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Impact of Mulching on Soil Temperature, Phosphorus and Plant Growth of Tomato in Maryout Soil

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ABSTRACT

Throughout two successive years, a field experiments in three completely randomized replications for each treatment were carried out in Maryout region at West El Delta- Egypt, located at 29º 10'53" N and 25º 33' " E**.** This soil irrigated by flooded irrigation system. Tomato seedlings were sown at 50 cm apart and 50 cm between rows. The final plant density was 16800 plant/fed. The mulching were bituminous emulsion at rates 0.0, 0.1, 0.4, and 0.8 L/m^3, and the rice straw at rates 0, 5, 10 and 15 ton/fed, while P rates were 25 and 50 kg P_2O_5/fed. Measurements were carried out for soil moisture and temperature throughout three soil layers at 0-5, 5–15, 15–30 cm. The tomato seedling, variety Yossi 97-3 cultivated in 15th of February with providing protection for seedlings against cold by using mulching, while the harvest stage months was in both of May and June.The obtained results assure that tomato fruits yield parameters and nutrients contents increased with increasing rates of the studied two mulching types. Mulching by bituminous emulsion was superior for fruit yields and nutrients of tomato, followed by rice straw and control treatment. The superior treatment was Bitumen 0.8 L/m^2 + P_2 and Rice straw 15 ton/fed + P_2 which achieved 28.1 and 24.6 ton/fed fruit, respectively. Economic rate for mulching by rice straw was 10 ton/fed, which was lower expensive than 15 ton rice straw/fed rate and achieved yield (24.2 ton/fed) of tomato fruits nearly from yield (24.6 ton/fed) of 15 ton/fed rate. The actual temperatures of soil gradually decrease with the studied soil depths, while the soil The actual temperatures of soil gradually decreases with soil studied depths, while the soil moisture contents increased with soil studied depths. The total heat content (soil heat + water heat) cal/g soil increased with the studied soil depths. This study recommends using mulching by rice straw 10 tons / acre or use bitumen emulsion at 0.8 L/m^2, to provide a suitable temperatures and moisture content in soil for the tomato growth and good production.

Key words: Mulching surface soil, Rice straw, Bitumen emulsion, P fertilizers, Tomato production, and sandy loam soil in Maryout region

Introduction

Mulching has been advocated as an effective means for conserving soil moisture. It works as an insulating barrier which prevents evaporation from soil surface. It protects the plant roots from heat, cold and drought or to keep fruit clean. Mulching is an agricultural and horticultural technique in which the use of organic materials (plant residues-straw, hay, groundnut hulls, leaf and compost, peat, wood products-saw dust and animal manures), and synthetic materials (paper, polyethylene, wax coated papers, aluminum, steel foils and asphalt spray emulsions etc.), Sarolia and Bhardwaj (2012).

Soil temperature is one of the most dynamic properties of the soil. Though its daily and seasonal changes, it has several effects on soil properties, such as moisture retention and movement, root growth as well as microorganisms' activity, availability and uptake of nutritive elements. Temperature of the soil surface responds mainly to the radiant energy through day- time heating mainly short wave radiation mostly shorter than 2 micron coming from both the sun and the sky. Night – time cooling results from the loss of energy by emission from the surface of the soil as long wave radiation which is mostly longer than 4 microns. Tomatoes needs mildly warm atmosphere, the optimum temperature ranging between 15-30 C^o and stands growth if the temperature dropped about 10 C^o and hold less than 13 C^o degrees of temperature happen. The rising high about 35 C^o lead for the failure of pollination, fertilization and yield formation process, it also effects on the coloration degree of fruits (Gudugi *et al.,* 2012).

Concerning to mulching effect on ripening of tomato; Rajbir (2005) stated that the mulching tomato plants recorded higher increases of fruits weight than control (without mulching) about 8.3, 12.4, 14.1 and 19.7% for rice straw, sugarcane trash, white and black polyethylene, respectively. Samalia *et al.,* (2011) decided that the mulching significantly increased fruit yield, fruit diameter and firmness over the no-mulched treatment, the highest yield achieved by 5 day irrigation interval, black polythene and 90kgN/ha. Gudugi *et al.,* (2012) reported that the highest number of flowers and the highest fruit yield was obtained at 4 days irrigation interval

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and mulching 5 ton/ha of rice straw. Alberto and Sanogo (2012) reported that the highest marketable yield of tomato fruits and eggplant obtained from plants grown in plots which mulched by rice straw (0.5 kg/m^2) . Gabriel *et al.,* (2014) reported that the mulching by maize stover and cassava peel composts are effective for the suppression of some weeds in tomato and recorded highest fruits yield when applied 90kg N/ha. Hou *et al.,*(2014) reported that the straw mulching was recommended as the main regulatory method to improve tomato quality, yield, and desalination effects. Edyta (2014) stated that the soil mulching with rye, corn and wheat straw increased the share of marketable yield, the total yield of broccoli and rye straw as well as the share of marketable yield of tomato.

Concerning to the mulching effect on soil temperature and moisture content; Moreno *et al.,* (2009) stated that the significant differences in mean soil temperature under mulches were observed (27.8ºC in biodegradable, 28.7ºC in aluminized and 31.8ºC in polyethylene), marketable tomato yields were similar in both biodegradable and polyethylene mulches (9.82 and 8.66 kg m^{-2}, respectively), and higher than those recorded in aluminized photodegradable mulch (6.85 kg m^{-2}). Hamid *et al.,* (2012) reported that the soil temperature increased under the various colored plastic; (white and black); mulches about 3 to 6 ˚C more than control, respectively. Number of branches and tomato leaves were better for the plants grown over plastic compared to bare soil. The highest early yield was obtained in clear plastic likely due to light entrance and raising soil temperature. Mulching increased marketable yield relative to bare soil as the plants grown on silver/black plastic mulch indicated a 65% increasing in marketable mulch compared to control treatment. The plastic mulches resulted in an 84-98% reduction in weed biomass. Singhm and Kamal(2012) reported that the highest soil temperature was obtained under the black plastic mulch during the early growth season. The difference in temperature between mulched and bare soil was 2.2 to 3.4°C. Black plastic mulch significantly affects the tomato yield. The yield increased with black plastic mulch from 20.7 to 29.8% as compared to bare soil.

