Meanwhile, the treatments of both seed coating and soaking recorded the least increments. The relative increases of grain yield compared to the control treatment due to the addition of the k-humate treatments from II to VII were 29, 45.7, 66.7, 57.4, 56.2 and 84.6%, respectively. The corresponding increments for straw yield were 13, 20.2, 52.2, 41.9, 28.5 and 53% as well as 19.3, 30.1, 57.8, 48, 39.3 and 65.3 for biological yield, respectively.

The results of soil application of K-humate go parallel with those obtained by Michael (2001) and Rafla (2012) who attributed the enhancing impact of K-humate addition to the soil on wheat yield to :

1- Increasing of the root absorptive surface through an ordered remodeling of the root morphology change the root area, primary root length, number of lateral roots and lateral root density.

Table 3 , 4

2- K-humate acts like auxins and gibberellins exhibiting high amounts of phenolic and carboxyl groups as a result, metabolic processes become better, raises the efficiency of plants to water uptake, increases the ability rate of leaves for photosynthesis process and seed filling intensity. Hence, it causes a faster development and the plants reach reproductive stage earlier than the control. As a result, the seed weight percentage as well as grain, straw and biological yields were increased. On the other hand, the promoting impact of soil application of K-humate on the nutrient contents may be attributed to:

1- It enhances the chelating agent by active groups and forming organo-metalic complexes which are considered as a storehouse and more mobile or available for uptake by plants (Salib, 2002).

2- It enhances cell permeability, which in turn gives a more rapid entry of minerals into root cells and so resulted in higher uptake of plant nutrients. This effect was associated with the functions of hydroxyls and carboxyls groups in these compounds (Michael, 2001). Yet, it reduces oxygen deficiency in plants,which results in better uptake of nutrients.

3- It enhances the use efficiency of the applied N-fertilizers, sustains the flow of ammonical nitrogen for a long time, increases P-uptake as a result of forming hemophosphate complexes which could be easily available by plants and causes highly root system growth which would have led to more nutrients uptake by providing better means for greater absorption (Salib, 2002 and Rafla, 2012).

Furthermore, the effective role of foliar spraying method on both wheat grain and straw yields and their nutrient contents could be ascribed to that humic molecules can get into the cellular nutrient stream and make the cellular membrane more permeable allowing the improvement of nutrient flow and cell divition (Allam, 2006).

It is also worth mentioning that the augments of wheat grain and straw yields as well as their nutrient contents due to addition of K-humate through grain coating or soaking may be due to their affect on germination characteristics and emergence of wheat grains (Habashy and Aly, 2005). They attributed the enhancing impact of grain soaking method to hydrolysis of complexes into simple sugars which are readily utilized in the synthesis of auxins and proteins. They added that the auxins produced help to soften cell walls to facilitate growth and proteins readily utilized in the production of new tissues.

Table (4) also revealed that protein content in wheat grains and nitrogen use efficiency (NUE) of the added N-fertilizer were positively elevated by the addition of different methods of K-humate. In this contex, soil application of 2L K-humate fed^{-1} achieved the highest values followed by its foliar spray at the rate of 1L fed^{-1} .In comparison with the control treatment, the relative increments in protein content were : 80.2, 66.1, 150.2, 170.5, 138 and 400.5% for the treatments from II to VII, respectively.while, the corresponding relative increases of NUE were: 29.17, 45.83, 66.2, 57.41, 56.48 and 84,26%. These results are in good agreement with those obtained by Salib (2002); Lamont (2003) and Ralfa (2012) who found that, the application of humic acid had a definite impact on the yield and nutrients uptake as well as protein and nucleic acids contents.

