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DYNAMIC ANALYSIS OF COMPOSTED MATERIAL AND ITS RELATION TO NUTRIENTS RELEASE

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ABSTRACT: ***This experiment was carried out in Faculty of Agriculture, Menofiya University to study the possibility of composting organic wastes such as rice straw (RS), maize stalk (MS), nutritional products refuse (NPR), farmyard manure (FYM) and poultry manure (PM), with or without mineral fertilizers and evaluate the physical and chemical changes that occurred during the decomposition process. Three piles were made. Pile A was a mixture of RS, MS, PM and NPR (as organic activators) at ratio 2:1:1:1/2 by weight respectively. Pile B mixture of RS, MS, FYM and NPR (as organic activators) at rate 2:1:1:1/2 by weight respectively. Pile C mixture of RS, MS at the rate 2:1, 10% of farm yard manure, 5% of urea and 1 % super phosphate which used as chemical activators. The values of bulk density, electrical conductivity and cation exchange capacity of the composted material were significantly increased with the increase of composting periods. The pH values were slight decreased, thereafter tented to be increased to reach maximum pH values of 8.94, 8.52 and 8.20 after 8 weeks of piles A, B and C respectively. However a decrease again was induced in pH values after 60 days of incubation. The changes in organic carbon, organic matter and C/N ratio showed a significant decrease gradually with the increase of composting periods. The values of total-N were significant increased from 1.6, 0.98 and 1.63 % at the first turning to 2.26, 1.64 and 2.40 % after 120 days of composting for piles A, B and C respectively. Available macro and micronutrients contents (mg/kg) were augmenting linearly with elongation the periods of composting. All of the determined parameters were significantly affected with the period of composting.***

Key words: ***Organic materials. Physical and chemical properties. Compost maturity.***

INTRODUCTION

Recently, under Egyption conditions, there are many kinds of organic agriculture wastes, which cause many environment problems such as the black cloud as the results to burn rice straw. On the other hand, there is intensive utilization of chemical fertilizers in cultivation of short seasonal crops which led to increase the pollution in soil, water, air and food, so on harmful the human being health. The utilization of agricultural wastes in

producing organic fertilizers under aerobic condition convert are minimize the environment pollution and overcome the organic matter deficiency. Composting is based on the decomposition of organic matter by microorganism under aerobic conditions. The composting process of organic materials prior to application is recommended to control of the spread of plant pathogens and weeds, to minimize the production of phototoxic substances, to improve storage and handing, to reduce unpleasant odors and biodegrade hazardous waste by mean of composting process (Marchesini *et al.,* 1988). Evaluation of the maturity of compost has been widely recognized as one of the most important problems concerning the composting process and the applications of this product to the soil. Many of the methods have been proposed to establish the degree of maturity. They may be grouped into physical, chemical and biological changes (Jimenez and Garcia, 1989). Physical changes such as temperature and bulk density give only rough information of the state of compost maturity. Rynk *et al.* (1992) reported that, composting led to a volume reduction of one-quarter to more than one- half of the initial volume; so that the bulk density value was increased significantly also Abd El- Wahab (1999) found that, the bulk density increased with the time of studied heaps compost. These increases were high significant by progressing the decomposition time from 15 to 60 days. Also Allam (2005) indicated that, the increase in bulk density is due to the reduction of raw materials volume as result of breaking down the original material, and as a consequence losses of CO_2 and water to atmosphere. Kaloosh (1994) indicated that, the C/N ratio tended to decrease with time. This was due to gaseous loss carbon as CO_2, while the nitrogen remained more tightly bound in organic combination. Also, Kenawy, Mona (2003) found that, the C\N ratio was decreased from 46.84 to 14.34 and from 48.48 to 19.30 in both acedic and anacedic heap. Similar findings were reported by Allam (2005) and Nasser (2007), on other composting materials. Wong *et al.* (2001) studied the co-composting of soybean residues and leaves and effect of turning frequency in compost quality. They found that, the changes in pH for the different piles followed the same trend with a slight decrease from the range of 6.1-6.8 to 5.3-6.1 in the first day. This was due to the decomposition of organic matter and production of organic and inorganic acid by the activities of microorganisms in soybean residues and leaves. The study of Abou El-Naga *et al.* (1997) showed a slight decrease in the pH values 6.5 in the first week and 6.2 in the second week and then they gradually turned to there neutral level which were higher in the case of farm residual compared with urban wastes. Kenawy, Mona (2003) reported that, CEC increased from 36.22, 35.40 to 74.10, 78.15 meq/100g in two pile composting after 120 days. Similar findings were reported by Allam (2005) where who found that, the CEC values of five piles varied in their compositions were increased from 37.10, 38.70, 31.30, 33.60 and 36.80 meq/100g dry weight at the initial time to 69.3, 77.10, 70.90, 78.20