Regard to the mulching effect and mineral fertilizers on fruits yield components and nutrients contents of tomato; Lambers *et al.,* (2014) stated that phosphorus involved in the photosynthesis, energy and nutrient transport in plant, it can establish a strong root base and produce strong all through the growth plant stages. Abugre and Ampofo (2011) decided that the highest tomato yield, (9.35 tons/ha) was obtained from the highest addition rate of mulch and fertilizer (15 tons/ha and 150 kg N/ha), while the control lowed the yield (2.8 tons/ha). Al - Mohammadi and Al – Zubi (2011) reported that the application NPK fertilizers increased N, P and K contents in leaves and fruits of tomato and improved fruits production. On other side, Ibrahim ORTAS(2013) stated that the under high N and K fertilizers (200 Kg ha^{-1} of N and K_2O) application, N fertilizer increased the plant N and P concentration while K fertilizer has no significant influence on nutrient concentration. While, Idowu *et al.,* (2013) decided that the phosphorus significantly increased growth, yield components and nutrients contents of snake tomato at addition 15kg up to 30 kg P/ha beyond which there was a reduction. Manoj *et al.,* (2013) reported that application of NPK; (180 kg N/ha, 80 kg P/ha and 75 kg K/ha); led to increase tomato yield nutrients contents. The objective of this work is approach the goal yield of tomato fruits by using rice straw as mulching to keep moisture soil contents and product tomato plants from unsuitable cold and heat conditions, while bituminous emulsion used as a synthetic mulching and soil conditioner, the mineral fertilizer (P) used to approach sufficient levels of nutrients which tomato plants need during different stages growth.

Materials and Methods

Throughout two successive years, a field experiments in three completely randomized replications for each treatment were carried out in Maryout region at West El Delta- Egypt, located at 29º 10'53" N and 25º 33' " E**.** This soil was irrigated by flooded irrigation system. Tomato seedlings were sown at 50 cm apart and 50 cm between rows. The final plant density was 5 plants/m^2 (16800 plant/fed). bituminous emulsion were applied at rates of 0.0, 0.1, 0.4, and 0.8 L/m^3, while the applied rates of rice straw were 0, 5, 10 and 15 ton/fed. Measurements were carried out for two soil moisture conditions and two heating/cooling cycles throughout three soil depths of 0-5, 5–15, 15–30 cm, to attain the dry and wet soil moisture conditions. Measurements were achieved before irrigation on the three growth stages of the plant;(vegetative, flowering and yield formation). Total heat retained (T_n), heat content of soil (Hs) and heat absorbed by soil moisture content of water (H_w) were calculated. Temperature measurements were taken through three plant growth stages before and after irrigation (heating & cooling). The experiment was conducted in a randomized complete plot design with three replicates in addition to the control treatment (without any mulch types).

The tomato plant variety Yossi 97-3 was cultivated as seedlings in 20th February with providing protection against cold, while the harvest stage was in the months of May and June. Analytical data of the studied soils are presented in table 1. according to Page, *et al.,* 1984 and Klute, (1986). Superphosphate was added as fertilizer at two rates (25 and 50 kgP_2O_5/fed, each rate divided into two equal doses, the first one was applied with organic matter during soil preparation process and the second dose with the life confidential. N and K applied at one rate 100kgN/fed and 75kg K_2O/fed through three equal doses after 30, 60 and 90 days from

transplanting date. The foliar micronutrients sprayed at one rate (200 ppm of Fe, Mn and Zn) for all studied treatments after 3 days from N and K soil fertilizers application date.

Table 1: Some physical properties of the studied soil.

Depth (cm)	Particle size distribution (%)				T.C.	CaCO3 (%)	ρb	ρS	O.M. (%)	Moisture % at	
	C.S 2000-200 µ	F.S. 200-20 µ	Silt 20-2 µ	Clay < 2µ			Kg.m-3			0.1 bar	15 bar
0-5	2.61	53.52	29.43	14.44	SL	36.40	1.32	2.40	0.80	19.11	8.29
5-15	2.78	54.83	24.39	18.00	SL	36.45	1.30	2.31	0.75	19.87	8.90
15-30	2.65	54.27	28.27	14.81	SL	36.51	1.30	2.43	0.68	18.48	8.43

c.s =Coarse sand, F.S. = Fine Sand, T.C. =Texture Class SL. =Sandy Loam, ρb=Soil Bulk Density, ρ_S =Particle Phase Density, O.M. = Organic Matter.

Samples of tomato plants were collected at the harvest stage at the end of experiment. The plant height plant (cm), weight fruits/plant (g), No fruits/plant, weight fruits (ton/fed) were recorded in the both studied seasons. Plant samples were analyzed for N, P and K content % and the total soluble solids (TSS %) in tomato fruits were determined by a hand refractor-meter according to Cottenie *et al.* (1982). Statistical analysis was carried out using randomize complete block design with three replicates for each treatment. The obtained data were statistically analyzed according to Gomez and Gomez (1984).

Results and Discussion

Effect of mulching and P fertilizer treatments on yield parameters of tomato plants:

Data in Table (2) stated that the fruits yield of tomato plants were significantly increased with increasing the addition P rates either with or without mulching application in the studied soil throughout the studied two seasons. Mineral P_1 fertilizer increased number fruits/plant, weight fruit (g) and weight fruit (g) /plant by 48.6, 62.1 and 64.1% than control respectively. These facts were due to the important role phosphorus in plant which involved in the photosynthesis, energy and nutrient transport in plant (Lambers *et al.,* 2014). The previous results agreed with such obtained by Abugre and Ampofo (2011), Idowu *et al.,* (2013) and Manoj *et al.,* (2013).

Concerning the effect of mulching on yield parameters of tomato plants, Table (2) assured that the fruits yield parameters increased with increasing application rates of the two studied mulching types. The mulching by bituminous emulsion was higher superior than straw rice for fruits yields of tomato. The increases were due to bituminous emulsion reached 23, 17.1 and 36.1% for No. fruits/plant, weight fruit (g) and weight fruit (g) /plant respectively. Generally, the superior treatment was bituminous emulsion 0.8 L/m^2 + P_2 (50kg P_2O_5/fed) and Rice straw 15 ton/fed + P_2 (50kg P_2O_5/fed) which produced 28.1 and 24.6 fruit ton/fed, respectively.

Economic treatment of rice straw mulching was 10 ton /fed which produced 24.2 ton/fed of tomato fruits, while treatment 15 tons/fed produced 24.6 ton/fed difference of 0.4 ton/fed of tomato fruits. Where that the price one kg of tomato fruits 1.5 LE, the price of 400 kg = 600 Egyptian pounds, while the cost of 5 tons of rice straw until it reach the place of field experience = 2500 LE, the 10 ton/fed rice straw treatment is less expensive than the 15 ton/fed rice straw treatment by 1900 LE, therefore the economic treatment was the least expensive and achieved a yield nearly to yield of 15 ton/fed rice straw treatment. These results were due to the important role of mulching for plant production, as mentioned by Maamoun, and Sherbeny (2015). Also, Sarolia and Bhardwaj (2012) who reported that mulching keep soil moisture by reducing evaporation processes from the soil surface. It prevented increasing soil temperatures during summer season and keeps the soil warm in winter. So, temperature degrees were more suitable for plant growth and kept soil clean against weeds and harmful insects. The previous factors reflected positively on the quantity and quality of tomato fruits. These results agreed with data obtained by Samaila *et al.,*(2011), Gudugi *et al.,* (2012) Hou *et al.,*(2014) and Edyta (2014).