3- Interaction effect of compost and application methods of K-humate

Data presented in Table (5) show the effect of different methods of K-humate under the two studied treatments of compost application on 1000-grain weight, wheat grain and straw yields as well as their total N, P, K and protein contents in addition to nitrogen use efficiency (NUE). It is well observed that the addition of K-humate in combined with compost generally further enhanced all the previous characteristics compared with the addition of the two investigated factors singly. For all the studied characters, the soil additions of $20m^3$ compost and 2 L fed^{-1} K-humate simultaneously recorded the highest

Table 5

increments followed by the dual treatment of compost and foliar spraying of 1L fed^{-1} K-humate. Meanwhile, the combination of K-humate as grain coating or soaking with compost gave the least increases compared with the control having neither compost nor K-humate application .These results clearly reveal that both factors under investigation act singly, as mentioned before, and their dual applications gave additional enhanced impacts for all the studied parameters.

CONCLUSION

Soil application of compost and K-humate at levels of $20m^3$ and 2L fed^{-1}, respectively in a dual treatment achieved the superior impact and recorded the highest values of wheat grain and straw yields as well as their N, P, K and protein contents in addition to nitrogen use efficiency (NUE) rather than their applications singly since, soil additions of both compost and humic acid increase the quantities of wheat grain and straw yields, improve their quantities and raise the use efficiency of the added N-fertilizer.

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تاثير الكمبوست و طرق اضافه هيومات البوتاسيوم على القمح

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معهد بحوث الاراضى و المياه و البيئه – قسم يحوث خصوبه الاراضى و تغذيه النبات

الملخص العربى

أجريت تجربتان حقليتان بمزرعه محطه البحوث الزراعيه بالجميزه – محافظه الغربيه– مصر خلال الموسمين الشتويين ٢٠١٣/٢٠١٢ , ٢٠١٤/٢٠١٣ لدراسه تاثير الاضافه الارضيه للكمبوست و تقييم بعض الطرق لاضافه هيومات البوتاسيوم ($10\%K_2O$) علـى انتاجيـه القمـح (محصـولى الحبـوب و القـش) ومحتـوى كليهمـا مـن النيتروجين و الفوسفور و البوتاسيوم و كذلك محتوى الحبوب من البروتين و كفاءه استخدام النيتروجين .

استخدم تصميم القطع المنشقه فى ثلاث مكررات حيث شغلت القطع الرئيسيه بمعاملتى الاضافه الارضيه للكمبوست :- ١- بدون اضافه (كنترول) - ٢- اضافه بمعدل ٢٠م٣ /فدان.

اما الطرق المختلفه لاضافه هيومات البوتاسيوم فقد تم توزيعها عشوائيا فى القطع المنشقه فى سبع معاملات هى بدون اضافه, تغليف ونقع الحبوب, الرش الورقى والارضى لمحلول هيومات البوتاسيوم بمعدل ١ و ٢ لتر/فدان لاى منهما.

وقد أجريت معاملات التغليف و النقع فى محلول هيومات البوتاسيوم بتركيز ١% قبل الزراعه مباشره و كذلك اضيفت المعاملات الارضيه برش محلول هيومات البوتاسيوم (بتركيز ٢،١ لتر/٢٠٠ لتر/فدان)بجوار صفوف زراعه الحبوب بعد الزراعه و قبل الرى مباشره اما معاملات الرش الورقى فقد تمت بعد ٣٥ يوم من الزراعه بنفس معدلات الرش الارضى.

و قد اشارت النتائج الى النقاط الهامه الاتيه :-

١- ادت اضافه الكمبوست الى زياده محصولى الحبوب و القش للقمح و زياده محتواها من النيتروجين و الفوسفور و البوتاسيوم و ايضا زياده محتوى الحبوب من البروتين .

٢- اضافه هيومات البوتاسيوم بجميع الطرق المختبره ادت الى زياده الانتاج الكمى لمحصولى الحبوب و القش و ايضـا تحسـين قيمتهمـا الغذائيـه و محتـوى الحبـوب مـن البـروتين. و قـد تحققـت اعلـى القـيم لجميـع الصـفات

المدروسه عند الاضافه الارضيه لمحلول هيومات البوتاسيوم بمعدل ٢لتر/فدان تلاها طريقه اضافه هيومات البوتاسيوم رشا على النبات بمعدل ١لتر/فدان. اما معاملات التغليف و النقع للحبوب قبل الزراعه فقد تحققت معهما اقل الزيادات مقارنه بمعامله الكنترول (بدون اضافه هيومات البوتاسيوم).

