ROLE OF COMPOST AND IRRIGATION WATER QUANTITY ON SOME PHYSICAL PROPERTIES OF SOIL UNDER SURFACE, SUBSURFACE DRIP IRRIGATION

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ABSTRACT

A field experiment was conducted in Ramadi district - Al-Anbar province during the autumn season of 2018. to study the role of compost (sheep residues) and irrigation levels in some physical properties of soil and water consumption a potato under surface and subsurface drip irrigation system. Randomized Complete Block Design (RCBD) in arrangement of a split-split-plot with three replication were used.The results showed that the addition of 10 Mg.h^{-1} resulted in a significant decrease in bulk density (BD) values of 1.12 Mg m^{-3}, and increase in the values of (MWD) and (Ks) to reach 1.47 mm and 10.3 cm. hr $^{-1}$ respectively. The addition of 50% of the NID reduced the BD to 1.24 Mg m^{-3}, The MWD and SHC were significantly higher to reach 1.24 mm and 8.1 cm hr^{-1} respectively. WHC increased with increasing of amount of irrigation water as it reached the highest value of 265.66 mm season^{-1} when adding 100% of the NID. The BD values decreased, whereas MWD and SWC increased under subsurface irrigation (SUBDI) treatment to be 1.23 Mg m^{-3}, 1.24 mm and 8.4 cm hr^{-1}, respectively.

Keywords: Compost; Drip Irrigation; water Quantity

مجلة العلوم الزراعية العراقية -2020 :51 (5):1300-1307 الشمري وآخرون

دور الكمبوست وكمية مياه الري في بعض الخصائص الفيزيائية تحت نظام الري بالتنقيط السطحي وتحت السطحي

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المستخلص

نفذت تجربة حقلية في قضاء الرمادي – محافظة الانبار خلال الموسم الخريفي 2018، لدراسة دور الكمبوست ومستويات الري في بعض الخصائص الفيزيائية تحت نظام الري بالتنقيط السطحي وتحت السطحي. استخدم ترتيب الالواح المنشقة المنشقة بتصميم القطاعات العشوائية الكاملة وبثلاثة مكررات. بينت النتائج أن اضافة 10 ميكاغرام هـ$^{-1}$ ادى الى انخفاض معنوي في قيم الكثافة الظاهرية اذ بلغ 1.12 ميكاغرام م$^{-3}$, وزيادة قيم معدل القطر الموزون والايصالية المائية المشبعة بلغ 1.47 مم و10.3 سم ساعة$^{-1}$ على التتابع. فيما ادى اضافة 50 % من صافي عمق الرية الى خفض الكثافة الظاهرية بلغت 1.24ميكاغرام م$^{-3}$, فيما تفوق معنوياً معدل قطر الموزون والايصالية المائية المشبعة اذ بلغ 1.24 مم و8.1 سم ساعة$^{-1}$ على التتابع. ازداد الاستهلاك المائي بزيادة كميات مياه الري اذ بلغ اعلى قيمة 265.66 مم موسم$^{-1}$ عند اضافة 100 % من صافي عمق الرية. كما انخفضت قيم الكثافة الظاهرية وازداد معدل قطر الموزون والايصالية المائية المشبعة عند معاملة الري تحت السطحي بلغت 1.23 ميكاغرام م$^{-3}$و 1.24 مم و8.4 سم ساعة$^{-1}$على التتابع.