Effect of mulching and P fertilizer treatments on nutrients contents of tomato plants:

Data presented in table (3) showed the effect of studied treatments on nutrients content in tomato plants. Regarding to mulching effect on nutrients content, data showed that N, P and K content in leaves and fruits of tomato increased with increasing mulching and P fertilizer application rates.

On the other side, the nutrients behavior in leaves and fruits tomato takes the same trend. The P_2 treatment recorded higher increases nutrients content in both leaves and fruits than the other treatments. The mulching by bituminous emulsion led to a significant higher increases of nutrients contents in leaves and fruits than mulching by rice straw by about 2.94, 9.04 and 5.82 % for N, P and K in leaves respectively, while in fruits they were 5.91, 12.4 and 8.61%. Also, the (TSS %) of tomato fruits increased with adding the studied two types of mulching rates. The highest mean values of TSS% in tomato fruits were 3.95 and 4.10 % when applied rice straw at 15 ton/fed and bitumen at 0.8L/m^2, respectively. It is important to mention that the concentration of the

studied elements in leaves is always higher that found in fruits. The pervious results agreed with the findings obtained by Al-Mohammadi and Al-Zubi(2011), Idowu *et al.,* (2013) and Manoj *et al.,* (2013).

Table 2: Effect of mulching treatments on the fruits yield components of tomato during the studied two sequence seasons.

Fertilizer P	Mulching treatments		No fruits /plant	Weight fruit g/fruit	Weight fruit g/plant	Weight fruit kg/plant	Weight fruit ton/fed
P1 (25kg P_2O_5/fed)	Control		29.8	28.7	855	0.86	14.4
	Rice straw Ton/fed	5	34.8	32.6	1134	1.13	19.1
		10	38.5	34.2	1317	1.32	22.1
		15	38.7	34.6	1339	1.34	22.5
	Bitumen L/m2	0.1	37.4	33.4	1249	1.25	21.0
		0.4	40.8	36.3	1481	1.48	24.9
		0.8	41.3	37.5	1549	1.55	26.0
P2 (50kg P_2O_5/fed)	Control		31.4	30.1	945	0.95	15.9
	Rice straw ton/fed	5	36.8	34.1	1255	1.25	21.1
		10	39.8	36.2	1441	1.44	24.2
		15	40.1	36.5	1464	1.46	24.6
	Bitumen L/m2	0.1	38.8	35.9	1393	1.39	23.4
		0.4	42.3	38.9	1645	1.65	27.6
		0.8	42.7	39.2	1674	1.67	28.1
LSD 0.05 Phosphorus			0.40	0.50	34	0.034	0.56
LSD 0.05 Bitumen			0.27	0.19	16	0.016	0.27
LSD 0.05 Rice straw			0.14	0.11	9	0.009	0.15
LSD 0.05 Bit x P			0.27	0.27	16	0.016	0.26
LSD 0.05 St x P			0.15	0.16	13	0.013	0.22

Table 3: Effect of mulching and P fertilizer treatments on nutrients contents and total soluble salts of tomato fruits (TSS) during the studied two sequence seasons.

Studied treatments			Nutrients in Leaves %			Nutrients in Fruits %			TSS in
			N	P	K	N	P	K	Fruits %
P1 (25kg P_2O_5/fed)	Control		2.32	0.066	1.37	1.35	0.042	0.57	3.26
	Rice straw Ton/fed	5	2.49	0.076	1.43	1.56	0.048	0.65	3.62
		10	2.56	0.086	1.49	1.68	0.059	0.83	3.73
		15	2.63	0.098	1.54	1.73	0.065	0.92	3.83
	Bitumen L/m2	0.1	2.58	0.084	1.51	1.61	0.057	0.74	3.77
		0.4	2.65	0.096	1.58	1.72	0.069	0.86	3.86
		0.8	2.71	0.108	1.63	1.81	0.077	0.98	3.99
P2 (50kg P_2O_5/fed)	Control		2.45	0.076	1.45	1.43	0.048	0.62	3.46
	Rice straw ton/fed	5	2.54	0.102	1.47	1.59	0.069	0.69	3.74
		10	2.61	0.114	1.54	1.70	0.077	0.84	3.85
		15	2.69	0.128	1.60	1.77	0.084	0.95	3.95
	Bitumen L/m2	0.1	2.61	0.112	1.58	1.8	0.074	0.80	3.89
		0.4	2.69	0.128	1.64	2.01	0.087	0.92	4.00
		0.8	2.75	0.136	1.69	2.61	0.095	1.04	4.10
LSD 0.05 Phosphorus			0.016	0.0065	0.016	0.062	0.0042	0.012	0.036
LSD 0.05 Bitumen			0.005	0.0006	0.006	0.024	0.0006	0.005	0.009
LSD 0.05 Rice straw			0.006	0.0009	0.004	0.013	0.0007	0.007	0.011
LSD 0.05 Bit x P			0.007	0.0006	0.006	0.034	0.0009	0.007	0.009
LSD 0.05 St x P			0.008	0.0013	0.006	0.019	0.0010	0.008	0.016

The bituminous emulsion mulching showed superior effect on increasing nutrients contents in leaves and fruits of tomato plants than rice straw mulching . These results may be due to the mulching keep on soil moisture and increased the availably of nutrients in soil and it keeps suitable temperatures to complete all biological processes in the plants. The previous factors reflected positively effects on nutrients content of tomato leaves and fruits (Sarolia and Bhardwaj 2012). Gudugi *et al.,* (2012) Hou *et al.,*(2014) and Edyta (2014).

Apparently the decrease in the maximum soil temperature upon applying bituminous emulsion can explained on basis that soil mulching by bituminous emulsion, which fasted down the evaporation rate from soil surface and hence decreased the soil moisture content and consequently heat capacity of the soil and its temperature. Considering the temperature along the wet soil profile after irrigation, (Table 3) in the flowering stage varied from 21.63 C◦ to 21.63 C◦ at 8:00 am (early morning), 23.38 C◦ to 23.96 C◦ at 2:00 pm (afternoon) and from 21.09 C◦ to 21.66 C◦ at 4.00 am (dawn) under the mulching with rice straw. The reverse was true under mulching bituminous emulsion treatments. Also pointed out that under wet conditions, the differences between soil temperatures under the various application levels of bituminous emulsion were not pronounceable due to increasing moisture content. The previous results were agreed with obtained by Hamid *et al.,* (2012) and Singhm and Kamal (2012).

