EFFECT OF POLYMERS ON SOIL PROPERTIES

WATER CONSERVATION, AND YIELD

BY

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INTRODUCTION

Since agriculture is very important in meeting the food needs of an increasing global population, production must be expanded, world -wide. More food must be produced by adopting and adapting new technology in the field of agriculture so as to optimize agricultural production return . Since water is usually the major limiting factor in agricultural development in arid and semi-arid regions, the major domain in such problem is the efficient use of water.

The shortage of water for agriculture in arid and semi-arid regions such as Jordan necessitates a good soil moisture management which is probably the most critical problem facing soil and water conservation researchers all over the world .

The economical use of water is required especially for crops grown during the Summer season, where the rate of evapotranspiration is relatively high .Consequently, the management strategy for such a problem recommends the use of polymers (synthetic soil conditioners) , which have become very important during the last ten years due to better economical justification of their uses . Improved scientific understanding of their behavoir increased after the symposium on the fundumentals of soil conditioning held in Ghent " Belgium " in 1972 .

Soil conditioning is not only concerned with the imporve in the physical and chemical properties of the soils, but also to give soils the needed physical prperties that allow plant growth , reduce evaporation , enhance soil stability , save water and increase water use efficiency.

Addition of polymers can change the physical properties of the soil dramatically . To understand this effect, the complex phenomenon has to be broken into simpler physico-chemical phenomena such as aggregation stability , water behavior , fertilizer behavior, evaporation and yield .

Four soils with different textures representing the major portion of the cultivated areas in Jordan were chosen in the present investigation and green - house experiments were set-up with the aim of studying the enfluence of application of two new polymers, namly Aquastock and Agri-SC on :

a . Some physical properties and water conservation of the four soils .

b . The yield of wheat (Triticum aestivum) and tomato (Lycopersicon esculentum) in the four soils , respectively .

c. The availability of some micronutrients in the four soils for wheat and tomatoes .

LITERATURE REVIEW

Water shotage in Jordan is a major problem in agricultural production . More than 90 % of the total cultivated land in Jordan, which represents 1.8 % of Jordan's total area or 3.5 million dunums[1], depend on limited and erratic rainfall for it's cultivation (Dar-Al-Handash and Nedeco , 1969).

There has been a renewed interest in applying chemical conditioners to soils for the alleviation of certain agricultural problems in recent years (De-Boodt (1975) and Pla (1975)).

Rare, indeed, would be a soil that possesses perfect physical condition for all possible uses . To day, there is a long list of physically and chemically active materials that are added to the soil and can improve its physical conditions . The physical condition , particularly , as it relates to soil water, is of major in soil management.

Aggregate stability is one of the basic physicl properties (Ram and Zwerman (1960) . Yield can be high or low depending on the status of the soil aggregate and their stability (De - Boodt et al.(1960)).

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(1) dunum is 1000 m^2

The addition of polyacrylaide (PAM), bitumen emulsion and Black liquor increased aggregate stability of sandy and calcereous soils (koch et al., 1974)). Similar effect was found when adding "PAM" and " Aqua-Gro " on fine - textured soil. (Hartmanin et al .(1975)). This effect was reported when applying either " PAM" or "Bitumen emulsion " on sand loam , silt loam , and clay loam soils (PLa (1975) and Carr and Greenland (1975)). The formation of water stable aggregates was promoted in clayey soil by the application of "Hydroxyaluminum " (Shiraishi, (1980)). The same results were indicated whe adding either " Gigtars-S " or "Magnafloc -351 " on sandy and loess soil (Szczypa and Monies, (1976)). Similar results were obtained when treating soil of silty clay texture with " Krillium Merloam " (Sepakhah et al (1980)). Labib et al (1983) found the same effect after the addition of " PAM " and " Bitumen emulsion " to sandy and calcereous soils . Gabrials (1975) reported similar result when adding " Asphalt emulsion " and " Krillium emulsion " on different textures . Moreover, adding "PAM " , polyvinyl-chloride "PVC" and "Bitumen emulsion " to sandy , sandy-loam and calcereous soils gave the same effect (Tayel et al. (1981 c)). Azzam and El-Hady (1983) found that water stable aggregates of "PAMGs " treated sand soil was more than that of clay soil . These effects were acheived after complete drying up to 10 % moisture or less (Groosens et al. (1979)) .

Water soluble polymers of high molecular weight increased aggregate stability of the soil (Schamp et al. (1975)). The extent of this effect depends mainly on soil texture (Hartmanin et al ; (1975)). Moreover, it was indicated that improvement in aggregate stability could be achieved even by using small doses of hydrolized Polyacry lonitrile (HPAN) , "PAM" and dimethylalky-Lammonium chloride (DMACI) (Vornin (1976).In addition to this , polymers had prevented the crust fomation up to 2 -cm depth of the seed bed through out the growing season of wheat crop (Oades (1976)).

Since synthetic polymers affect soil aggregation, it is expected that they would affect both soil apparant specific gravity and porosity . Carpenter (1955) found that Vinylacetate (VAMA) improved soil structure and that the soil remained porous and in good physical condition.

The addition of "PVA" decreased apparant specific gravity of clayey soil and decreased it's porosity (Oades, (1976)). These results were idicated after application of "Hygromull " and "Agrosil - LR " on calcereous soil (Khoury et al . (1978)). Similar effects were obtained when adding "Hydroxy aluminum " on clayey soil (Shiraishi, (1981)) and " PAMGs " on sandy soil (Azzam and El-Hady (1983) and labib (1983)).

The real challenge in arid and semi-arid regions, like Jordan , is to conserve water, or in other words , to prevent runoff, decrease evaporation , reduce perculation , manage water for crops, and to increase water use efficiency . De-Boodt(1975) indicated that synthetic soil conditioners have the ability to condition the soil and to conserve water . Therefore , soil conditioners and their effects on the water holding capacity of soil can provide a tool for water conservation.

Water requirement of a 100 - day rice crop grown in sandy loam was reduced from 346 to 255 cm by the application of "Bentonite "to the soil (Das and Dakshnamuri (1975)). In addition , irrigation intervals in the field of sandy soil were extended from 3 to 7 days after "Hygromull" application (sayegh et al. (1982)). Same results were obtained after "Gigtars " and "Magnafloc -351 " were added to sandy and loose structure soil (Szczypa and Monies (1976)). Moreover, adding "PAM" , "PVA " and Bitumen emulsion " to sandy soil improved water retention (Mcguire et al (1978)). Similar results were found after "Mendina " application to silt loam soil. Water holding capacity and available water were increased after the application of "PAMG's " on sandy and clayey soils (Azzam and El-Hady (1983)), or "Hygromull " and " Agrosil - LR " (Nimah et al .(1983)).

The increase was found to be directly proportional to polymer concentrations (Azzam (1983)).

"PAM" conditioner (Labib et al (1983)) or "Betumen emulsion (Lenvain and De-Boodt (1976a)) were found to increase water use efficiency of barley in sandy and calcereous soils or coarse-textured soils.

Soil conditioning is thought of as to modify structure and to improve water budget in the soil . This would indirectly improve water budget in the soil and micro and macronutrients availability. Some polymers has the ability to improve the fertility of the soil becouse they contain some macro-and micronutrients within their structure such as Agrosil-LR.

Carpenter(1955) reported that " VAMA" polymer tended to inhibit the uptake of phosphorous fertilizer by oat in silt clay soil . Similar result was found after "Krillium Merloam " polymer adding to silt clay soil grown with sugar beet, especially at high rates (Sepaskhah et al.(1980)). Phosphorous up take by barley was increased by the addition of "PAM" , "PVA_c" and " Bitumen " conditioners , while , k-uptake was enhanced in sandy soil when treated with "PVA_c " and in calcereous soil when treated with "PAM" (Abed et al.(1981) El-Hady et al. (1983)) indicated that P-uptak by pepper from sandy soil was five times more than that of the control by adding 0.2 % of 30 % anionic "PAMG " whereas, k-uptake increased up to 146 % . Moreover, the addition of "PAM" to sandy soil increased p-uptake by barley in all treatments, where as, k-uptake was enhanced in calcereous soils only (Labib et al " (1983)).

Sepashah et al . (1980) reported that the up-take of Zn and Fe by sugar beet was reduced after soil conditioning with " Krillium Merloam " . While the addition of 30% anionic "PAMG " at arate of 0.2 % to fertile clayey soil increased the uptake of Zn , Mn , Fe and Cu. In addition , Fe uptake by barley was increased by the addition of "PAM" on sandy soils (Labib et al. (1983)).

Polymers was found to have a direct effect on yield. Significant increase in yield of tomato and barley was obtained when grown in "PVA" conditioned loam soils (Carr and Green land (1975)). Agrosil-LR also was reported to increase the yield of bean grown in sand and calcereous soils (sakr and Imam (1978)). The yield of vegetables was increased when adding" Hygromull" and Agrosil to calcereous clayey and loam soils (Sayegh et al .(1982)). The increase in yield was also obtained when applying "$PAMG_s$ " to sandy soil grown with pepper. Similar result was obtained when adding "PAM" on calcereous and sandy soils, grown with barley (Labib et al .(1983)). Both yield height of corn and soybeans grown in silt loam soil were not affected by " Mendena " application (Jones et al. (1978)).

The germination rate of barley seeds were increased in "PAM" treated sandy and calcereous soil, whereas , Black liquor had no effect on seed germination (Labib and Awad (1981))(Azzam (1983) and El- Hady (1983)). "PVA_c" and "Bitumen emulsion found to delay barley germination in sandy and sandy loam soils (Tayel et al .(1981)). Similar decrease was obtained when adding "PAM" to calcereous and sandy soils.

MATERIALS AND METHODS

I Sampling and Soil Preparation :

Bulk samples of the soils surface were collected from four different areas in Jordan ; namely Marro (Irbid), Series 31 (Ramtha), Zizia, and Ghour (University of Jordan . "Agricultural Research station " in the central region of the Jordan Valley (Figure 1)). The texture of Irbid , Ramtha, Zizia and Ghour soils were clay , clay loam, silt loam , and sandy , respectively . Through the discussion , the four soils will be refered to by their locations.

The bulk soil samples were air-dried , then thoroughly mixed . Representive subsamples of 4-kg each were taken for anlysis and soil charactarization . The subsamples were passed through a 2-mm sieve , except the samples for aggregate stability which were passed a 4-mm seive. The following soil properties were measured (table 1) . Particle size distribution (natural clod samples) was determined after carbonates and organic matter were removed by hydrometer method (Paul R.D.(1965)). Electrical conductivity was measured for the saturated extract using the conductivity bridge (Jackson, (1958)). PH was measured on Paste extract using glass electrode method (Jackson (1958)). Carbonate was dedermined by Acid-Neutralization Method (Allison and Moodle (1965)).

Figure 1 : A map of Jordan showing the locations of the four soils used in the study.