كلمات مفتاحيه: الكمبوست، مستوى الري، ري بالتنقيط

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INTRODUCTION

The soil organic fertilizers of various sources have a positive important role in the improvement of soil physical properties, increasing water-holding capacity, improvement of porosity, permeability, and bioactivity. Its role is to stabilize the soil particles with each other, increase the soil water infiltration, reduce surface runoff and improve crop growth by improving soil structure. The values of porosity increase to reduce bulk density, which facilitates plant roots penetration in soil profile (1). Many studies have tried to find different methods in programming irrigation operations by controlling the quantities of added irrigation water, and scheduling the addition using modern irrigation methods, especially in areas of limited water because of limited water resources and losing large quantities of them during conventional irrigation operations. Surface and subsurface drip irrigation systems are the most important of these techniques, which are one of the most efficient irrigation systems because this system provides water to the plant at the perimeter of the root zone (Rhizosphere) during different stages of plant growth(17). The addition of manure at different levels 0, 30 and 60 tons. ha^{-1} in a silty clay soil resulted in a significant superiority in the values of mean weight diameter, which increased from 0.34 to 0.40 and 0.75 mm it also increased hydraulic conductivity from 6.48 to 14.07 and 14.62cm.hr^{-1} (18). The addition of manure at a of 10 tons.h^{-1} caused the lowest value of bulk density which is 1.14 Mg.m-3 while the 1.25 and 1.33 Mg $m^{-3}$when adding 5 tons.h-^{1}without the addition of organic fertilizer respectively attributing the reason to the ability of organic fertilizers to improve soil structure through increased porosity, the stability of soil aggregate increased pore percentage, and movement of water and air in the soil. Increased levels of deficit drip irrigation was also resulted in non-significant difference in bulk density values, where it was 1.24 Mg.m^{-3} in irrigation treatment of 100% in comparison with50%and 75% levels which were 1.24 and 1.23 Mg.m^{-3} with an increase of 0 and 0.8% respectively (3). The bulk density values increased significantly with increasing water stress ratios, which reached 1.40, 1.38 and 1.34 Mgm.m^{-3} at the exhaustion treatment of 40%of the available water, and reached 1.42, 1.39, and1.26 Mg.m^{-3} at deficit treatment50% of available water, while the highest values were 1.43, 1.41 and 1.38 Mg.m^{-3} at the depletion treatment of 60% of the available water for the full and half and triple additions consecutively (4). The object of this study is investigating the role of compost manure and irrigation levels under surface and subsurface drip irrigation system and some physical soil properties.

MATERIALS AND METHODS

A field experiment was conducted at Albo Farraj region – Ramadi district in province of Anbar western of Iraq, in a Silty Loam texture soil during fall season of 2018. The soil class is Typic Torrifluvent subgroup according to US Taxonomy system (21). The field was totally sampled to (0-30) cm depth randomly and some physical, chemical, and properties were measured in them. Particles size distribution was measured using pipette and hydrometer methods. Bulk density measured by metal core sampler according to (7). The volumetric moisture content of soil was measured at (33, 300, KPa) using Pressure plate membrane. Saturated hydraulic conductivity (SHC) determined by consant water head method (12) in(Table1) Chemical properties of soil were measured in saturated soil past according to (14). Analysis of irrigation water, which has been used in this experiment ,illustrated in (Table2).Experiment was carried out at (300 m^2) 12 x 25 m area. The experimental land soil tilled by two orthogonal ploughs by the mouldboard plough, softened, and levelled. The field was totally divided to three blocks of(2x25) m^2 with 2 m spaces among blocks. Experimental factors were distributed in split-split plots at randomized complete block design (RCBD) of three replicates. Each block divided into two main plots for two compost levels (0,10 Mgm) and each one subdivided into two sub-plot .The two irrigation methods (surface and subsurface) were distributed into subplots. The spaces between each two plots were1.5 meters. Each subplot was then divided into three terraces as experimental units in which irrigation levels of 50%,75% and 100% of the

NID were distributed. The drip irrigation system was evaluated at pressures of 40, 50 and 60 kPa to select the best operating pressure that can be adopted during the growing season and according to the uniformity coefficient of water distribution(UC),the discharge variation (DV). The UC was 96.60% and the lowest variance between points was10.20%.The surface and subsurface drip irrigation system was utilized T-Tape drips. The US evaporation pan class A was considered in irrigation time determination Actual water consumption (ETa) equivalent to the added water depth (d) and the timing of irrigation were calculated according to the following equations. The volumetric soil moisture (VSM) at irrigation time determined like mentioned in (2)

$$\Theta_{wi} = \Theta_{F.C} - (\Theta_{A.W} \ {}^{*}dp) \text{......... ....(1)}$$

Where **Θwi** is VSM at irrigation time (%), **dp** is moisture depletion ratio, $\Theta_{F.C}$ is VSM at field capacity (%).

Water depth added to soil (d) computed by:

$$d = \frac{\theta_{F.C} - \theta_{.Wi}}{100} * D \text{ .... (2)}$$

Where d is water depth added to soil (cm) , D is active Rhizosphere (cm).