٣- اضافه الكمبوست و هيومات البوتاسيوم معا حققت افضل الزيادات فى جميع الصفات المحصوليه و الغذائيه المدروسه مقارنه باضافه اى منهما منفصله، و فى هذا الصدد حققت المعامله الارضيه لكل من الكمبوست و هيومات البوتاسيوم (بمعدل ٢لتر/فدان) الصداره فى تحقيق اعلى محصول كمى للحبوب و القش و رفع قيمتهما الغذائيه.

٤- كان لاضافه اى من الكمبوست او هيومات البوتاسيوم تاثيرا ايجابيا على زياده استفاده النباتات من التسميد النيتروجينى المضاف و قد تحققت أعظم استفاده عند اضافتهما معا للتربه خاصه عند الاضافه الارضيه لهيومات البوتاسيوم بمعدل ٢لتر /فدان.

ومن ثم يمكن القول انه يمكن الحصول على اعلى محصول كمى لحبوب و قش القمح و تحسين قيمتهما الغذائيه و كذلك رفع معدل الاستفاده من التسميد المعدنى النيتروجينى المضاف من خلال الاضافه الارضيه للكمبوست وهيومات البوتاسيوم معا بمعدلى ٢٠م^{٣}, ٢لتر/فدان على التوالى.

Table 3: Effect of compost on the yield and some nutrients contents of wheat plants (combined analysis of 2012/ 2013 and 2013 / 2014 seasons).

Compost (m^3 fed^{-1})	1000 - grain weight (g)	Yield (ton fed^{-1})			Nutrient contents (kg fed^{-1})									Grain protein content (kg fed^{-})	Nitrogen use efficiency (NUE)
					N			P			K				
		grain	straw	Biological	grain	straw	total	grain	straw	total	grain	straw	total		
0	68.11	2.17	3.0	5.17	34.97	19.2	54.17	12.48	0.81	13.39	16.95	38.46	55.41	199.21	29.00
20	77.72	2.64	3.57	6.21	47.99	27.15	75.14	16.5	1.04	17.54	21.48	54.11	75.59	273.56	35.1
F.test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

Table 4: Effect of application methods of K-humate on the yield and some nutrient contents of wheat plants (combined analysis of 2012/2013 and 2013/2014 seasons).

*Methods of K-humate application	1000 grain weight (g)	Yield (ton fed^{-1})			Nutrient contents (kg fed^{-1})									Grain protein content (kg ed^{-1})	Nitrogen use efficiency (NUE)
					N			P			K				
		grain	straw	Biological	grain	straw	total	grain	straw	total	grain	straw	total		
I	52.7	1.62	2.53	4.15	17.02	14.03	31.05	9.17	0.49	9.66	12.23	33.12	45.35	97.02	21.6
II	63.48	2.09	2.86	4.95	30.68	20.06	50.74	12.27	0.69	12.96	16.39	40.1	56.49	174.85	27.9
III	67.97	2.36	3.04	5.4	28.28	21.17	49.45	13.79	0.71	14.5	18.39	42.52	60.91	161.16	31.5
IV	82.71	2.7	3.85	6.55	42.64	27.78	70.42	16.3	1.02	17.32	21.53	54.06	75.59	242.73	35.9
V	77.09	2.55	3.59	6.14	46.05	26.38	72.43	15.76	1.21	16.97	20.63	51.34	71.97	262.48	34.0
VI	73.82	2.53	3.25	5.78	40.51	23.26	63.77	15.43	0.97	16.4	20.31	46.22	66.53	230.88	33.8
VII	92.66	2.99	3.87	6.86	85.19	29.58	114.77	18.71	1.39	20.1	25.01	56.65	81.66	485.58	39.8
LSD 5%	2.69	0.23	0.15	0.28	5.33	1.16	5.56	1.45	0.09	1.45	1.89	1.92	2.87	30.40	3.112