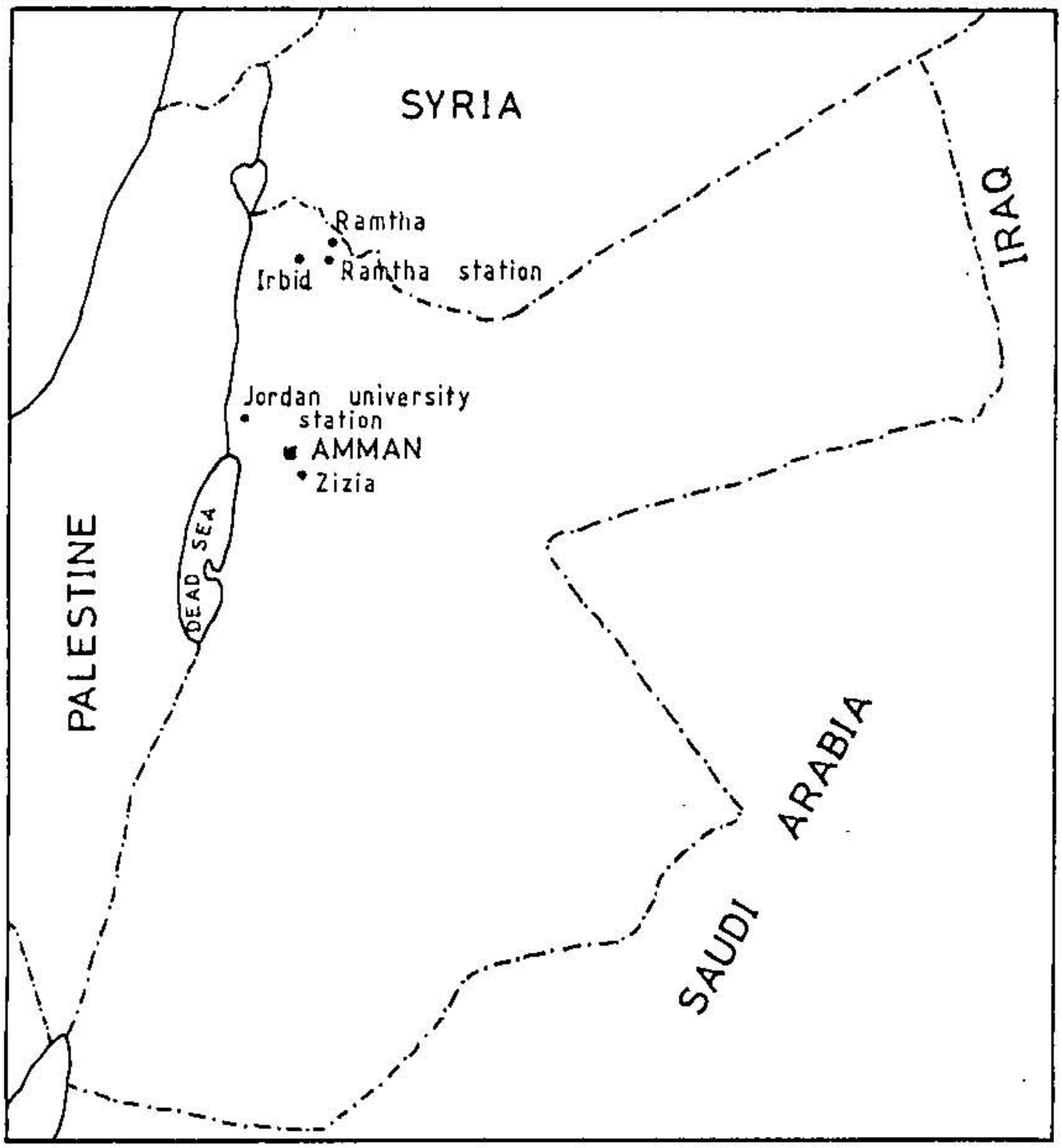

Table 1 : Some physical and Chemical Properties of the four different soils used in the study 1984/1985

soil Name	Particle size distribution (1)								carbonate %	Apparant Specific gravity gm/c.c	p^H	$EC_e X10^2$ (mmhos/cm
	with out removing carbonate				with removing carbonate							
	Sand%	Silt %	Clay%	soil texture	Sand%	silt%	Clay%	soil texture				
Irbid	1.6	32.0	66.4	clay	2.1	31.8	66.1	clay	2.39	1.25	7.8	0.39
Ghour	73.6	10.0	16.4	Sandy	60.1	36.8	3.1	S.L (2)	20.3	1.62	7.7	2.75
Ramtha	8.6	45.2	46.2	C.L.	18.1	40.3	41.6	C.L (3)	16.7	1.13	7.8	0.46
Zizia	17.6	56.0	26.4	S.L.	8.2	58.8	33.0	S.C.L (4)	19.1	1.34	7.9	0.29

(1) Classification of soil type according to textural triangle.

(2) Sandy Loam .

(3) Clay Loam .

(4) Sandy Clay Loam.

Moodle (1965)).

II. Green House Experiment :

The pot experiments were conducted in the green-house at the university of Jordan campus in Jubieha. The design used in the experiments was Latin square design (Figure 2) . Four levels of both " Agri-SC " (first year) and "Aquastock " (second year) were applied to the four soils. Each treatment was replicated four times to give a total of 16 pots.

"Agri-SC " was applied at the rates of 0.0 , 14.2, 28.4 , and 56.8 grams/15 liters / dunum, and "Aquastock " was applied at the rates of 0, 1,2, and 4% (by weight). These rates were used following the manufacturer recommendation .

a - First Year Experiment :

The experiment was conducted in plastic pots having an inside diameter of 25 cm filled with 8 kg of air -dried soils. Fertilizers were added at rates of 12 kg/dunum of ammonium sulfate (21 % N) and 5kg/dunum of triple super-phosphate (45 % p_2O_5) before planting .

"Agri-SC " was diluted with water, prior to application and was sprayed on the air-dried soils.Care

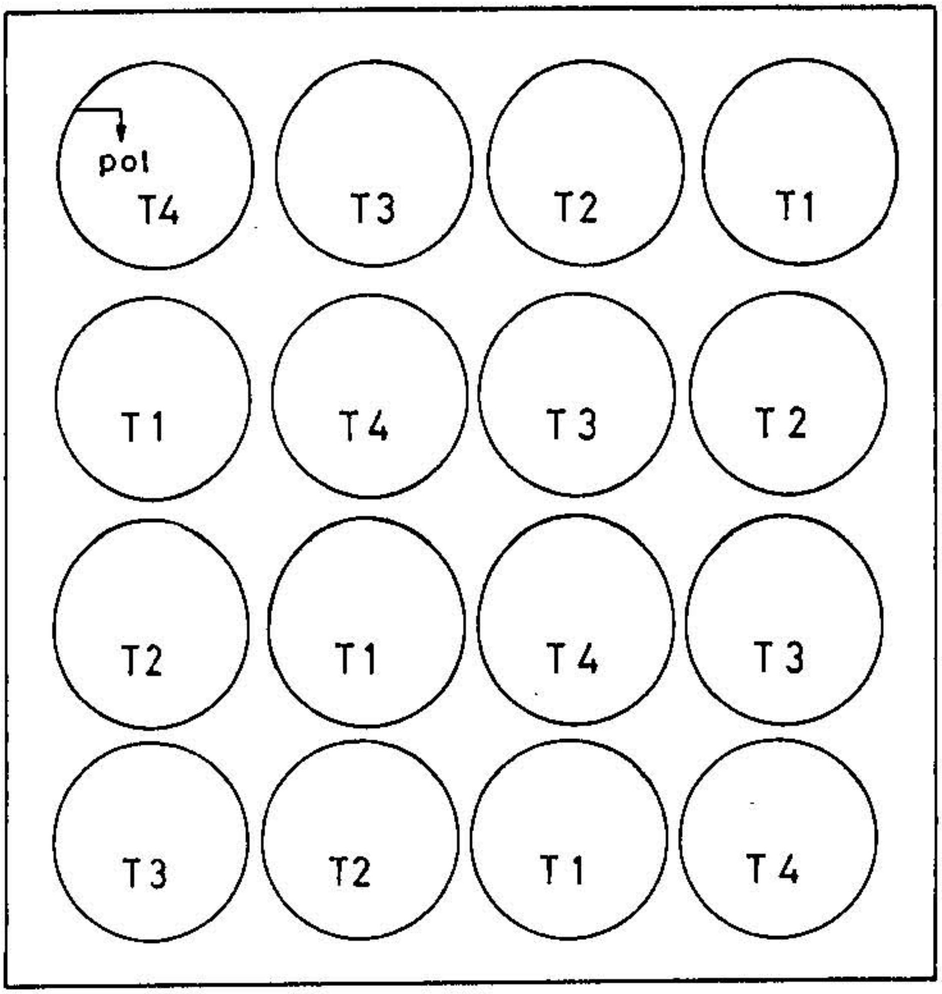

Figure 2 : Layout of latin square design used in the study in green house at University of Jordan (1984 / 1985) .

was taken to ensure homogeneous soil-polymer mixing . The pots were subjected to four wetting and drying cycles before planting (De-Boodt (1975)). 17 seed of "Horani " wheat (Triticum aestivum) were planted on Dec . 9th,1983, in each pot and were thinned to 11 plants per pot, after one and half a week.Pots were irrigated with water at o.7 bar tension using tensiometers.

The wheat grains from each pot were harvested on May 25th, 1984 . The yield in grams was calculated as gram per pot . The data were statistically analysed, and the means of treatments were compaired using the Duncan's Multiple Range Test. Finally the dried grains were milled for micronutrients measurements.

b - Second Year Experiment :

The experiment was conducted in the same place using the same pots, filled with 6 kg of air-dry soil . Fertilizers were added at rates of 50 kg/dunum of ammonium sulfate (21 % N) and 25 kg dunum of triple super-phosphate (45 % p_2O_5) before planting .

"Aquastock " aggregates were mixed with soil as homogeneously as possible, the pots were wetted and dried four times before planting .

Three seeds of "Rafia " tomato (Lycopersicon esculentum) were planted in each pot on Aug. 4th, 1984, and were thinned to one plant per pot after one week. pots were irrigated at o.3 bar tension using tensiometers.

The tomato yield was calculated as grams per pot. In addition , tomato shoot lengths, fresh and dry mass, root lengths and dry mass were measured just before plants were harvested on Jan. 29th, 1985 .

The yield, shoot length, fresh and dry mass, root lengths and dry mass were statistically analysed and the means of treatments for each soil were compaired using the Duncan's Multiple Range Test . The leaves of tomatoes were ground and milled for micronutrients measurements. The juice of tomato plant was tested for total soluble solids, PH , and titratable acid.

III Amount and Times of Irrigation

Water applied to plants was calculated by the amount of water needed to restore each soil to tension needed (suction measurements by tensiometers before starting the experiments (Ritchards and Marsh (1961) started . Tensiometers were installed in each pot as indicators for timing of irrigation . The average volume in millilletters of water applied in each irrigation per pot is shown in table 2 .

IV Analysis on Polymer-treated soils (With no Plant).

2- and 4mm Seived - Soils were treated with different rates of "Agri-SC " and " Aquastock " (after four wetting - drying cycles) the treated and untreated soils were prepared for physical and chemical analysis .

a - Physical Properties : (Average of 3 samples) .

Soil moisture desorption measurements were determined using the ceramic plate apparatus (Richards (1948) . The soil moisture by weigh determinations were made at tensions of 0.1 , 0.3 , 0.5 , 0.7 , 1.0 , 3.0 , 5.0 , 7.0 , 10.0 and 15,0 bar. The apparant specific gravity was determined (from each pot in the experiment before planting) by using the core method (Blake G.R.) . The porosity (%P) was calculated by assuming real specific gravity (Rs) to be equal to 2.65 using the following relationship :

$$P\ \% = \left(1 - \frac{As}{Rs}\right) 100$$.(Vomocil , J.A.)

Aggregate stability was determined by wet sieving , using the following relationship :

$$MWD = \sum_{i=1}^{i=n} Dn\ Wn/Do$$ (Van Bavel (1950)

Where :

Table 2 : Total amount of water applied (ml)[1] in each irrigation/ pot according to tensiometer readings.