Reference evapotranspiration (Et_0) computed by (2) equation:

$$Et_0 = \frac{ETa}{Kc} \text{..................... (3)}$$

Where ET_0, **ETa,** and K_c are the reference evapotranspiration, actual evapotranspiration ($mm.day^{-1}$), and crop factor respectively.The (0.8 , 0.75, 1.15, and 0.8) values in (19) were considered as a representative for vegetative growth, tubers formation, tubers swelling , and maturity stages respectively. Irrigation schedule timed according the value of E_{pan}, which is equivalent to exhaustion ratio in equation (3) as follows:

$$E_{pan} = \frac{ET0}{Kp} \text{ .... (4)}$$

Where, Epan is the evaporation measured in the basin ($mm.day^{-1}$) , Kp is a coefficient of E-pan , Water quantity added to soil as a leaching requirement, which was 6%, calculated according to (9) equation that concerned the modern systems irrigation like drip irrigation as follows:

$$LR = \frac{ECiw}{2(MAX\ ECe)} \times 100 \text{ .... (5)}$$

LR is Leaching Requirement (%), EC_{iw} is Electrical Conductivity of Irrigation Water (20 $dS.m^{-1}$), MAX_{ECe} is the Maximum EC ($dS.m^{-1}$). These percentage values units converted to water depth units of irrigation according to (7) which is:

$$d_L = LR * d \text{ .... (6)}$$

d_L is Leaching Requirement Depth (mm), d is Irrigation Water Depth required (cm). The total water depth (irrigation + leaching requirement water) that must be added to soil estimated in eq. 7

$$TDI = \frac{d + d_L}{Ei} \text{ .... (7)}$$

Where TDI is Total Irrigation Depth; d_L is Leaching Requirement depth, E_i is Efficiency of drip irrigation, which was 85% in this study.Irrigation time estimated according to (2) equation:

$$q * t = a * d \text{ .... (8)}$$

Where q is applied quantity discharge (m^3h^{-1}); t is Time of irrigation (hour); a is Area of witting circle for dripper (m^2) d is the Depth of added water (m).

Table1.Physical and chemical properties of the soil

Property		Quantity	Units	Property		Quantity	Units
Sand		420		pH		8.0	——
Silty		506	$g\ kg^{-1}$	EC_e		3.0	$dS\ m^{-1}$
Clay		74			Ca^{2+}	22.50	
Texture		Silt Loam		Positive	Mg^{2+}	12.50	
Bulk density		1.32	$Mg\ m^{-3}$	Dissolved	Na^{+}	7.30	
hydraulic conductivity		4.28	$cm\ hour^{-1}$	Anion	K^{+}	0.13	
soil moisture	33	35.60			SO_4^{2}	8.06	$meq\ l^{-1}$
	1500	10.20	%			2.00	
available water		25.30		Negative	HCO_3^{-}		
$CaSO_4$		3.5	$g\ kg^{-1}$	Dissolved Anion	CO_3^{2-}	Nill	
$CaCO_3$		165.0			Cl^{-}	9.0	

Table 2.chemical properties of irrigation water

EC dS m^{-1}	pH	Anion Dissolved meq l^{-1}								$NO_3^=$ Ppm	SAR	Class
		Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	Cl^{-}	SO_4^{-2}	HCO_3^{-}	$CO_3^{=}$			
1.25	7.5	1.21	4.1	4.94	0.24	4.0	5.4	2.0	0.0	2.10	2.4	C_3S_1

RESULTS AND DISCUSSION

Bulk densist (BD)

Fig.1. Shows the effects of different factors on BD values.BD values decreased by 35% and 22.3% at the addition of 0 and 10 Mgm.h^{-1} of compost levels respectively compared to the same values before cultivation (Table1), as a result to soil structure improvement due to manure addition by increasing soil porosity, aggregates stability and also increasing units of soil volume respectively(6). Surface and subsurface drip irrigation systems have significant effects on BD values as shown in Fig.1.BD value was decreased under SUBDI to 1.23 Mgm. M^{-3} where it reached 1.33 under SDI which can be contributed to the lack of wetting-drying cycles because of availability of sufficient amounts of water that cause movements of fine particles with percolated water inside soil pores and decrease porosity due to compaction of soil under ordinary surface irrigation style (11 and 13). Increasing irrigation levels, as shown in Fig.1 caused significant differences in BD values where its value was 1.31 Mg.m^{-3}under100% irrigation treatment compared to 1.27 and 1.24 Mg. $M^{-3}$for 75%and 50%of the NID, the increasing percentage was 1% and 6% for each on respectively. The later may be caused by differentiation of water quantity that give a chance for suitable water reservation for a long period, lack of wetting-drying cycles between irrigation terms, soil structure improvement, and increasing soil porosity and this emphasize that rapid wetting-drying periods, swelling of soil were the cause of structure's deterioration (4).