Effect of mulching and P fertilizer treatments on the actual soil temperature:

Data in tables (from 4 to 7) showed that the values of the actual temperature of the dry soil (before irrigation) in the absence of mulching rice straw were higher than the corresponding values of the same treatment under mulching with rice straw and bituminous emulsion. The values of maximum soil temperatures in the control treatment (without mulching). the actual soil temperature decreased with mulching rate increasing of rice straw and bituminous emulsion. When compared between the studied two types mulching, the bituminous emulsion was higher temperature than rice straw. The mulching rice straw with 15 ton/fed record 21.5C◦ and 19.6 C◦ in the upper two soil depths 2:00 pm, while the temperature was 19.2 C ◦ in the bottom soil depth at max. temp. But under bituminous emulsion at 0.8L/m^2 record 23.1 C◦ and 22.2 C◦ in the upper two soil layers, while it was 21.3 C◦ in the bottom layer at the same recording times. On percentage basis, the decrease of maximum temperature of the soil before irrigation due to mulching ranged between 2.33 to 0.26%. Nevertheless such trend is vanished and becomes negligible during the period from the night to the onset of morning (8:00 am).

Table 4: Effect of mulching and P fertilizer treatments on the actual soil temperature and moisture content before irrigation in Mars during the studied two sequence seasons.

Treat.		Depth	Soil temperature C0			Soil Moisture w/w			Soil Temperature C0			Soil Moisture w/w		
		(cm)	8AM	2PM	4am	8AM	2PM	4am	8AM	2PM	4am	8AM	2PM	4am
			P_1 (25kg P_2O_5/fed)						P_2 (50kg P_2O_5/fed)					
Control		0-5	22.1	24.7	21.8	13.6	11	12.3	22.4	25	22	13.7	11.2	12.5
		5--15	21.8	23.4	21.4	14.5	12.5	13.5	22.2	23.8	21.7	14.7	12.6	13.6
		15-30	21.5	23.1	20.9	15.3	13.3	14.3	22.1	23.5	21.2	15.5	13.5	14.5
Straw rice ton/fed	5	0-5	18.9	22.6	18.8	15.3	13.6	14	19.1	22.9	19	15.5	13.7	14.2
		5--15	18.2	21.7	18.2	16.1	14.3	15.7	18.5	22	18.5	16.3	14.5	15.9
		15-30	17.5	20.6	17.4	17.3	15.1	16.7	17.8	20.8	17.6	17.5	15.3	16.9
	10	0-5	17.8	21.6	17.7	16.8	14	16	18	22	18.3	17	14.2	16.2
		5--15	17.5	20.9	17.4	17.3	14.9	16.1	17.7	21.3	17.9	17.5	15.1	16.4
		15-30	17.3	20.4	16.8	18	15.8	17	17.6	20.8	17.3	18.2	16	17.2
	15	0-5	17.6	21.5	17.5	17.8	14.7	16.1	17.8	21.7	17.8	18.1	14.9	16.3
		5--15	17.1	19.6	17.2	18.2	15.3	16.9	17.4	19.8	17.4	18.4	15.6	17.2
		15-30	16.1	19.2	16.3	18.6	16.6	17.8	16.3	19.4	16.5	18.8	16.8	18.1
Bituminous L/m2	0.1 L	0-5	21.9	24	21.7	16.3	14.2	15.1	22.2	24.3	22	16.5	14.4	15.3
		5--15	21.4	23.3	21.1	16.9	14.7	15.8	21.7	23.5	21.4	17.2	14.9	16
		15-30	20.8	22.4	20.1	17.7	15.7	16.3	21	22.7	20.4	17.9	15.9	16.5
	0.4 L	0-5	21	23.4	20.6	17.1	14.9	15.8	21.2	23.7	20.8	17.3	15.1	16.1
		5--15	20.3	22.7	20.3	17.8	15.3	16.4	20.6	23	20.6	18	15.5	16.6
		15-30	19.4	21.8	19.2	18.1	15.9	16.8	19.7	22.2	19.5	18.3	16.2	17.1
	0.8 L	0-5	20	23.1	19.3	18	15.1	16.6	20.2	23.4	19.5	18.2	15.3	16.9
		5--15	19.6	22.2	19.2	18.4	15.5	17.1	19.8	22.5	19.5	18.7	15.7	17.4
		15-30	19	21.3	18.5	18.8	16.8	18	19.3	21.6	18.7	19.1	17	18.2
LSD 0.05 Bitumen			0.36	0.17	0.32	0.33	0.35	0.3	0.35	0.16	0.3	0.34	0.36	0.31
LSD 0.05 Straw			0.13	0.1	0.12	0.13	0.09	0.12	0.13	0.1	0.12	0.13	0.1	0.12
LSD 0.05 Depth			0.07	0.06	0.07	0.04	0.05	0.05	0.07	0.06	0.07	0.04	0.05	0.05
LSD0.05 Dep. x St			0.13	0.11	0.12	0.07	0.08	0.08	0.13	0.11	0.12	0.07	0.08	0.09
LSD0.05Bit x Dep.			0.1	0.09	0.1	0.06	0.07	0.07	0.1	0.09	0.1	0.06	0.07	0.07

It is also evident that the lag periods for approaching the maximum soil temperature was in the upper soil depths (0 -5 and 5 – 15 cm) while decreased in bottom depth (15 – 30 cm) during all night even 7 am. This may be due to the relative increase in the soil moisture which can be rended to the fact that a temperature gradient must be developed before heat begins to flow to the lower depths, and thus a time lag before the maximum temperature occur at the lower depth and the resistance to heat conduction through soil tend to damp the temperature cycle at deeper depths. These findings are in concordance with those of Hanks & Ashcroft (1980).

Regarding the mulching treatments effects on soil temperature, the higher application rate of bituminous emulsion (0.8 L/m^2) decreased soil temperature compared to the lower ones. This behavior may be explained on the basis that bituminous emulsion, especially upon using higher application rate has resulted in a positive impact on concerning soil moisture content.

The obtained data of soil moisture revealed that soil moisture content under mulching with rice straw was appreciable higher than the corresponding values of the mulched bituminous emulsion soil . As for the influence of mulching rice straw revealed that the values of actual temperature of mulched soil under all the application rates of rice straw , were relatively lower than those observed under bituminous emulsion conditions. The results obtained agreed with obtained by Gudugi *et al.,* (2012), Hou *et al.,*(2014) and Edyta (2014).

Data clear that relived the soil temperature and soil moisture increased with increasing P fertilizer rates so that the P_2 treatment was higher increased for soil temperature and soil moisture content than P_1 treatment. These results were due to the P fertilizer helps to complete the biological processors in plant and improve

growth and production of tomato fruits these facts agreed with obtained by Al - Mohammadi and Al – Zubi (2011), Manoj *et al.,* (2013) and Lambers *et al.,* (2014).

Table 5: Effect of mulching and P fertilizer treatments on the actual soil temperature and moisture content before irrigation in April during the studied two sequence seasons.