Site / tension	Irbid	Ghour	Ramtha	Zizia
0.3 bar	1500	742	1118	988
0.7 bar	1885	815	1415	1115

(1) milliliter .

MWD : Mean weight diameter

Dn : Diameter of a sieve

n : numbers of sieves

W_n : Weight of soil after sieving at each sieve

W_o : Total oven dry soil sieved weight .

The aggregates size were also determined by relating aggregate weight at each sieve to the total sieved weight multiplied by 100 using the following relationship:

$$\text{Aggregate size \%} = \frac{\text{Soil oven weight at each sieve}}{\text{Total oven dry sieved soil}} \times 100\ \%$$

Liquid -limit was determined by mechanical liquid device (Sowers , G.F.). Plastic - limit was determined also by sowers, G.F. The water use efficiency (EW) was determined by the following relationship : (Israelsen and Hansen (1976)) .

$$EW = 100(\text{Yield/Volume of water consumed})$$

b - Chemical analysis :

Extractable soil Fe , Mn , cu , and Zn were determined by using DTPA as an extractant as described by Lindsay and Norvell(1978) . Extractable phosphorous with sodium by carbonate was determind by spectrophotometry (Watanabe and Olsen (1965) . Potassium was extracted with ammonium sulfate and was determined by flame photometry (Pratt and Morse(1954)).

V Micronutrient Measurment in Plant:

The wet digestion of ground dry tomato leaves (70 c^{O}) and milled grain of wheat was used . Total Fe, Cu, Zn , and Mn for each crop were determined by atomic absorption spectrometer as recommended by jones and Ulrich (1959) .

IV Aquastock analysis :

The manufactures chemical analysis of this polymer is as follows :

- Carbon 45 %
- Nitrogen 12 %
- Hydrogen 5.5 %
- Oxygen 27 %
- Sulfur <10 ppm
- Chlorine <10 ppm
- Copper 11 ppm.

RESULTS AND DISCUSSIONS

Aggregate Water Stability and Aggregation Size :

Aggregate water stability represented by mean weight diameter (AWD) after four wetting-drying cycles, for the four different soils as affected by different concentrations of Agri-SC. and Aquastock are shown in figures 3 through 6 . Using Agri-SC .Aggregate stability of the Ghour sandy soil had increased at the first and second concentrations, the aggregate stability was 105 % for the control as shown in figure 3 . Agri - SC, had a negative effect on the aggregate stability of the Irbid clayey soil at all concentrations as shown in figure 4. Aggregate stability was improved by Agri-SC application in both zizia silt loam and Ramtha clay loam soils at all concentrations as shown in figures 5 and 6 , respectively. The correlation between polymer concentrations and MWD was only significant for Ramtha clay loam soil and was insignificant for the other soils (Appendix) .

Aquastock as shown in figures 3 through 6 gave better aggregation stability and had increased the water stability of aggregates for all soils . It is clearly shown that the aggregate stability had increased as the polymer concentration increased . The increase in aggregate stability at the highest concentration was 688 , 390 , 389,

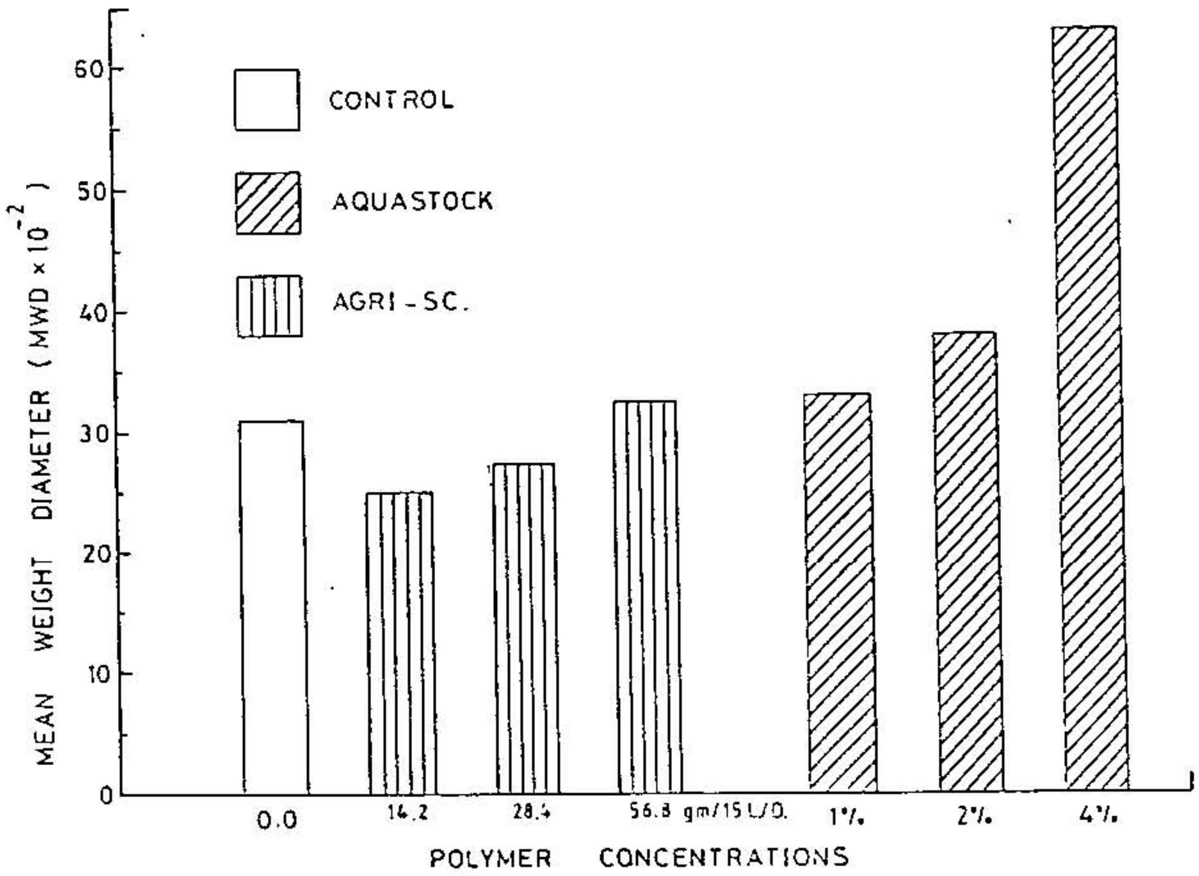

Figure 3 : Aggregate stability represented by MWD after four wetting-drying cycles of Ghour sandy soil as affected by different concentrations of Agri-SC. and Aquastock polymers 1984/1985.

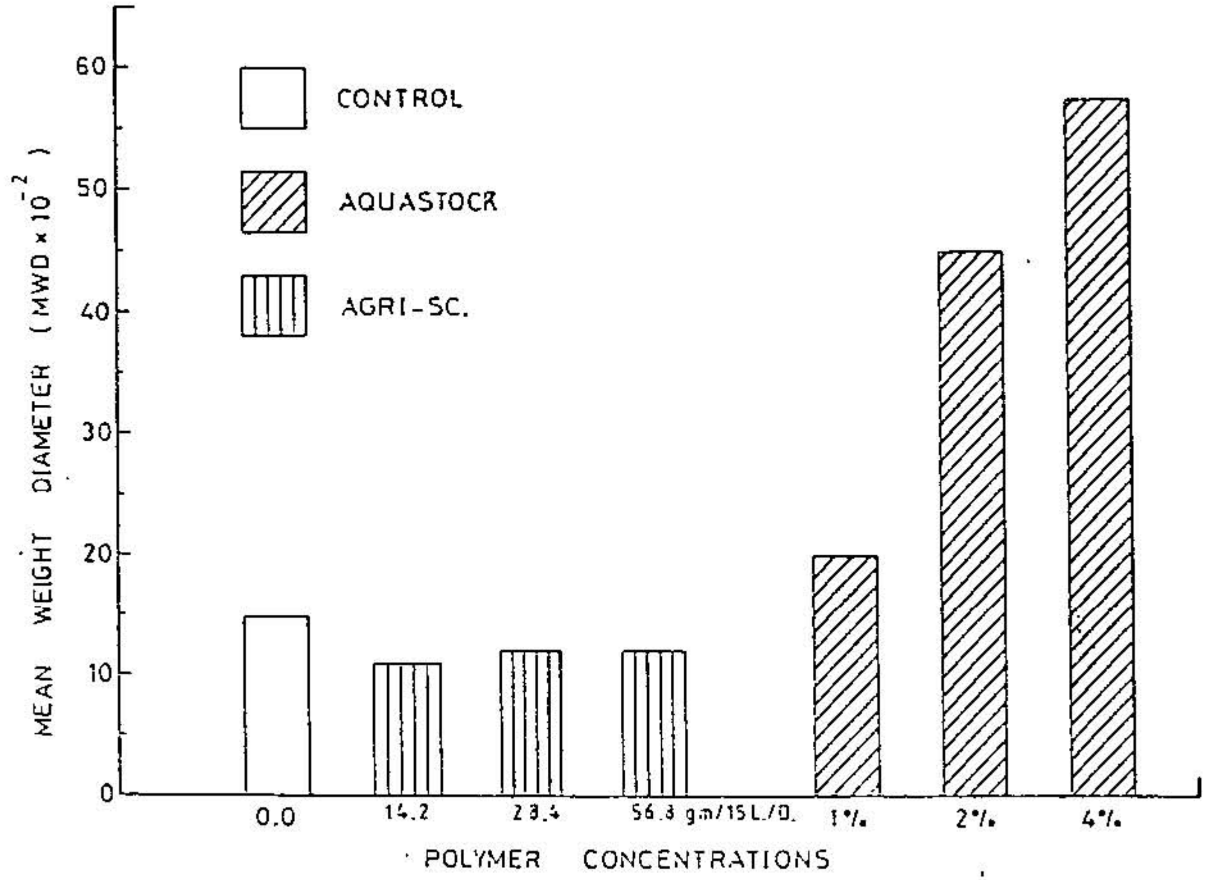

Figure 4 : Aggregate stability represented by MWD after four wetting - drying cycles of Irbid clayey soil as affected by different concentrations of Agri-SC and Aquastock polymers 1984 / 1985.