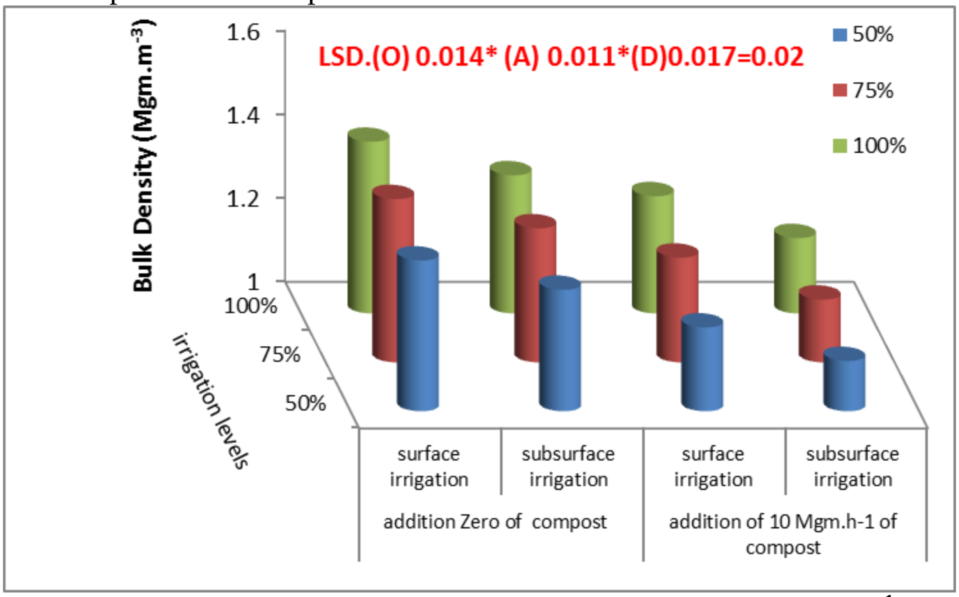

Figure 1. Effects of treatments on soil Bulk Density (Mgm m^{-1})

Mean weight diameter (WMD)

Fig. 2. illustrates the highest value of MWD (1.47 mm) as a result of 10 Mgm.ha^{-1} of compost addition in comparison with 0.76 mm for zero addition, this can be attributed to increasing aggregates' stability and formation of cementing agents due to decomposition of compost by soil microbes as a result of organic acids formation (like Humic, Fulvic, … etc), surface encasement of soil particles to reduce their moistening rapidity (18). Fig. 2. also shows significant effects of SDI and SUBDI n MWD values. The SUBDI systems cause a significance in crane MWD value of 1.24 mm for MDW in comparison with 0.98 mm for SDI . This result may be because the role of SUBDI in conserving soil moisture in sufficient amount for different stages of plant growth at the Rhizosphere region, this is consistent with (10). Increasing irrigation levels caused significant differences in MWD values (Fig.2).Generally, the MDW decreased significantly with increasing irrigation levels, where the least value was 0.95 mm in 100% of

the net irrigation depth (NID), Similarly, MWD values were 1.14 and 1.24 mm for 75% and 50% for NIDs respectively. The reason of decreasing in MWD values with the increase in irrigation levels is the destruction of soil aggregates, which leads to the deposition of fine particles between the pores, which led to an increase in the values of soil BD, which reflected on the stability of soil aggregates (3).