and 75.60 meq/100 g dry weights, respectively after 16 weeks of the composting process. Kenawy, Mona (2003) found that, the content of available N, P and K increased during the composting process of the heap from at initial 139.00, 239.00 and 517.33 mg/kg to 1171.00, 490.17 and 832.33 mg/ kg at the end of composting process respectively. Moreover, she found an increase in micronutrients availability during the composting process of Fe, Zn, Mn and Cu. Also Nasser (2007) reported that an increase of macro and micronutrients during the composting process in three heaps, this increase may be attributed to decomposition and mineralization of organic materials.

The objective:-

The present study was carried out to achieve the main objective that represented by decreasing the environmental pollution throughout utilization some used of organic wastes (rice straw and maize stalk which caused an Egyptian wide environmental problems) as an organic fertilizer. As well as to reach the most beneficial combination from mineral and organic fertilizers for achieving the maximum yield of both wheat and maize yield grown on the sandy and alluvial soil.

MATERIALS AND METHODS

Three piles (A, B and C) were made from mixture of chopped rice straw, maize stalk, refuse of nutritional products factory. Pile A was a mixture of RS, MS, PM and NPR (as organic activators) at ratio 2:1:1:1/2 by weight respectively. Pile B was a mixture of RS, MS, FYM and NPR (as organic activators) at rate 2:1:1:1/2 by weight respectively. Pile C was a mixture of RS, MS at the rate 2:1, 10% of farm yard manure, 5% of urea and 1 % super phosphate which used as chemical activators. The chemical analysis of the used organic wastes was carried out according to Cottenie *et al.* (1982) and the obtained data were shown in Table (1).

Table (1): Organic wastes content of some nutrients.

Nutrients / Organic wastes	T.C	OM	T.N	C/N ratio	T.P %	T. Fe	T.Mn	T. Zn
	%					mg/kg		
Rice straw	48.08	82.80	0.63	76.32	0.088	527.0	260	76
Maize stalk	49.59	85.50	0.70	70.84	0.110	440	80	30
Farmyard manure	31.56	54.31	1.09	28.95	0.151	6609	3562	33.5
Poultry manure	40.25	69.29	4.33	9.30	1.23	5960	2042	267
Pea crust	44.4	76.54	2.5	17.4	0.179	286	18.7	17.9

Each type of organic wastes was cut to small pieces (2- 4 cm) and arranged in 10 equal height layers proliferate good conditions for aeration and decomposition processes. The organic wastes successively with the activators (organic or mineral) were placed on plastic sheet over an area of about 2 m in width, 3 m in length and 1.5 m in height in almost triangular shape in 10 layer.

Each layer of a pile was properly moistened to reach about 60% of its water holding capacity. Top, bottom and sides of the heap were covered with plastic sheets, and left to decay. Each pile was turned upside down every 15 days starting from the top and sides into the center to enhance the aerobic decay process. Additional water was sprayed during the turning process to keep moisture content of each pile at almost 60 % of water holding capacity. The organic wastes were satisfactorily decomposed by this method (Abou El-Fadl, 1960) after 120 days. Representative sample from heaps were manually taken after (15, 30, 45, 60, 75, 90, 105 and 120 days). These samples air dried, ground and analyzed for chemical and physical properties as follows:-