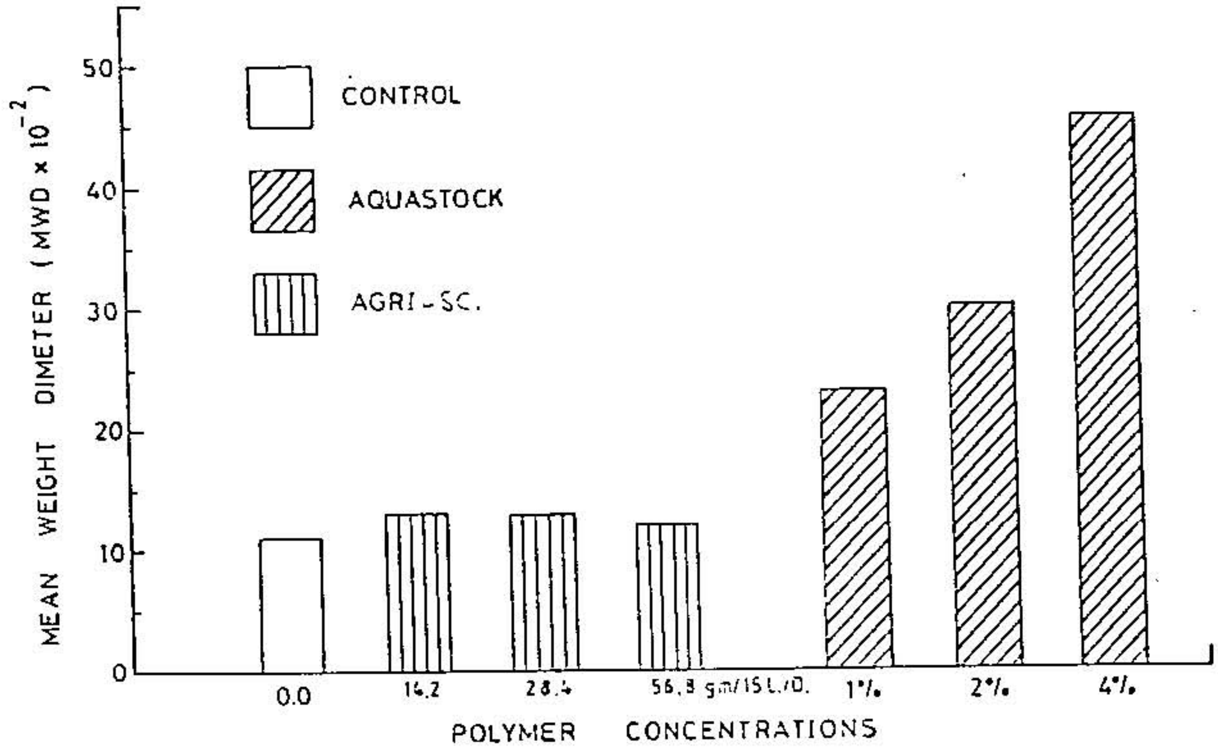

Figure 5 : Aggregate stability represented by MWD after four wetting - drying cycles of Zizia silt loam soil as affected by different concentrations of Agri-SC and Aquastock polymers 1984 / 1985.

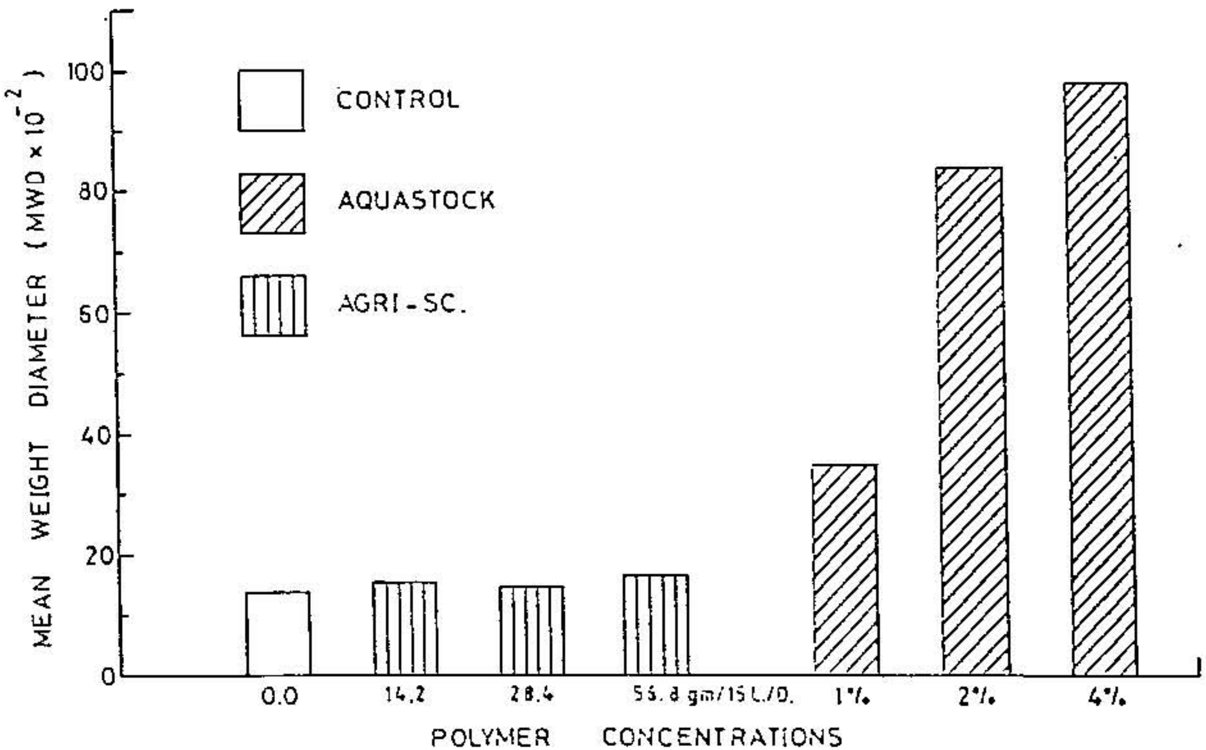

Figure 6 : Aggregate stability represented by MWD after four wetting - drying cycles of Ramtha clay loam soil as affected by different concentrations of Agri -SC and Aquastock polymers 1984 / 1985.

and 205 % of the untreated soil for Ramtha clay loam, Irbid clayey, Zizia silt loam, and Ghour sandy soils, respectivly. Addition of Aquastock at all concentrations significantly increased aggregate stability of all soils (Appendix).These results are in general agreement with other findings.(De-Boodt et al .(1960); Koch et al.(1974); Hartmanin (1975); Szczypa and Monies (1976);Grossens et al.(1979); Sepaskhah (1980); Tayel et al.(1981,C); Nimah et al.(1983); and Azzam and El-Hady (1983). The effect of polymers on aggregate stability could be contributed according to Shirashi (1981), to the coating of aggregates by the polymers thus protecting them and making them more stable against breaking and dispersion. According to Greenland et al (1962), this effect could be due to the occupation of polymers to the weak sites of the aggregates which leads to the stabilization and strengthening of the aggregates without changing the surface properties of soil.Comparatively small doses of polymers increased water stability as was indicated by voronin (1979). According to Schamp (1975) high molecular weight polymers increased aggregate water stability of the soil more than other polymers .

Aggregation size after four wetting-drying cycles of the four soils treated with different concentrations of Aquastock and Agri-SC, are shown in tables 3 through 6 . Aggregation size of more than 2mm had increased by addition of Aquastock and

Table 3 . Aggregation size after four wetting - drying cycles by the Irbid clay soil previously treated with (1%, 2% and 4%) Aquastack and (14.2 28.4 and 56.8 grams/15 liters/dunum) Agri-SC , 1984/1985 .

Treatments	> 2	1-2	0.5-1	0.25-0.5	0.125-0.25 mm	0.063-0.125	0.053-0.063	< 0.053
Control	1.004	1.816	3.392	4.264	35.360	33.950	10.732	9.482
1%	4.684	1.028	2.864	5.188	34.084	31.948	11.268	8.936
2%	11.832	3.684	6.560	46.084	17.748	8.932	1.252	3.903
4%	24.244	1.288	2.888	7.492	16.820	25.684	15.508	6.076
14.2 (1)	1.380	0.912	2.080	2.356	3.300	84.090	0.512	5.390
28.4	1.476	1.732	1.720	1.952	7.148	78.104	0.105	7763
56.8	1.320	1.520	2.412	2.888	11.028	70.036	0.296	10.500

(1) grams/15 liters / dunum

Table 4 . Aggregation size after four wettin-drying cycles by the Ghour sand soil previously treated with (1% , 2% and 4%) Aquastock and (14.2,28.4,and 56.8 grams/15liters/dunum Agri- SC. ,1984/1985.

Treatment	>2	1-2	0.5-1	0.25-05	0.125-0.25 mm	0.063-0.125	0.053-0.063	<0.053
Control	1.356	2.832	19.756	54.752	10.764	1.560	1.404	7.476
1%	3.392	2.484	12.864	56.488	14.236	7.120	0.464	2.952
2%	5.520	3.488	16.584	55.688	10.500	3.948	0.068	4.204
4%	10.140	4.688	72.680	7.316	3.068	0.296	0.444	1.369
14.2 (1)	0.788	2.092	8.696	59.172	13.448	4.488	1.768	9.548
28.4	0.644	4.064	10.908	56.304	14.560	7.428	4.420	1.672
56.6	0.684	1.440	10.920	56.848	12.836	7.120	0.384	9.768

(1) grams/15 liters/dunum

Table 5 . Aggregation size after four wetting-drying cycles by Ramtha clay loam soil previously treated with (1% , 2% and 4%) Aquastock and (14.2,28.4,and56.8 grams/15 liters/dunum Agri-SC, 1984/1985 .

Treatments	>2	1-2	0.5-1	0.25-0.5	0.125-0.25 mm	0.063-0.125	0.053-0.063	<0.053
Control	1.092	1.952	2.828	6.840	19.244	57.840	1.296	8.908
1%	7.784	5.544	10.744	14.412	33.012	18.688	2.628	7.138
2%	37.740	1.636	5.628	5.932	6.960	33.808	0.940	7.368
4%	39.988	4.996	13.452	14.372	13.168	8.596	5.240	0.188
14.2 (1)	2.708	1.624	4.716	6.404	9.136	39.664	17.744	8.004
28.4	2.048	2.168	4.312	7.584	9.544	27.324	38.708	8.312
56.8	2.212	2.196	3.444	37.400	21.036	24.580	0.920	8.210

(1) grams/15 liters / dunum .

Table 6. Aggregation size after four wetting - drying cycles by the Zizia clay loam soil soil preveously treated with (1% , 2%and 4%) Aquastock and (14.2,28.4,and56.8 grams/ 15liters/dunum)Agri-SC , 1984/1985 .

Treatments	>2	2-1	0.5-1	0.25-0.5	0.125-0.25 mm	0.063-0.125	0.053-0.063	<0.053
Control	0.890	0.80	2.520	4.812	24.568	51.832	0.684	13.804
1%	3.604	3.312	6.808	12.964	30.392	39.248	0.236	3.436
2%	3.632	5.924	11.328	35.504	22.232	19.224	0.428	1.728
4%	11.040	8.660	14.044	17.928	17.604	28.544	0.468	1.712
14.2 (1)	0.744	1.148	4.176	8.936	24.040	50.764	0.364	9.828
28.4	1.304	1.328	3.176	6.872	14.440	60.836	0.504	11.540
56.8	0.804	1.396	4.140	7.884	10.728	47.540	15.196	12.312

(1) grams/15 liters/dunum.

was 36,24,12, and 7 times more than that of untreated soils, for Ramtha,Irbid, Zizia and Ghour soil, respectively.It is clear from tables 3 through 6 that aggregation size of Agri-SC. treated soils could be decreased, increased,or remain unhanged.It is obvious that Aquastock polymer had increased the aggregation size much more than that of Agri-SC.Generaly, a satisfactory way in fighting wind and water erosion is one of the main prerequisites for opening new farm land. This will acheive by good stabilization of aggregates and good aggregate stability.These results are in agreement with Sepaskhah (1980); Nimah(1983); and labib (1983)).

Apparant Specific Gravity and Porosity :

The effect of different concentrations of Agri-SC, and Aquastock on the apparant specific gravity of Irbid,Ghour, Ramtha, and Zizia soils after four wetting-drying cycles are shown in figures 7, 8, 9, and 10 respectively.Aquastock had decreased the soil apparant specific gravity greatly.The decrease in apparant specific gravity at the highest concentration of Aquastock was 77, 71, 71, and 58% of the untreated soils for Irbid, Zizia,Ramtha, and Ghour soils,respectively. The decrease in soil apparant specific gravity was greatest at the lowest polymer concentration and the decrease in apparant specific gravity of all soils started to decrease with increasing the polymer concentration.It is clear that apparant specific gravity of clayey soil was affected more than the apparant specific gravity of sandy soil by the addition of Aquastock.