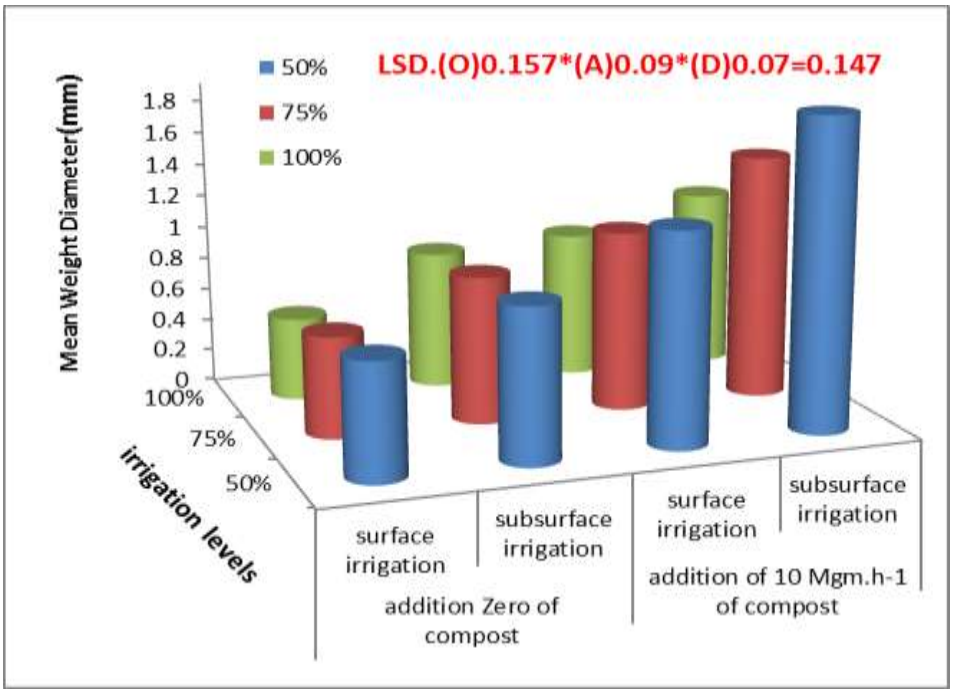

Figure 2. Effects of treatments on MWD (mm)

Saturated hydraulic conductivity (Ks)

Fig.3. Shows Effects of treatments on SHC values. The SHC values were increased in comparison with their pre-cultivation values, which were 5.2 and 10.4 $cm.hr^{-1}$at the level 0and 10 $Mg.ha^{-1}$of compost additions respectively compared to their values after cultivation (Table.1), this increasing values of SHC contributed to increase cementing agents with increase compost levels, which connect soil particles (8).The same figure shows effects of SDI and SUBDI on SHC. There was a significant increase in SHC values to reach 8.4, 6.9cm. hr^{-1} for SUBDI and SDI respectively, and this can be attributed to the direct impact of SDI in destruction of aggregates at water entrance to soil and explosion of reserved air bubbles to smash those aggregates. Furthermore may be because of wetting-drying circles among irrigations, or the erosive power of moving on wetting front, which cause partial movement of fine particles through water percolation, which clog pore spaces and rise BD value that reflects on soil's HC (3). The effects of irrigation levels on SHC were illustrated in Fig.3. a negative relationship can be observed among them, where SHC value was 7.2-cm. $hour^{-1}$ at 100% level and increased respectively to 7.7, 8.1 cm. $hour^{-1}$ for 75% and 50% sequences. This inversely relationship may be because of drying-wetting operation consequences that cause dispersion and separation of soil particles to deposit in pore-spaces and clog them to form impermeable layers of high BD, which cause less downward water moving in also because of irrigation frequency (20). The interference among factors on SHC mean values can be concluded from Fig.3. There was a significant increase in SHC value to be 10.3 cm. hr^{-1}at addition of 10 $Ton.ha^{-1}$ of compost level under 50% NID of SUBDI, this increasing SHC was agreed with(5) attributions to the effect of organic fertilizers and SUBDI on soil structure improvement as a result to MWD increase that decrease values of BD.