Treat.		Depth	Soil temperature C0			Soil Moisture w/w			Soil Temperature C0			Soil Moisture w/w		
		(cm)	8AM	2PM	4am	8AM	2PM	4am	8AM	2PM	4am	8AM	2PM	4am
			P_1 (25kg P_2O_5/fed)						P_2 (50kg P_2O_5/fed)					
Control		0-5	23.8	26.8	20.8	12.8	9.9	11.8	24.1	27.2	21	13	10	12
		5--15	23.5	25.6	20.7	13.3	11.3	12.3	24	25.9	20.9	13.4	11.4	12.4
		15-30	23.2	25.3	20	14.2	12.1	13.2	23.9	25.7	20.2	14.3	12.3	13.3
Straw rice ton/fed	5	0-5	20.6	24.7	20.3	14.8	12.5	13.5	20.8	25	20.6	15	12.7	13.7
		5--15	19.9	23.8	19.8	15.5	13.2	14.1	20.2	24.1	20	15.7	13.3	14.3
		15-30	19.2	22.7	18.9	15.9	13.7	14.9	19.5	23	19.1	16.1	13.9	15.1
	10	0-5	19.5	23.7	19.3	15.2	13.1	14.3	19.7	24.2	19.8	15.3	13.3	14.5
		5--15	19.2	23.1	18.7	16.3	14.4	15.4	19.4	23.5	19.2	16.5	14.6	15.6
		15-30	19	22.5	17.8	16.9	14.9	15.8	19.3	23	18.4	17.1	15.1	16
	15	0-5	19.3	23.6	19	15.9	14.1	14.8	19.5	23.9	19.3	16.1	14.3	15.1
		5--15	18.8	21.7	18.9	17.1	14.9	15.9	19.1	22	19.1	17.3	15.1	16.2
		15-30	17.8	21.3	18.3	17.7	15.5	16.3	18.1	21.6	18.5	17.9	15.7	16.5
Bituminous L/m^2	0.1 L	0-5	23.6	26.1	22.2	15.3	13.2	14.8	23.9	26.4	22.4	15.5	13.3	14.9
		5--15	23.1	25.4	21.8	15.8	13.9	15.2	23.4	25.7	22	16	14.1	15.4
		15-30	22.5	24.6	20.7	16.5	14.1	15.8	22.7	24.9	21	16.7	14.3	16
	0.4 L	0-5	22.7	25.5	23.1	16.1	13.9	15.4	23	25.8	23.4	16.3	14.1	15.7
		5--15	22	24.8	22.6	16.7	14.6	16.2	22.4	25.2	23	17	14.8	16.4
		15-30	21.1	24	21.6	17.1	15.1	16.8	21.5	24.4	22	17.3	15.3	17.1
	0.8 L	0-5	21.7	25.3	23.3	17	14.6	16.1	21.9	25.6	23.6	17.2	14.9	16.4
		5--15	21.3	24.3	23	17.7	15.5	16.9	21.5	24.6	23.3	17.9	15.7	17.1
		15-30	20.7	23.4	22.4	18.2	16.6	17.4	21	23.8	22.8	18.4	16.9	17.7
LSD 0.05 Bitumen			0.36	0.17	0.65	0.38	0.39	0.47	0.36	0.16	0.64	0.38	0.4	0.48
LSD 0.05 Straw			0.13	0.1	0.07	0.11	0.13	0.12	0.13	0.09	0.1	0.11	0.14	0.13
LSD 0.05 Depth			0.07	0.06	0.05	0.04	0.05	0.04	0.07	0.06	0.05	0.04	0.05	0.04
LSD0.05 Dep. x St			0.13	0.11	0.09	0.07	0.08	0.06	0.13	0.11	0.08	0.08	0.08	0.07
LSD0.05Bit x Dep.			0.1	0.09	0.07	0.06	0.07	0.05	0.1	0.09	0.07	0.06	0.07	0.05

Table 6: Effect of mulching and P fertilizer treatments on the actual soil temperature and moisture content before irrigation in May during the studied two sequence seasons.

Treat.		Depth	Soil temperature C0			Soil Moisture w/w			Soil Temperature C0			Soil Moisture w/w		
		(cm)	8AM	2PM	4am	8AM	2PM	4am	8AM	2PM	4am	8AM	2PM	4am
			P_1 (25kg P_2O_5/fed)						P_2 (50kg P_2O_5/fed)					
Control		0-5	27.7	32	26.4	11.7	8.4	10.7	28	32.4	26.7	11.8	8.5	10.8
		5--15	27.3	31.9	26.4	12.1	10.2	11.1	27.8	32.3	26.7	12.3	10.3	11.3
		15-30	26.8	31.1	25.6	13	11.5	12.3	27.6	31.7	25.9	13.2	11.6	12.5
Straw rice ton/fed	5	0-5	26.6	31.1	26	13.9	12	12.7	26.9	31.6	26.3	14.1	12.1	12.8
		5--15	25.9	30.3	25.4	14.7	12.7	13.3	26.3	30.7	25.7	14.9	12.9	13.5
		15-30	25.1	29.2	24.5	15.2	13.1	14.9	25.5	29.6	24.8	15.4	13.3	15.1
	10	0-5	25.5	30.1	24.9	14.3	12.3	13.5	25.8	30.7	25.6	14.5	12.5	13.7
		5--15	25.2	29.5	24.5	15.9	13.3	14.9	25.5	30.1	25.3	16.1	13.4	15.1
		15-30	25.2	29	23.9	16.2	14.8	15.3	25.5	29.6	24.6	16.4	15	15.5
	15	0-5	25.1	30.1	24.7	16	13.9	14.8	25.5	30.4	25	16.2	14.1	15.1
		5--15	24.8	28.2	24.3	17	14.6	15.9	25.2	28.5	24.7	17.2	14.9	16.2
		15-30	23.8	27.8	23.5	17.2	15.5	16.7	24.2	28.1	23.8	17.5	15.8	17
Bituminous L/m^2	0.1 L	0-5	28.7	31.7	27.8	14.5	12	13.9	29	32.1	28.2	14.7	12.1	14.1
		5--15	28.1	30.8	27.4	15.3	13.4	14.4	28.4	31.1	27.8	15.5	13.6	14.6
		15-30	27.1	29.9	26.4	16.7	14.3	15.3	27.4	30.3	26.7	16.9	14.5	15.5
	0.4 L	0-5	29.7	32.6	28.8	15.9	12.9	14.7	30	33	29.1	16.1	13.1	14.9
		5--15	29.2	31.3	28.3	16.8	13.8	14.9	29.6	31.7	28.7	17	14	15.1
		15-30	28.5	30.4	27.3	16.9	14.9	15.6	29	31	27.8	17.2	15.1	15.8
	0.8 L	0-5	29.9	33.3	28.9	16.2	13.2	15.5	30.2	33.7	29.3	16.5	13.4	15.7
		5--15	29.5	32.1	28.6	16.7	14.7	16.9	29.9	32.5	29	16.9	14.9	17.1
		15-30	29.2	31.7	28.1	17.9	15.8	17.2	29.6	32.2	28.5	18.1	16	17.4
LSD 0.05 Bitumen			0.66	0.27	0.63	0.45	0.4	0.47	0.66	0.26	0.61	0.46	0.41	0.47
LSD 0.05 Straw			0.12	0.1	0.11	0.14	0.14	0.14	0.13	0.07	0.1	0.14	0.15	0.14
LSD 0.05 Depth			0.06	0.06	0.05	0.05	0.06	0.05	0.06	0.06	0.05	0.05	0.06	0.06
LSD0.05 Dep. x St			0.1	0.1	0.09	0.09	0.11	0.09	0.1	0.1	0.09	0.09	0.11	0.1
LSD0.05Bit x Dep.			0.08	0.08	0.07	0.07	0.09	0.08	0.08	0.08	0.07	0.07	0.09	0.08