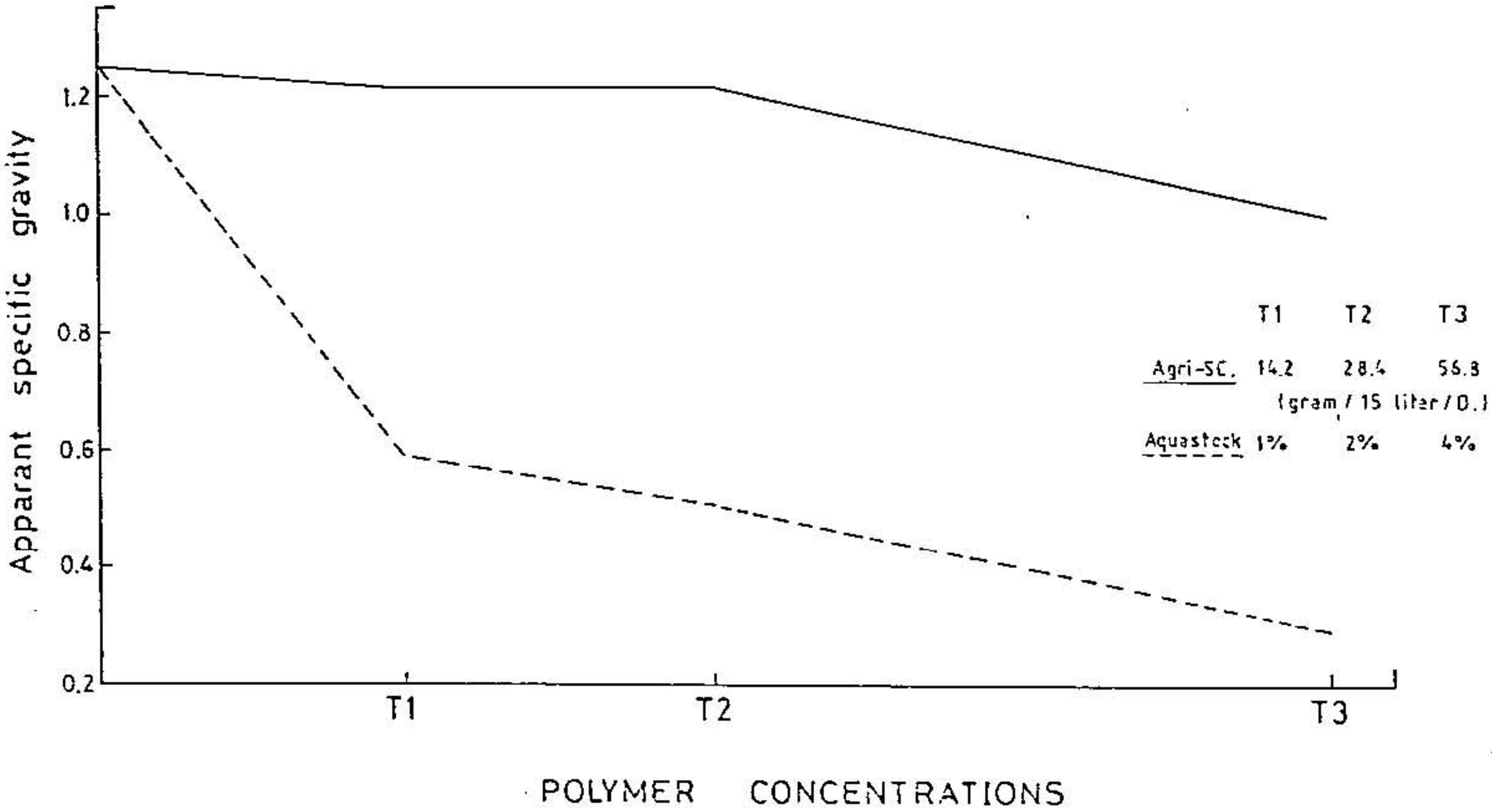

Figure 7: Apparant specific gravity curves after four wetting-drying cycles of Irbid clay soil as affected by different concentrations of Agri-SC. and Aquastock polymers 1984/1985

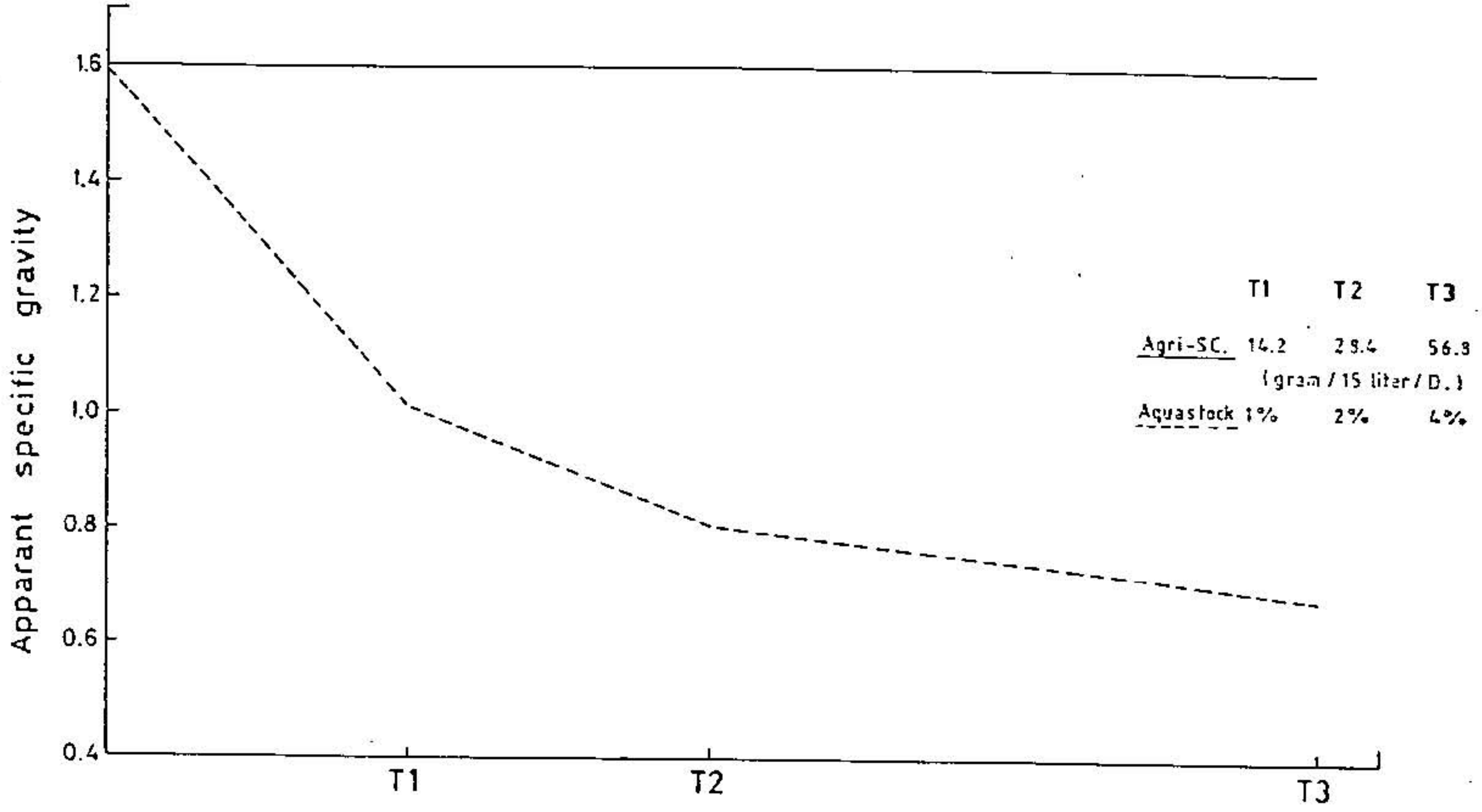

Figure 8: Apparant specific gravity curves after four wetting-drying cycles of Ghour sandy soil as affected by different concentrations of Agri-SC. and Aquastock polymers 1984/1985.

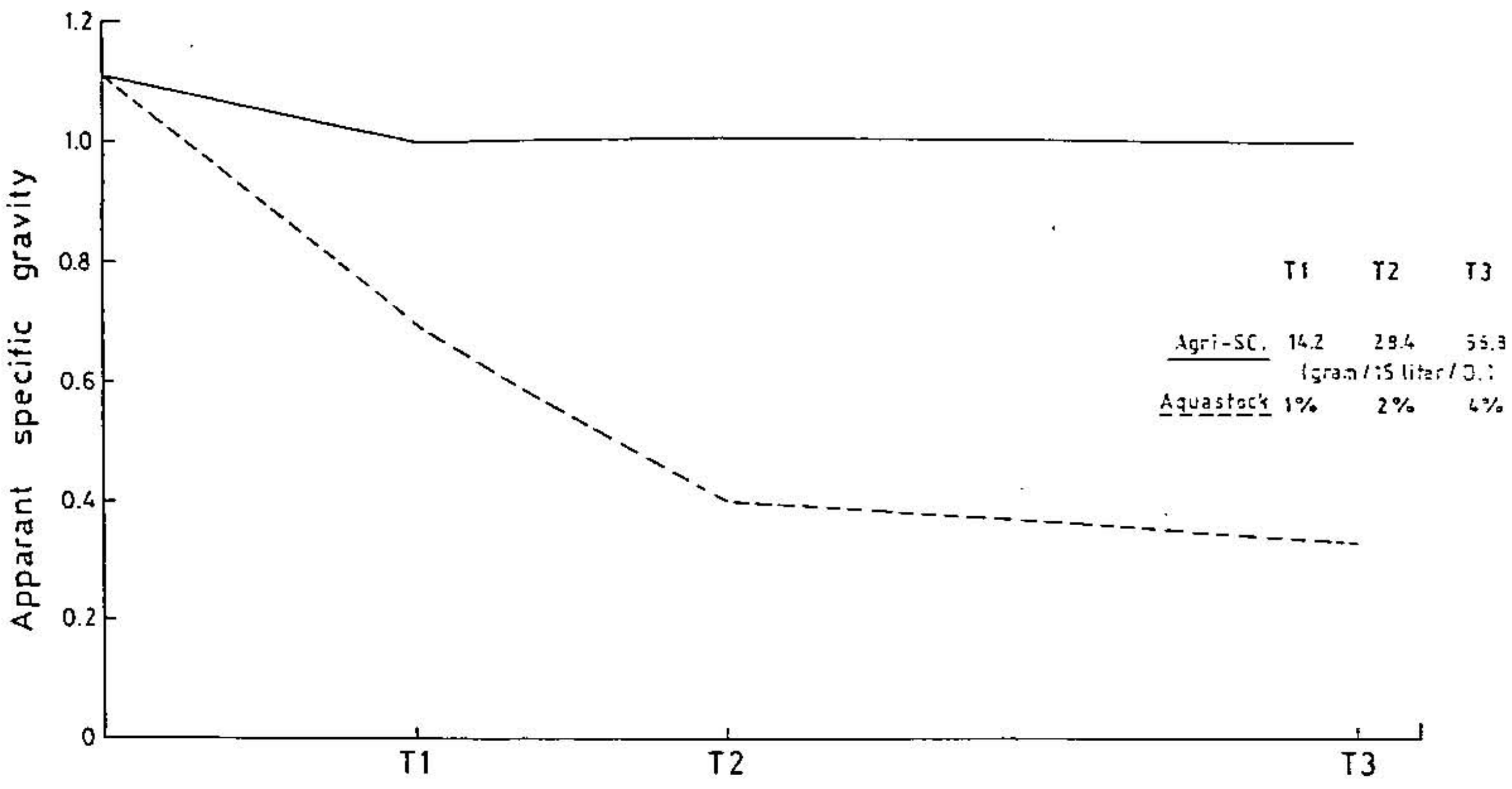

Figure 9: Apparant specific gravity curves after four wetting-drying cycles of Ramtha clay loam soil as affected by different concentrations of Agri-SC. and Aquastock polymers 1984/1985.