- Bulk density (BD g / cm^3) was measured according to Vomocil (1965)
- pH: Samples of 5 gm from each composted material were shaken with 50 ml distilled water (1:10 w/v) for 30 min, the pH was measured using Beckman pH meter as reported by Page (1982).
- Total soluble salts were determined as electrical conductivity (EC dS/m): 5 gm sample were mixed with 50 ml distilled water, shaken for 2 hour and filtered. The electrical conductivity was measured in the filtrate using electrical conductivity meter (Jackson, 1973).
- Cation exchange capacity (CEC meq/100g) was determined using sodium acetate with pH 8.2 and ammonium acetate of pH 7 according to the method described by Harada and Inoko (1980).
- Organic carbon (OC %) and organic matter (OM %): Total organic carbon was determined according to Walkely and Black (1934).The organic matter (%) was calculated by multiplying the organic carbon content (%) by Van Bemmelen factor of 1.724 based on the assumption that organic matter contents 58 % as organic carbon.
- Total nitrogen (%):- Determination of total nitrogen in composted samples was carried out using the conventional method as described by Jackson (1967).
- C|N ratio: - C|N ratio was calculated as the ratio between the total organic carbon and total nitrogen that were previously measured.
- Available nitrogen was extracted with 2N KCL at extraction ratio of 1:10 and determined according to Page (1982).
- Available phosphorus was determined using 0.5 N $NaHCO_3$ at extraction ratio of 1:50 and determined according to Olsen *et al* (1954).
- Available potassium and some micronutrients (Fe, Mn, and Zn) were extracted by using DTPA at extraction ratio of 1:10 according to Soltanpour

(1985). Potassium was measured by flam- photometer (Page, 1982) and available Fe, Mn and Zn were determined in DTPA extraction using atomic absorption according to Lindsay and Novell (1978).

RESULTS AND DISCUSSION

Data presented in Table (2) indicated that, there is a gradual increase in bulk density with the increase of composting periods. The bulk density increases by more than double fold for A and B and three fold for C compost at the end of incubation period compared to 15 days of incubation. The increase in bulk density is due to reduction of row materials volume as a result of breaking down the original materials, and a consequence loss of CO_2 and water to atmosphere. The variation in the bulk density values of the heaps could be due to the difference of chemical and physical of the organic materials and organic or mineral activators used for composting.

Changes of pH of the three composts as affected by different input sources of composts and activators type are given in Table (2). Data indicate that, the changes in pH for the different piles followed the same trend with a slight decrease from the range of 7.82, 7.64 and 7.57 to 7.33, 7.23 and 7.10 in the first 30 days of piles A, B and C respectively. This was due to the decomposition of organic matter and production of organic and inorganic acids by the activities of microorganisms in the piles (Nasser, 2007), thereafter tented to be increased to reach maximum pH values of 8.94, 8.52 and 8.20 after 8 weeks of A, B and C compost respectively. This higher pH value may explained by ammonification and mineralization of organic through microbial activities .While the decrease again in pH values after 60 days of incubation due to the production of CO_2 and organic acids resulting from microbial activity (Elvira *et al .,* 1998). Then the pH values achieved a gradual decrease. This slight decline may be due to the volatilization of ammonium and release of hydrogen ions from the nitrification process late in composting period by nitrifying bacteria. Diaz-Ravia *et al* (1989) showed that, during the cooling and maturation stages the pH dropped close to neutral value, then stabilized. The same trend was obtained by Wong *et al.* (2001) and Kenawy, Mona (2003).

Significant increase in EC during composting processes. The initial EC values of composted heap at 15 day were 3.31, 2.49 and 3.10 dS/m for heaps A, B and C respectively. The difference between these original EC values may be due to the nature of each material. The EC value significantly increased to reach 5.20, 4.0 and 5.09 dS/m after 90 days composting of A, B and C heaps respectively, then slight EC increases were observed. These increases in EC of composted materials could be due to the release of different ions such as Ca, Mg, Na and phosphate ions resulting from the microbial decomposition of easily decomposable materials. CEC values of heap A, B and C were considerably increased throughout the composting periods. Wherever, it promoted linearly with increasing the period of

Table 2

incubation. CEC raised in the three heaps of compost (A, B and C) by more than double fold at the end of composting period in comparison with determined CEC after 15 days of composting processes. The increase in CEC may be due to breakdown of organic wastes to fine particles, accumulation of materials bearing a negative charge such as lignin and to increase of carboxyl and / or phenolic hydroxyl groups in the formed humus (Lax et al. 1986).