It is striking to notice that the mean values of moisture content of the mulching bituminous emulsion treatments throughout the soil profile before irrigation at all the studied times were higher than it with mulching rice straw. This fact was due to the role bituminous emulsion role in preventing as much as possible from the water lost through evaporation from the soil surface, when compared with rice straw. The previous results were agreed with obtained by Hillel, (1998) found that bituminous emulsion treatments caused higher soil moisture content w/w.

Data in tables (4 to 7) which represents ripening stage shows the same trend as mentioned above in both tables 2 and 3. The suitable studied treatment was 10 ton/fed of rice straw and bituminous emulsion treatments at the rate of 0.8 L/m^2 which recorded suitable soil temperature and soil moisture content to grow and produce tomato plants and achieved 24.2 and 28.1 ton/fed of tomato fruits.

Table 7: Effect of mulching and P fertilizer treatments on the actual soil temperature and moisture content before irrigation in Jon during the studied two sequence seasons.

Treat.		Depth	Soil temperature C^0			Soil Moisture w/w			Soil Temperature C^0			Soil Moisture w/w		
		(cm)	8AM	2PM	4am	8AM	2PM	4am	8AM	2PM	4am	8AM	2PM	4am
			P_1 (25kg P_2O_5/fed)						P_2 (50kg P_2O_5/fed)					
Control		0-5	33.1	38.5	32.5	10.9	8.9	9.9	33.4	39	32.9	11	9	10
		5--15	32.8	37.2	32.2	11.4	9.3	10.4	33.4	37.8	32.6	11.5	9.5	10.5
		15-30	32.4	36.9	31.7	12.2	10.2	11.7	33.4	37.6	32.1	12.3	10.3	11.9
Straw rice ton/fed	5	0-5	29.8	36.3	29.6	14.1	10.8	12.8	30.2	36.8	30	14.2	11	13
		5--15	29.2	35.5	29	14.8	11.4	13.9	29.6	36	29.4	15	11.6	14.1
		15-30	28.4	34.4	28.1	15.6	12.5	14.5	28.9	34.8	28.5	15.7	12.6	14.7
	10	0-5	28.8	35.3	28.5	14.6	11.6	13.5	29	36	29.4	14.8	11.7	13.7
		5--15	28.4	34.7	28.2	15.1	12.1	14.3	28.8	35.4	29	15.3	12.3	14.5
		15-30	27	34.2	27.5	16	13.4	14.8	27.3	34.9	28.4	16.2	13.5	15.1
	15	0-5	28.5	35.3	28.3	15	12	13.8	28.9	35.7	28.7	15.2	12.2	14
		5--15	28.1	33.4	27.9	15.8	12.7	15	28.5	33.8	28.3	16	12.9	15.2
		15-30	28.3	33	27.1	16.4	14	15.2	28.8	33.4	27.5	16.7	14.2	15.5
Bituminous L/m^2	0.1 L	0-5	32.9	37.8	32.4	14.7	11.3	13.4	33.2	38.2	32.8	14.9	11.5	13.6
		5--15	32.4	36.9	31.9	15.1	11.6	14.1	32.8	37.3	32.3	15.3	11.8	14.3
		15-30	31.7	36	30.9	15.7	12.6	14.6	32.1	36.4	31.3	15.9	12.7	14.8
	0.4 L	0-5	31.9	37.2	31.4	15.2	12.1	14.1	32.3	37.6	31.8	15.5	12.3	14.3
		5--15	31.3	36.5	31.1	15.8	12.7	14.9	31.8	37	31.5	16	12.8	15.1
		15-30	30.3	35.6	30.1	16.2	13.6	15.1	30.9	36.3	30.5	16.5	13.8	15.3
	0.8 L	0-5	30.9	37.1	30.9	15.9	12.8	14.6	31.3	37.5	30.5	16.1	13	14.8
		5--15	30.5	36.2	30.4	16.1	13	15.3	30.9	36.7	30.4	16.3	13.2	15.5
		15-30	30	35.1	29.2	16.7	14.2	15.5	30.3	35.6	29.7	17	14.4	15.7
LSD $_{0.05}$ Bitumen			0.42	0.17	0.36	0.38	0.35	0.36	0.43	0.15	0.29	0.4	0.35	0.37
LSD $_{0.05}$ Straw			0.14	0.1	0.12	0.11	0.11	0.12	0.15	0.09	0.11	0.12	0.11	0.12
LSD $_{0.05}$ Depth			0.07	0.06	0.07	0.05	0.05	0.05	0.07	0.06	0.07	0.05	0.04	0.05
LSD$_{0.05}$ Dep. x St			0.11	0.11	0.12	0.09	0.08	0.09	0.11	0.11	0.12	0.09	0.07	0.09
LSD$_{0.05}$Bit x Dep.			0.09	0.09	0.1	0.07	0.07	0.07	0.09	0.09	0.1	0.07	0.06	0.07

Effect of mulching and P fertilizer treatments on Total heat content (Hc):

Tables (8 to 11) presents the values of total heat content (heat soil+ heat water) as affected by applied the studied treatments. In the case of wetted soil, i.e. after irrigation clarify that the values of total heat content averaged during tomato growth season in the two upper and one bottom soil depths mulched by rice straw ranged from 369 to 397 and 382 to 403 cal/g. at 8 am , 403 to 425 and 410 to 428 cal/g. at 2 pm, 347 to 376 and 361 to 380 cal/g. at 4 am respectively. Also the data revealed that the gain and loss of heat of the mulched rice straw dry soil during the periods from 8 am to 2 pm and 2 pm to 4 am ranged from 7.0 to 9.0 & 11.8 to 13.6 % in the two upper soil depths and 6.1 to 7.3 & 11.6 to 12.2 % in the one bottom depth respectively.