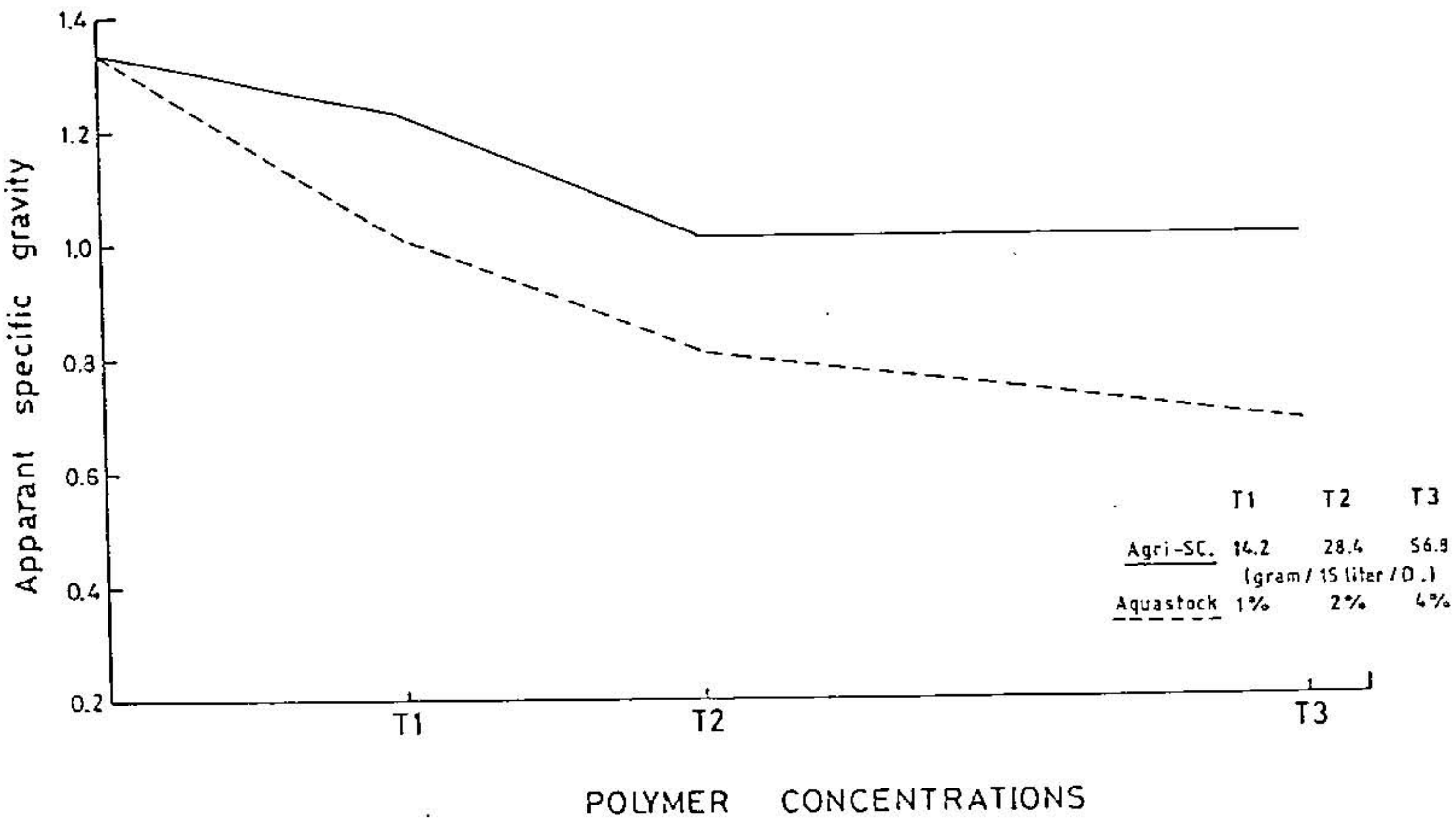

Figure 10: Apparant specific gravity curves after four wetting-drying cycles of Zizia silt loam soil as affected by different concentrations of Agri-SC. and Aquastock polymers 1984/1985.

The effect of Agri-SC on apparent specific gravity of different soil types are shown in figures 7 through 10 . In general , Agri-SC. had decreased the apparent specific gravity of all soils except for the sandy soil. The decrease in apparent specific gravity at the highest concentration of Agri-SC. was 24, 22, 11, and zero% of the untreated soil for Zizia , Irbid , Ramtha and Ghour soils, respectively .These findings are consistant with the other findings (Oades(1976) ; Khoury et al. (1978);shiraishi (1981); and Azzam (1983)). The effect of polymers on apparent specific gravity could be contributed according to Carpenter (1955) to the improvement in soil structure.

The effect of different concentrations of Agri-SC and Aquastock on the porosity for the four soils after four wetting-drying cycles are shown in figures 11, 12, 13 ,and 14 respectively . Aquastock had increased soil porosity greatly. The increase at the highest concentration was 152, 169, 179 , and 190% of the untreated soil, for Ramtha, Irbid, Zizia and Ghour soils, respectively . The increase in soil porosity was greatest with the lowest concentration of Aquastock then the increase in soil porosity started to decrease with increasing Aquastock concentration for all soils . The increase in soil porosity at the highest concentration of Agri-SC was zero, 7,18 , and 23 % of the control for Ghour , Zizia , Irbid , and Ramtha

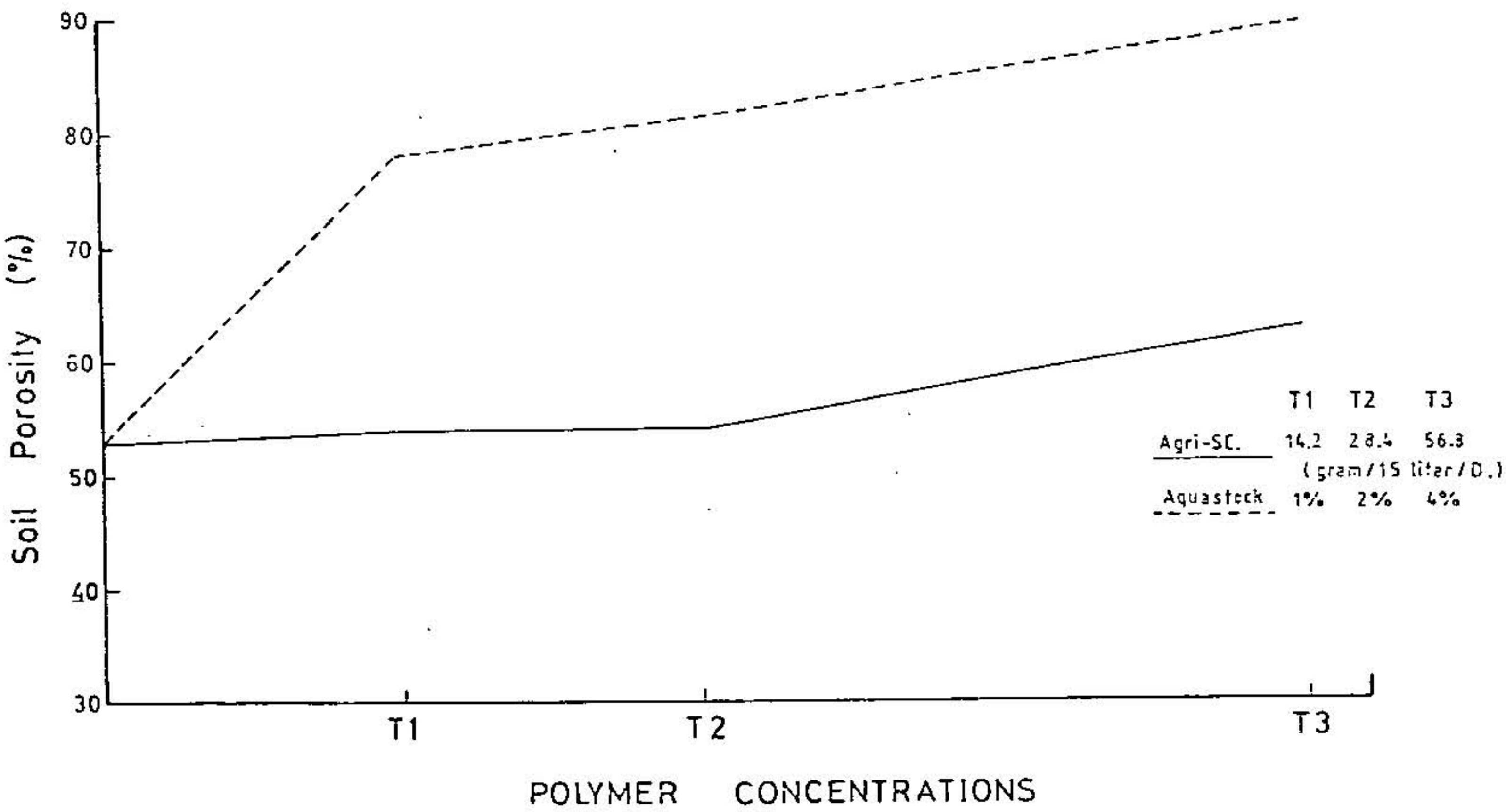

Figure 11 : Soil porosity curves after four wetting-drying cycles of Irbid clayey soil as affected by different concentrations of Agri-SC. and Aquastock polymers 1984 / 1985 .