Concerning the changes in organic carbon during the composting process, Data Table (3) showed a significant decrease from 41.49, 43.44 and 42.15 % at the beginning of composting to 27.85, 23.45 and 28.84 at the end of composting process for A, B and C respectively. The decrease in organic carbon may be due to loss of carbon as CO_2 via microbial oxidation during the composting process. Also data show that, a significant increase of TN from 1.60, 0.98 and 1.63 % at first turning (15 days) to 2.26, 1.64 and 2.40 % after 120 days of composting for A, B and C composts, respectively. This increase could be due either to mineralization the organic materials consequently enhancing the nitrogen release from decomposed materials or to biological nitrogen fixation by some non-symbiotic microbes in compost (Wong *et al.* 2001).

C/N ratio values were decreased as a result of decreasing OC % and increasing N % during composting process progress. Data also showed that, high significant decrease in C/N values from 25.84, 44.33 and 25.95 :1 to 12.35, 14.38 and 12.00:1 after 120 days for heaps A, B and C, respectively. C/N ratio values were decreased as a result of decreasing OC % and increasing N % during composting process progress. Data also showed that, high significant decrease in C/N values from 25.84, 44.33 and 25.95 :1 to 12.35, 14.38 and 12.00:1 after 120 days for heaps A, B and C, respectively(Nasser 2007).

Data in Table (4) revealed that, the available nitrogen was augmented linearly with elongation the period of composting, whereas it raised by more than eight-fold compared to nitrogen determined after 15 days of incubation. It was observed that the available –N values in heaps A and C were more than those in heap B. This augmentation in available –N may be attributed to decomposition of organic material, urea addition and biological fixation by compost microorganisms.

Data in Table (5) elucidate an increase in micronutrients (Fe, Mn and Zn) extracted by DTPA during the composting process. The content (mg/kg) of available –Fe at the end of 120 days of incubation period increased by more than double-fold of that at 15 days of composting period for the three composts (A, B and C). Likewise an enhancement in the available Mn and Zn were occurred progressively with the time of incubation .Whereas this augmentation of extracted Mn and Zn (mg/kg) at 120 days reached to be more than 200 % of that one determined after 15 days of composting process. The facts which ought mentioned herin that, composting the different organic

Table 3

Table 4

Table 5

matetials play a very effective role in releasing a lote of macro and micronutrients consequently its reflection on the soil received these materials and plant production.

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ديناميكية التحلل للمواد المكمورة و علاقتها بانطلاق المغذيات

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الملخص العربي

أجرى البحث فى مزرعة كلية الزراعة –جامعة المنوفية وتهدف هذه الدراسة إلى إمكانية الاستفادة من بعض المخلفات الزراعية وتدوير هذه المخلفات بما يعرف بتكنولوجيا المخلفات العضوية المكمورة (الكمبوست) لإمكانية استخدامها في زيادة إنتاجية الأراضي الزراعية والحد من الإسراف فى استخدام الأسمدة المعدنية التي أصبحت تمثل عاملا رئيسيا في التلوث البيئي ودراسة التغيرات الطبيعية والكيماوية التى تحدث أثناء عملية الكمر للمخلفات العضوية ولذلك تم عمل ثلاث كومات من الكمبوست كالأتي:

١- الكومة الأولى – (A) تتكون من قش الأرز وحطب الأذرة وسماد دواجن بياضه بدون فرشة وقشر البسلة (مخلفات صناعات غذائية) بنسبه ٢-١ -١-٢/١ على التوالى.

٢- الكومة الثانية –(B) تتكون من قش الأرز وحطب الأذرة وسماد حبوانى بدون فرشة وقشر البسلة (مخلفات صناعات غذائية) بنسبه ٢-١-١-٢/١ على التوالى

٣- الكومة الثالثة –(C) تتكون من قش الأرز وحطب الأذرة بنسبه ٢-١ مع إضافة منشطات كيماوية وهى ٥ % يوريا و ١ % سوبر فوسفات و ١٠ % سماد حيواني كبادئ ووضعت المخلفات العضوية بعد تقطيعها (٢-٤ سم) مع المخلوط المنشط (عضوى –معدنى) على التوالى فى ١٠ طبقات متساوية على مفرش بلاستيك (X٢ ٣ متر) بارتفاع ١.٥متر حيث كانت فى النهاية بشكل مثلث وتم ترطيب كل طبقة بالمياة حتى تصل الى ٦٠ % من السعة المائية.