The same trend was found in bitumen behavior, so that the gain and loss of heat of the mulched soil by bitumen ranged from 5.0 to 6.4 & 10.9 to 12.1 % in the two upper soil depths and 4.7 to 6.9 & 10.2to 12.4 % in the one bottom depth respectively. It is evident that surface depths (0-5 cm and 5 – 15 cm) displayed the highest gain and loss of heat compared to the bottom soil depth and control treatment. The values of total heat content in the different soil depths mulched rice straw showed the same trend mentioned above in tables, but the bituminous emulsion treatments were highest. Values of total heat content under wetted soil (after irrigation) were higher than those corresponding dry soil (before irrigation). This behavior could partly due to its relatively higher albedo with consequent higher reflection of the incoming radiation and partly to the higher absorbing latent heat, the high recorded soil temperature upon applying bituminous emulsion may be attributed to its black color which increases the absorption of the incident solar radiation during the day time (Hillel, 1998). These results agreed with the findings by Moreno *et al.,* (2009) and Singhm and Kamal(2012).

In conclusion, the fruits yield parameters increased with increasing rates of the studied two mulching types. The mulching by bituminous emulsion was higher superior than straw rice for fruits yields of tomato, while the mulching by straw rice was higher than control treatment about 23, 17.1 and 36.1% for number of fruits/plant, weight (g) fruit and weight (g) fruit /plant respectively. The superior treatment was Bitumen 0.8 L/m^2 + P_2 and Rice straw 15 ton/fed + P_2 which achieved 28.1 and 24.6 fruit ton/fed respectively. Economic treatment of rice straw mulching which added with 10 ton /fed which achieved 24.2 ton/fed of tomato fruits, while treatment 15 tons/fed achieved 24.6 ton/fed difference of 0.4 ton/fed of tomato fruits. The bituminous

emulsion mulching was superior effect on increasing nutrients contents in both leaves and fruits of tomato plants than mulching rice straw. The actual temperatures of soil gradually decreased with soil studied depths, while the soil moisture contents increased with increasing the studied soil depth. The total heat content (soil heat + water heat) cal/g soil increased with increasing the studied soil depth. This study recommended to use mulching by economic rate of straw rice was 10 ton/fed or use bitumen emulsion at 0.8 L/m^2 to provide a suitable temperatures and moisture content in soil for the tomato growth and good production.

Table 8: Effect of mulching and P fertilizer treatments on the total heat content (cal/g soil) before irrigation in Mars during the studied two sequence seasons

Treat.		Depth	Total heat (cal /g soil)									
		(cm)	8AM	2PM	4am	Gain%	Loss%	8AM	2PM	4am	Gain%	Loss%
			P_1 (25kg P_2O_5/fed)					P_2 (50kg P_2O_5/fed)				
Control		0-5	254	302	246	15.9	18.5	262	315	254	16.8	19.5
		5--15	262	314	257	16.6	18.2	271	331	272	18.1	17.9
		15-30	279	318	268	12.3	15.7	281	326	276	13.8	15.4
Straw rice ton/fed	5	0-5	273	305	268	10.5	12.1	283	318	281	11.1	11.8
		5--15	281	315	278	10.8	11.7	296	330	292	10.2	11.4
		15-30	296	325	287	8.9	11.7	303	332	294	8.6	11.4
	10	0-5	285	307	271	7.2	11.7	292	313	278	6.8	11.4
		5--15	298	318	280	6.3	11.9	305	324	287	6.0	11.6
		15-30	304	328	289	7.3	11.9	307	332	294	7.6	11.6
	15	0-5	297	310	277	4.2	10.6	305	316	282	3.6	11.0
		5--15	308	319	286	3.4	10.3	312	322	288	3.1	10.7
		15-30	314	330	291	4.8	11.8	318	333	295	4.5	11.5
Bituminous L/m^2	0.1 L	0-5	288	312	270	7.7	13.5	306	330	287	7.4	13.2
		5--15	294	321	283	8.4	11.8	311	344	304	9.6	11.5
		15-30	311	327	292	4.9	10.7	318	335	301	5.2	10.4
	0.4L	0-5	295	314	279	6.1	11.1	307	328	290	6.4	11.5
		5--15	306	327	287	6.4	12.2	319	340	297	6.1	12.5
		15-30	311	335	294	7.2	12.2	322	346	304	6.9	11.9
	0.8 L	0-5	304	317	284	4.1	10.4	313	325	292	3.8	10.1
		5--15	312	331	288	5.7	13.0	321	339	294	5.4	13.3
		15-30	318	342	305	7.0	10.8	322	347	311	7.3	10.5
LSD $_{0.05}$ Bitumen			1.24	0.58	0.51	0.63	0.01	1.28	0.44	0.24	0.64	0.01
LSD $_{0.05}$ Straw			1.12	0.65	0.44	0.6	0.06	1.1	0.68	0.43	0.61	0.06
LSD $_{0.05}$ Depth			0.97	0.63	0.45	0.24	0.12	1	0.64	0.46	0.24	0.12
LSD$_{0.05}$ Dep. x St			1.68	1.09	0.77	0.41	0.2	1.74	1.1	0.79	0.42	0.21
LSD$_{0.05}$Bit x Dep.			1.37	0.89	0.63	0.34	0.17	1.42	0.9	0.64	0.34	0.17

Table 9: Effect of mulching and P fertilizer treatments on the total heat content (cal/g soil) before irrigation in April during the studied two sequence seasons

Treat.		Depth	Total heat (cal /g soil)									
		(cm)	8 AM	2 PM	4 am	Gain%	Loss%	8 AM	2 PM	4 am	Gain%	Loss%
			P_1 (25kg P_2O_5/fed)					P_2 (50kg P_2O_5/fed)				
Control		0-5	270	330	261	18.2	20.9	273	335	264	18.4	21.1
		5--15	288	339	273	15.0	19.5	293	346	278	15.3	19.7
		15-30	315	342	308	7.9	9.9	325	355	318	8.4	10.4
Straw rice tn/fed	5	0-5	292	327	284	10.7	13.1	302	339	294	11.0	13.4
		5--15	312	340	303	8.2	10.9	318	349	309	8.8	11.4
		15-30	324	350	310	7.4	11.4	329	357	315	7.9	11.9
	10	0-5	298	335	285	11.0	14.9	307	346	294	11.3	15.2
		5--15	313	356	305	12.1	14.3	323	368	315	12.3	14.6
		15-30	331	365	314	9.3	14.0	335	371	318	9.8	14.4
	15	0-5	303	346	297	12.4	14.2	311	354	305	12.2	13.9
		5--15	320	362	307	11.6	15.2	329	370	316	11.1	14.7
		15-30	338	371	316	8.9	14.8	341	375	319	9.1	15.1
Bituminous L/m^2	0.1 L	0-5	321	348	302	7.8	13.2	328	358	309	8.3	13.7
		5--15	337	356	307	5.3	13.8	342	363	312	5.9	14.2
		15-30	343	367	319	6.5	13.1	349	374	325	6.8	13.3
	0.4L	0-5	323	357	307	9.5	14.0	332	369	316	10.0	14.5
		5--15	338	363	315	6.9	13.2	341	368	318	7.4	13.7
		15-30	347	379	321	8.4	15.3	353	388	327	8.9	15.7
	0.8 L	0-5	328	365	315	10.1	13.7	331	369	318	10.4	13.9
		5--15	339	373	316	9.1	15.3	342	377	319	9.4	15.5
		15-30	349	382	327	8.6	14.4	353	388	331	9.1	14.8
LSD $_{0.05}$ Bitumen			1.41	1.11	1.4	0.1	0.89	1.46	1.29	1.11	0.11	0.9
LSD $_{0.05}$ Straw			1.34	0.44	0.5	0.36	0.24	1.32	0.53	0.49	0.37	0.24
LSD $_{0.05}$ Depth			1.07	0.88	0.43	0.16	0.18	1.1	0.9	0.43	0.17	0.19
LSD$_{0.05}$Bit x Dep.			1.51	1.24	0.6	0.23	0.26	1.56	1.27	0.61	0.23	0.26
LSD$_{0.05}$ Dep. x St			1.85	1.52	0.74	0.28	0.32	1.91	1.55	0.75	0.29	0.32