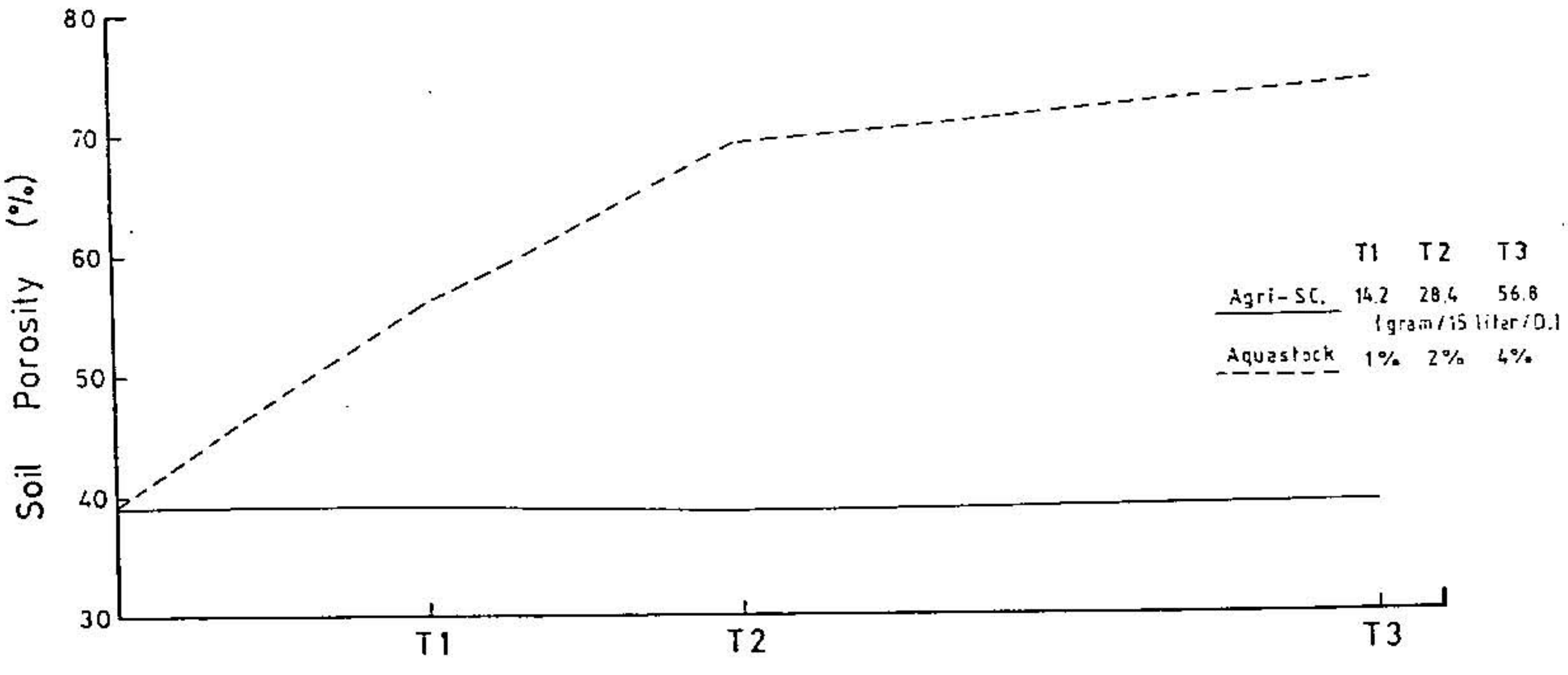

Figure 12 : Soil porosity curves after four wetting-drying cycles of Ghour sandy soil as affected by different concentrations of Agri-SC and Aquastock polymers 1984 / 1985 .

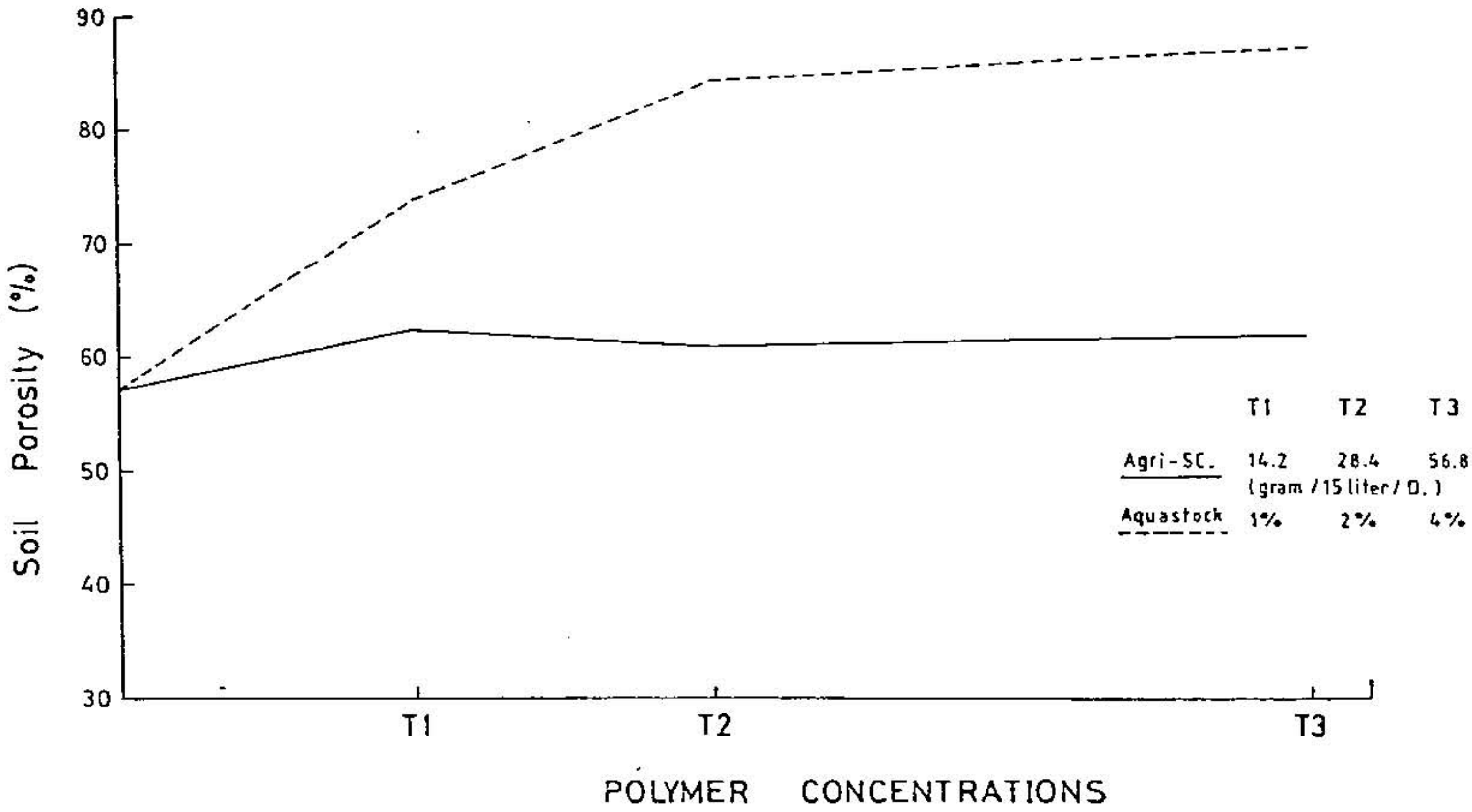

Figure 13 : Soil porosity curves after four wetting-drying cycles of Ramtha clay loam soil as affected by different concentrations of Agri-SC and Aquastock polymers 1984 / 1985 .

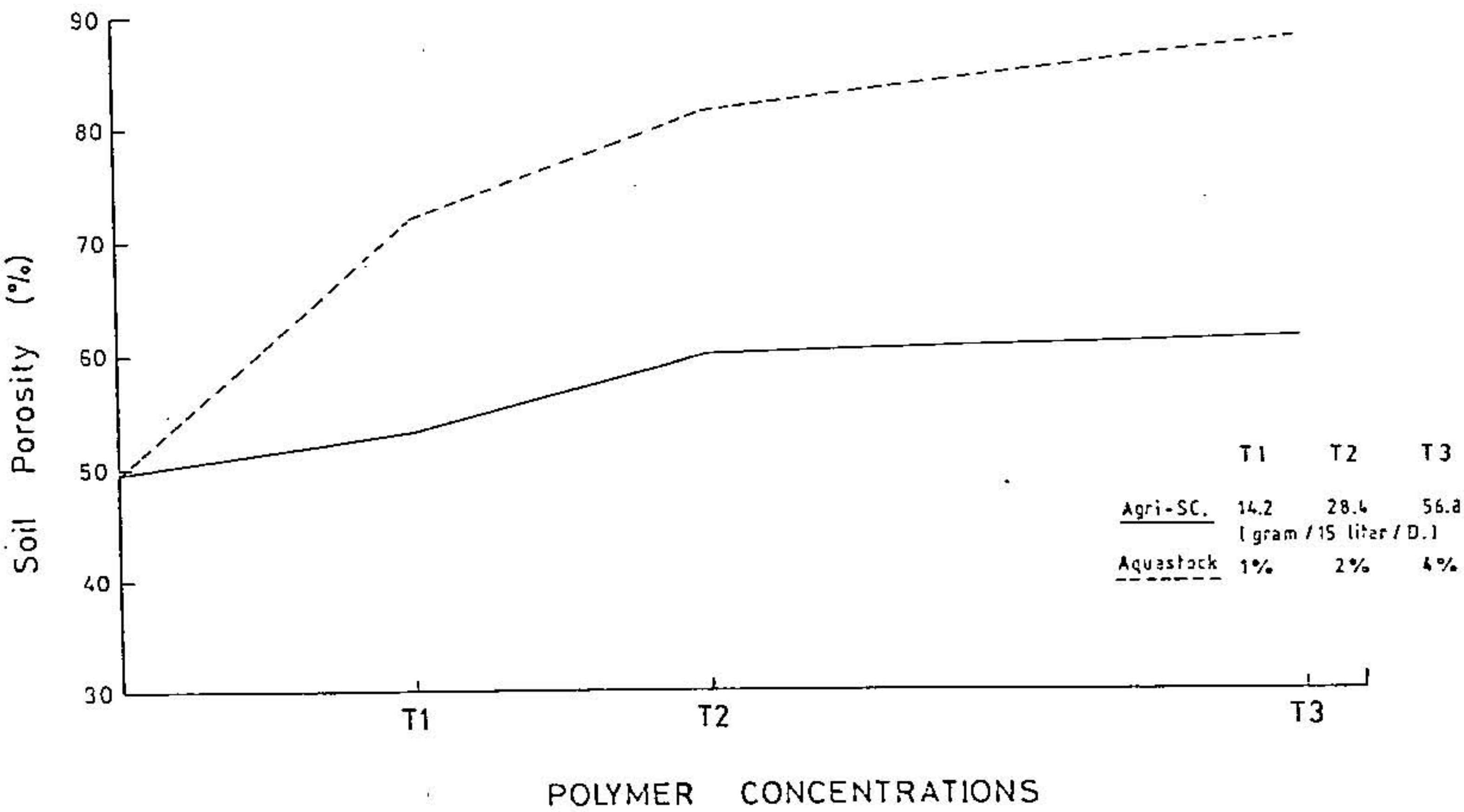

Figure 14 : Soil porosity curves after four wetting-drying cycles of Zizia silt loam soil as affected by different concentrations of Agri-SC. and Aquastock polymers 1984 / 1985

soils, respectively . It is clear that Aquastock was significantly more effective in increasing porosity and improving structure more than the Agri-SC (Appendix)).These fingdings are similar to the results of Khoury et al .(1978); Azzam (1983) and Labib et al. (1983). Generaly, the increase in soil porosity of the soil will increase water holding capacity and oxygen diffusion which will enhance microbial activities and plant growth. The correlation between apparant specific gravity and porosity and Aquastock concentration was significant for all soils, whereas, the correlation between apparant specific gravity and porosity and Agri-SC concentration was only significant for Zizia and Irbid soils.

Water Conservation and Water Holding Capacity :

The effect of different consentrations of Aquastock on the moisture charactaristics curves for the four soils are shown in figures 15 through 18 . Table 7 shows the effect of different concentrations of Agri-SC on moisture charactaristics curves of the four soils.