تم تغطية كل كومة بالبلاستيك وتركت للتحلل مع تقليبها كل ١٥ يوم وذلك لتهويتها وترطيبها حتى يتم التحلل تحت الظروف الهوائية ثم أخذت عينات بعد التقليب وجففت هوائى ثم طحنت وتم

تقدير EC ، pH ، OM، TN، CEC وحسبت نسبة C/N والكثافة الظاهرية وكذلك محتواها من العناصر الغذائية الميسرة .

وكانت اهم النتائج:

حدثت زيادة تدريجية فى الكثافة الظاهرية بتقدم عمليه الكمر فالكومات الكمبوست تحت الدراسة وكانت أكبر قيمه فى الكومة (A) وهى ٠.٦٣٩جم/سم٣ وأقل قيمة مع المكمورة (C) وكانت ٠.٤٩٥ جم/سم٣

حدث إنخفاض فى درجة الحموضة للكومات الثلاثة تحت الدراسة ثم إرتفع فى الفترة (٤٥ – ٦٠ يوم) ثم حدث إنخفاض مرة أخرى وإستمر الإنخفاض حتى وصلت إلى ٧.٥٤ – ٧.٤٠– ٧.٢٢ للكومات A ، B ، C على التوالى كما حدث زيادة تدريجية فى درجة التوصيل الكهربى للكومات الثلاث حتى وصلت فى النهاية إلى ٥.٣٦– ٤.٢ – ٥.٢٥ dS/m للكومات A، B، C على التوالى.

إرتفعت السعة التبادلية الكاتيونية حنى وصلت الى ٦٥ – ٦٨ – ٤٧ ملليمكافئ /١٠٠ جم للكومات A، B، C على التوالى و إنخفض محتوى الكربون والمادة العضوية تدريجى ووصلت المادة العضوية الى٤٠.٢٧– ٤٠.٤٣–٣ ٤٩.٧ للكومات A، B، C على التوالى.

حدث زيادة فى قيم النتروجين الكلى خلال الكمر مع ملاحظة إرتفاع معدل الزيادة فى الكومتين A , C وكانت ٢.٢٦ ، ٢.٤٠ % على التوالى مقارنه بالكومة الثالثة وكانت ١.٦٤ % للكومة B

حدث إنخفاض تدريجى فى نسبة ك/ ن حتى وصلت الى ١٢.٣٥ ،١٤.٣٨ ، ١٢.٠٠ للكومات A، B، C على التوالى . إرتفع محتوى الكمبوست من العناصر الكبرى (ن،فو،بو) خلال عملية الكمر حيث كانت أعلى زيادة من ١٧٥ الى ١٥٤٠ جزء فى المليون للكومة المضاف إليها مخلفات الدواجن وكانت أقل زيادة من ١٤٠ الى ١١٢٠ جزء فى المليون للكومة المضاف إليها السماد الحيوانى (B بالنسبة لعنصر النتروجين.

بالنسبة للفوسفوركانت أعلى قيمةللكومة A حيث زادت من ٨٥٠ الى ١٥٠٠ جزء فى المليون فى الكومة A وكانت أقل قيمة فى الكومة B حيث ارتفعت من ٥٥٠ الى ٩٧٥ جزء فى المليون.

وأظهرت زيادة البوتاسيوم نفس الإتجاه السابق لعنصرى النتروجين والفوسفور وهذا يعنى أن محتوى الكومات A ,C كانت أعلي من NPK عن الكومة B.

أشارت النتائج إلي زيادة محتوى الكومات من العناصر الصغرى مع زيادة عملية الكمر حتى وصل الحديد إلى ٣٦٠ ،٤٨٠ ،٢٦١ جزء فى المليون كما وصل المنجنيز إلى ٩٣ ،١٣٢، ١٠٣، جزء فى المليون كما وصل الزنك إلى ١٢٢ ،٣٧، ٤٠ جزء فى المليون للكومات A و Bو C على التوالى.