Table 10: Effect of mulching and P fertilizer treatments on the total heat content (cal/g soil) before irrigation in May during the studied two sequence seasons

Treat.		Depth (cm)	Total heat (cal /g soil)									
			8 AM	2 PM	4 am	Gain %	Loss%	8 AM	2 PM	4 am	Gain%	Loss%
			P_1 (25kg P_2O_5/fed)					P_2 (50kg P_2O_5/fed)				
Control		0-5	402	451	385	10.9	14.6	408	459	391	11.1	14.8
		5--15	409	458	397	10.7	13.3	411	463	399	11.3	13.9
		15-30	416	469	410	11.3	12.6	419	470	413	10.9	12.2
Straw rice ton/fed	5	0-5	405	466	392	13.1	15.9	412	475	399	13.3	16.1
		5--15	414	476	404	13.0	15.1	418	483	408	13.4	15.5
		15-30	422	486	413	13.2	15.0	421	487	412	13.5	15.4
	10	0-5	408	457	406	10.7	11.2	414	462	412	10.3	10.8
		5--15	419	471	409	11.0	13.2	422	475	412	11.2	13.3
		15-30	429	475	418	9.7	12.0	432	477	421	9.5	11.8
	15	0-5	409	463	403	11.7	13.0	417	473	411	11.8	13.1
		5--15	427	472	415	9.5	12.1	429	475	417	9.7	12.3
		15-30	435	479	423	9.2	11.7	437	482	425	9.4	11.9
Bituminous L/m^2	0.1 L	0-5	425	429	406	0.9	5.4	429	435	410	1.4	5.8
		5--15	433	452	411	4.2	9.1	435	455	413	4.4	9.3
		15-30	443	477	415	7.1	13.0	445	478	417	6.9	12.8
	0.4 L	0-5	428	430	409	0.5	4.9	433	436	414	0.7	5.1
		5--15	435	452	418	3.8	7.5	439	457	422	4.0	7.7
		15-30	445	468	425	4.9	9.2	448	473	428	5.3	9.6
	0.8 L	0-5	432	429	412	-0.7	4.0	435	433	415	-0.5	4.2
		5--15	438	467	421	6.2	9.9	442	473	425	6.6	10.2
		15-30	452	482	432	6.2	10.4	457	488	437	6.4	10.6
LSD $_{0.05}$ Bitumen			0.08	2.84	2.2	0.77	1.31	0.05	3.09	1.83	0.78	1.32
LSD $_{0.05}$ Straw			1.5	0.34	0.52	0.4	0.08	1.46	0.43	0.53	0.4	0.09
LSD $_{0.05}$ Depth			1.12	0.8	0.48	0.16	0.13	1.16	0.82	0.48	0.16	0.13
LSD$_{0.05}$Bit x Dep.			1.58	1.13	0.68	0.23	0.18	1.64	1.16	0.68	0.23	0.18
LSD$_{0.05}$ Dep. x St			1.94	1.38	0.83	0.28	0.22	2.0	1.42	0.83	0.28	0.23

Table 11: Effect of mulching and P fertilizer treatments on the total heat content (cal/g soil) before irrigation in Jon during the studied two sequence seasons

Treat.		Depth (cm)	Total heat (cal /g soil)									
			8AM	2PM	4 m	Gain%	Loss%	8AM	2PM	4 m	Gain%	Loss%
			P_1 (25kg P_2O_5/fed)					P_2 (50kg P_2O_5/fed)				
Control		0-5	445	483	437	7.9	9.5	450	506	478	11.1	5.5
		5--15	456	496	446	8.1	10.1	466	502	471	7.2	6.2
		15-30	489	506	469	3.4	7.3	493	512	485	3.7	5.3
Straw rice ton/fed	5	0-5	504	512	445	1.6	13.1	510	519	485	1.7	6.6
		5--15	510	519	460	1.7	11.4	517	526	485	1.7	7.8
		15-30	520	525	473	1.0	9.9	523	531	494	1.5	7.0
	10	0-5	508	515	457	1.4	11.3	514	522	475	1.5	9.0
		5--15	518	526	476	1.5	9.5	521	529	473	1.5	10.6
		15-30	523	531	482	1.5	9.2	527	535	487	1.5	9.0
	15	0-5	518	522	465	0.8	10.9	520	527	484	1.3	8.2
		5--15	521	529	485	1.5	8.3	525	533	493	1.5	7.5
		15-30	526	533	491	1.3	7.9	529	541	500	2.2	7.6
Bituminous L/m^2	0.1 L	0-5	509	528	467	3.6	11.6	515	519	451	0.8	13.1
		5--15	515	539	479	4.5	11.1	522	525	465	0.6	11.4
		15-30	523	545	488	4.0	10.5	528	532	479	0.8	10.0
	0.4 L	0-5	512	533	473	3.9	11.3	517	526	462	1.7	12.2
		5--15	522	549	482	4.9	12.2	527	530	468	0.6	11.7
		15-30	527	556	491	5.2	11.7	532	539	480	1.3	10.9
	0.8 L	0-5	519	547	477	5.1	12.8	526	531	461	0.9	13.2
		5--15	525	552	488	4.9	11.6	530	538	463	1.5	13.9
		15-30	531	564	498	5.9	11.7	535	541	498	1.1	7.9
LSD $_{0.05}$ Bitumen			4.43	6.96	2.02	0.48	1.01	4.53	7.3	2.52	0.48	1.02
LSD $_{0.05}$ Straw			1.02	0.61	0.32	0.1	0.2	0.97	0.73	0.14	0.1	0.21
LSD $_{0.05}$ Depth			1.14	1.12	0.62	0.1	0.17	1.18	1.15	0.61	0.11	0.17
LSD$_{0.05}$ Dep. x St			1.97	1.95	1.07	0.18	0.29	2.04	2	1.06	0.18	0.29
LSD$_{0.05}$Bit x Dep.			1.61	1.59	0.87	0.15	0.23	1.67	1.63	0.87	0.15	0.24

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