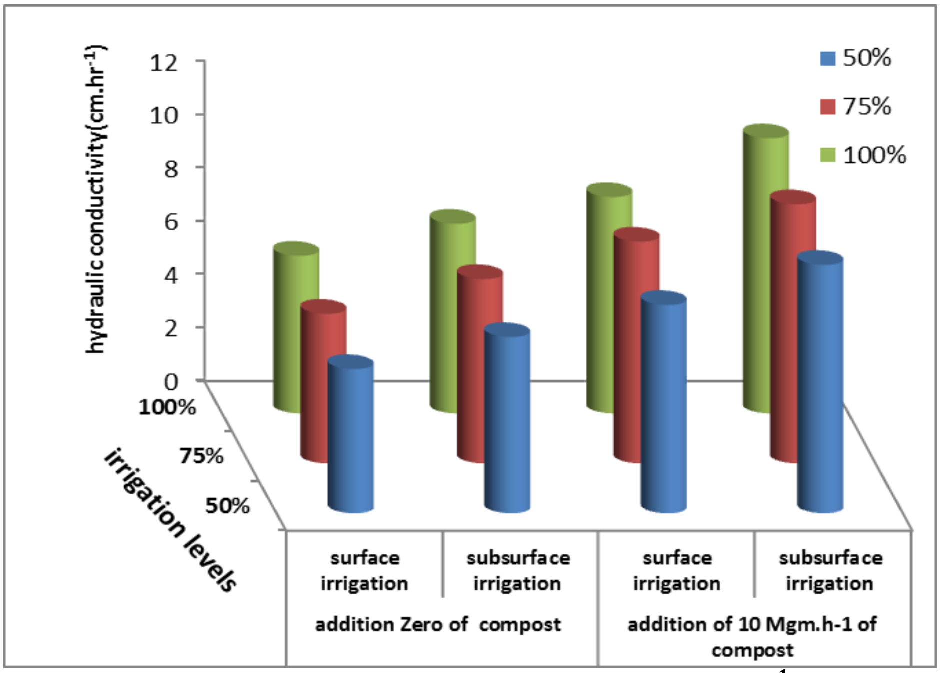

Figure 3. Effects of treatments on SHC ($cm.hr^{-1}$)

Mean of Water Consumptive Use (WCU) ($mm.season^{-1}$)

Table.3 Shows WCU values of potatoes at different growth stages, it is observed that applied depths irrigation water increased successively with growth stages to reach 88.55, 66.43, and 44.28 mm for irrigation levels 100%,75%, and 50% of NID respectively due to increasing depth of roots' extension in soil with plant age progress, roots' expansion was also increase soil volume,. Furthermore, the intense need of plants to water and available nutrients in these two stages for bioactivities, tissues, and cells especially in stage of tubers swelling. The reason of decreased WCU at the end of growth season was attributed to the sufficiency of plant tissues, cells, and the degrease of bioactivity, which cause in WCU (11). The irrigations' number was reduced with progression of growth stages where the highest irrigations' number was 10 at pre-germination stage and 1 irrigation at maturity stage; this decrease was due to time of each growth stage where the longest period was 30 days at pre-germination stage. Table 3. Shows that actual WCU values were 293.41, 223.97, and 154.25 mm for irrigation levels 100%, 75%, and 50% of NID respectively. The same table shows positive relationship between water saving ratio (WSR) and irrigation levels ratio (ILR). The ILR of 50% and 75% of NID treatments saved 580.25 and 406.01 m^3 of WSR compared to ILR of 100%, these water volumes can be invested in other areas that equivalent to 3.75 and 3.34 $Ton.ha^{-1}$ of total yield.

Table 3 . Effect of irrigation levels in depths and volumes of added water

Stage	Duration Of stage (Day)	Irrigation levels	Roots depth (cm)	Required Water Depth (mm)	Leaching Requirement Depth (mm)	Number of irrigations	Irrigation Requirement $M^3. ha^{-1}$
Growth Stage	30	%40	15	15.10	0.94	10	944.43
Vegetative Growth Stage	12	%50	20	25.30	1.51	3	115.06
		%75		37.96	2.27		161.22
		%100		50.61	3.03		230.13
Tuber Initiation Stage	17	%50	26	31.62	1.89	3	142.44
		%75		47.45	2.84		187.89
		%100		63.25	3.79		284.88
Tuber Bulcking Stage	17	%50	33	37.95	2.27	2	246.34
		%75		56.94	3.41		311.12
		%100		75.90	4.55		493.34
Maturation Stage	7	%50	39	44.28	2.65	1	76.34
		%75		66.43	3.98		94.78
		%100		88.55	5.31		152.67
Total		%50	-	146.71	9.26	19	1524.94
		%75		223.97	13.44	19	1699.44

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