Table (2): Changes of bulk density (BD), pH, electrical conductivity (EC) and cation exchange capacity (CEC) during composting process

Parameter / Period (Days)	A				B				C				
	BD g/cm^3	pH 1:10	EC dS/m	CEC Meq/100g	BD g/cm^3	pH 1:10	EC dS/m	CEC meq/100g	BD g/cm^3	pH 1:10	EC dS/m	CEC meq/100g	CEC meq/100g
15	0.230	7.82	3.31	25	0.210	7.64	2.49	27	0.139	7.57	3.10	22	22
30	0.254	7.33	3.42	32	0.224	7.23	2.57	34	0.172	7.10	3.20	27	27
45	0.274	7.92	3.58	34	0.252	7.73	2.72	37	0.192	7.20	3.39	29	29
60	0.311	8.94	4.13	38	0.279	8.52	3.00	40	0.225	8.20	4.00	32	32
75	0.418	8.32	4.68	43	0.375	8.15	3.22	45	0.303	7.90	4.56	34	34
90	0.503	7.85	5.20	47	0.473	7.63	4.00	49	0.385	7.44	5.09	37	37
105	0.583	7.63	5.29	60	0.513	7.52	4.12	63	0.423	7.35	5.17	40	40
120	0.639	7.54	5.36	65	0.589	7.40	4.20	68	0.495	7.22	5.25	47	47
F -test	**	**	**	**	**	**	**	**	**	**	**	**	**
L.S.D	0.012	-	0.15	5.23	0.011	-	0.21	5.96	0.012	-	0.20	4.91	4.91

Table (3): Changes of organic carbon (OC), organic matter (OM), total nitrogen (T.N) and C/N ratio during composting process.

Parameter / Period	A				B				C			
	OC %	OM %	T.N %	C/N ratio	OC %	OM %	T.N %	C/N ratio	OC %	OM %	T.N %	C/N ratio
15	41.49	66.36	1.60	25.84	43.44	74.89	0.98	44.33	42.15	72.68	1.63	25.95
30	39.40	66.20	1.67	23.60	40.78	70.31	1.20	34.13	39.31	67.78	1.69	23.34
45	39.07	66.04	1.70	22.98	40.50	69.83	1.08	31.65	38.55	78.68	1.73	22.34
60	38.31	64.78	1.77	21.64	36.65	63.20	1.36	27.01	37.85	65.25	1.80	21.02
75	34.64	59.72	1.81	19.10	34.46	59.41	1.41	24.45	36.29	62.57	1.83	19.77
90	31.75	49.56	1.88	16.89	30.64	52.82	1.48	20.68	33.57	57.88	1.92	17.49
105	29.84	43.69	2.10	13.60	26.20	45.16	1.61	16.35	30.07	51.85	2.18	13.79
120	27.85	40.27	2.26	12.35	23.45	40.43	1.64	14.38	28.84	49.73	2.40	12.00
F -test	**	**	**	**	**	**	**	**	**	**	**	**
L.S.D	1.28	2.69	0.04	0.87	1.96	3.37	0.08	2.05	1.43	2.53	0.04	0.85

Table (4): Changes of macronutrients (mg / kg) availability during composting process .

Parameter / Period (Days)	A			B			C		
	N	P	K	N	P	K	N	P	K
15	175	850	1800	140	550	1515	192	1050	1080
30	365	956	1960	290	625	1645	395	1106	1205
45	583	1106	2110	450	705	1780	570	1164	1325
60	750	1214	2230	616	770	1913	710	1195	1448
75	920	1309	2320	796	835	2033	890	1234	1569
90	1163	1394	2410	907	898	2135	1135	1273	1691
105	1320	1469	2500	1012	948	2225	1285	1324	1781
120	1540	1500	2640	1120	975	2296	1400	1375	1820
F-test	**	**	**	**	**	**	**	**	**
L.S.D	39.43	62.74	101.10	31.72	51.15	74.7	28.83	59.57	86.5

Table (5): Changes of micronutrients (mg / kg) availability during composting process .

Parameter Period (Days)	A			B			C		
	Fe	Mn	Zn	Fe	Mn	Zn	Fe	Mn	Zn
15	145	36	42	193	51	17	105	40	19
30	163	44	51	217	61	20	118	48	22
45	179	53	59	239	75	23	130	59	26
60	204	60	63	272	86	25	148	67	28
75	229	66	70	305	95	28	166	74	31
90	250	72	76	333	102	30	181	80	34
105	305	86	90	406	123	34	221	96	37
120	360	93	122	480	132	37	261	103	40
F-test	**	**	**	**	**	**	**	**	**
L.S.D	25.02	11.17	13.90	24.04	12.59	9.0	17.36	12.30	11.12