* I Without the addition of K-humate (control). II Grain coating with 1% K-humate solution in the presence of adhesive agent (Triton B). III Grain soaking with 1% K-humate solution for 24 hours. IV Foliar spraying with 1 L K-humate fed^{-1}. V Foliar spraying with 2 L K-humate fed^{-1}. VI K-humate sprayed on the soil surface at a rate of 1L fed^{-1}. VII K-humate a sprayed on the soil surface at a rate of 2L fed^{-1}

Table 5: Yield and contents of some nutrients for wheat plants as affected by the interaction between compost and application methods of K-humate (combined analysis of 2012/2013 and 2013/2014 seasons)

Compost (m^3 fed^{-1})	*Methods of K-humate application	1000 grain weight (g)	Yield (ton fed^{-1})			Nutrient contents (kg fed^{-1})									Grain protein content (kg fed^{-1})	Nitrogen use efficiency (NUE)
						N			P			K				
			grain	straw	Biological	grain	straw	total	grain	straw	total	grain	straw	total		
O	I	48.17	1.39	2.37	3.76	14.48	12.07	26.55	7.71	.43	8.14	10.24	29.34	39.57	82.56	18.57
	II	58.88	1.93	2.56	4.49	27.39	16.08	43.47	11.01	.61	11.62	14.74	32.55	47.29	156.1	25.73
	III	63.66	2.18	2.73	4.91	24.67	17.36	42.03	12.36	.64	13	16.5	34.53	51.03	140.6	29.06
	IV	79.07	2.37	3.59	5.96	34.75	23.81	57.56	13.67	.92	14.59	18.4	45.94	64.34	197.43	31.59
	V	72.48	2.36	3.19	5.55	35.48	21.17	56.65	13.82	1.03	14.85	18.54	41.07	59.61	202.25	31.42
	VI	69.03	2.32	2.97	5.29	34.71	19.28	53.99	13.55	.85	14.4	18.51	38.17	56.68	197.83	30.97
	VII	85.52	2.66	3.57	6.23	73.28	24.65	97.93	15.23	1.22	16.45	21.75	47.63	69.38	417.68	35.50
2O	I	57.23	1.84	2.68	4.52	19.56	15.98	36.54	10.63	.55	11.18	14.21	36.89	51.1	111.47	24.57
	II	68.07	2.25	3.16	5.41	33.96	24.04	58	13.52	.77	14.29	18.03	47.64	65.67	193.59	30.04
	III	72.32	2.55	3.36	5.91	31.88	24.98	56.86	15.22	.78	16	20.28	50.51	70.79	181.72	33.95
	IV	86.34	3.02	4.1	7.12	50.53	31.74	82.27	18.93	1.12	20.05	24.66	61.18	85.84	288.02	40.26
	V	81.69	2.74	3.98	6.72	56.61	31.59	88.2	17.7	1.38	19.08	22.74	61.61	84.33	322.7	36.52
	VI	78.6	2.74	3.52	6.26	46.3	27.24	73.54	17.3	1.09	18.39	22.1	54.27	76.37	263.9	36.52
	VII	99.8	3.31	4.17	7.48	97.1	34.5	131.6	22.19	1.56	23.75	28.36	65.66	94.02	553.47	44.12
LSD 5%		2.67	0.33	0.21	0.39	7.54	1.64	7.86	2.05	.13	2.05	2.67	2.71	4.05	43.0	4.420

* I Without the addition of K-humate (control). II Grain coating with 1% K-humate solution in the presence of adhesive agent (Triton B). III Grain soaking with 1% K-humate solution for 24 hours. IV Foliar spraying with 1 L K-humate fed^{-1}. V Foliar spraying with 2 L K-humate fed^{-1}. VI K-humate sprayed on the soil surface at a rate of 1L fed^{-1}. VII K-humate sprayed on the soil surface at a rate of 2L fed^{-1}