Aquastock had increased the water content for all soils at different suctions as shown in figures 15 through 18.The increase in water retention was the greatest with the highest concentration. The retained water at 0.1

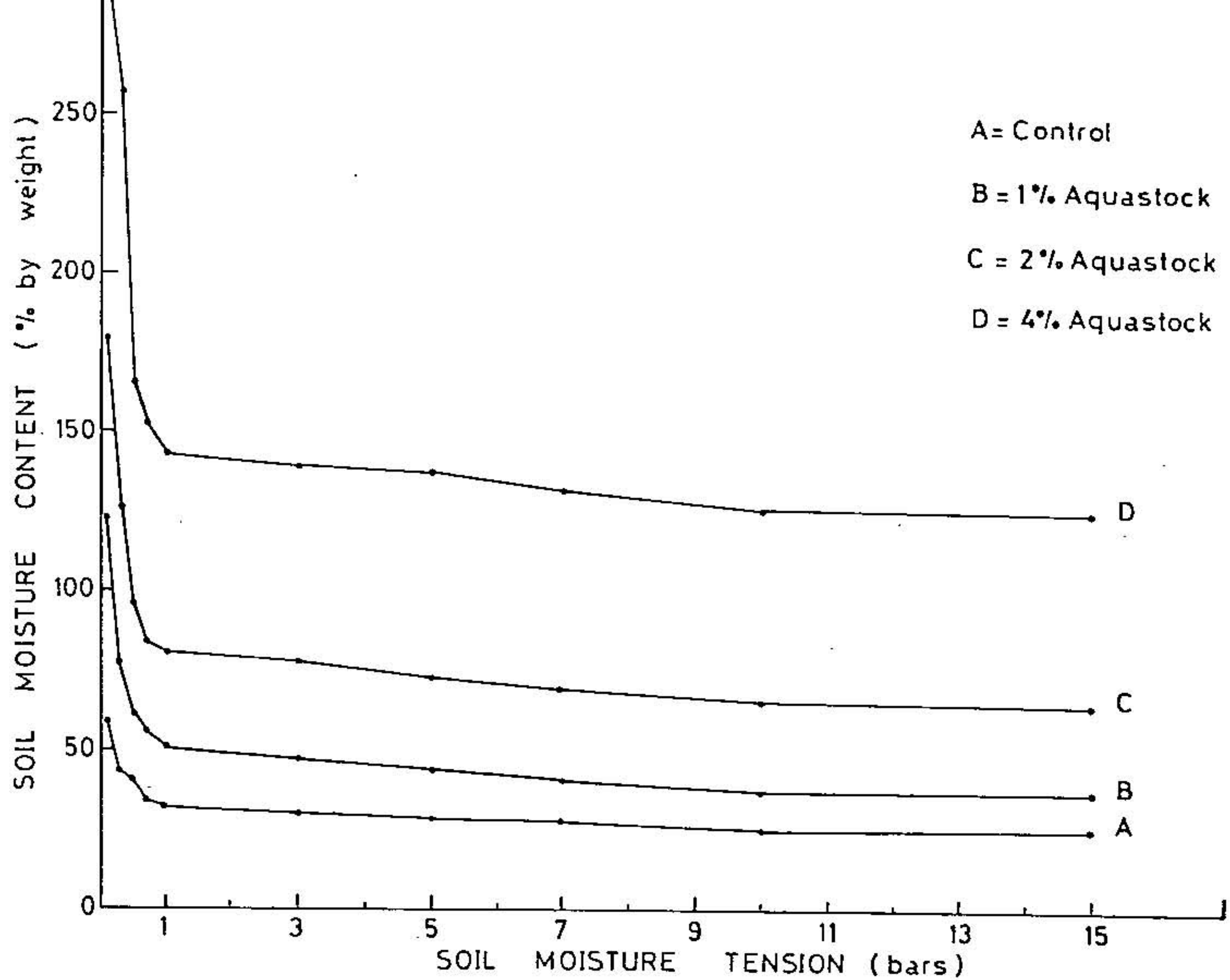

Figure 15: Soil moisture charactaristics curves after four wetting - drying cycles for Irbid clay soil as affected by different concentrations of Aquastock polymer, 1985.

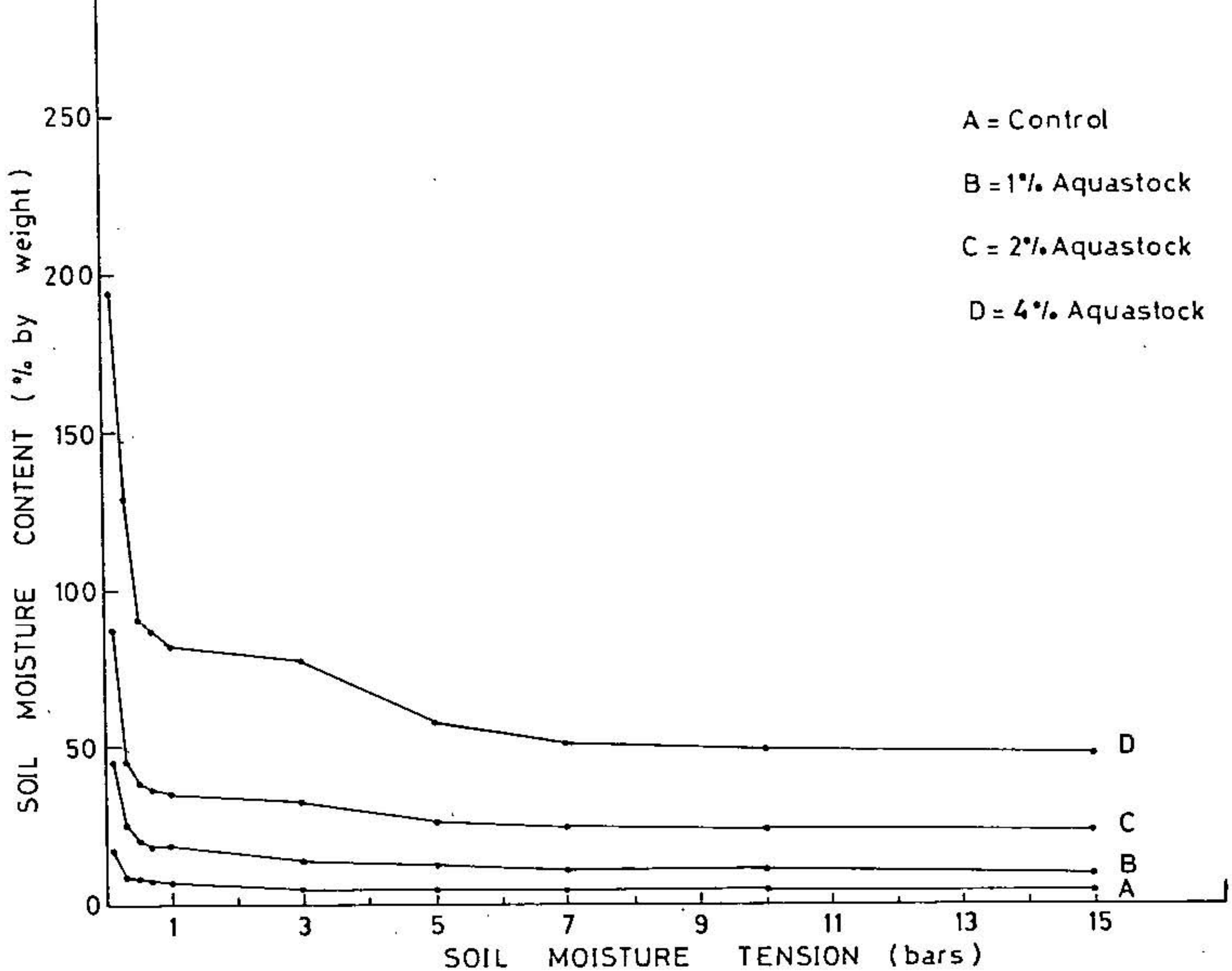

Figure 16: Soil moisture characteristics curves after four wetting - drying cycles for Ghour sandy soil as affected by different concentrations of Aquastock polymer, 1985.

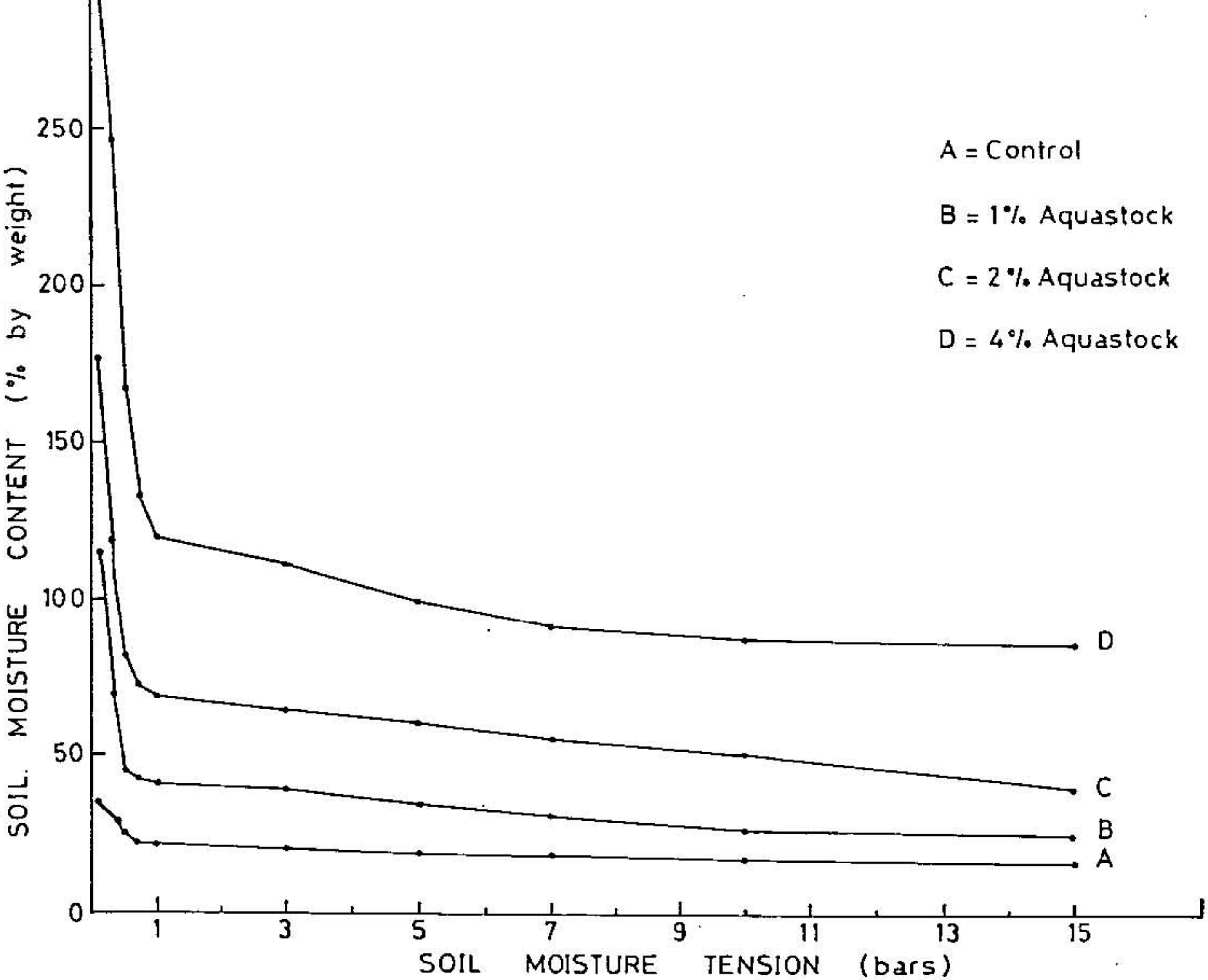

Figure 18 : Soil moisture characteristics curves after four wetting - drying cycles for Zizia silt loam soil as affected by different concentrations of Aquastock polymer , 1985 .

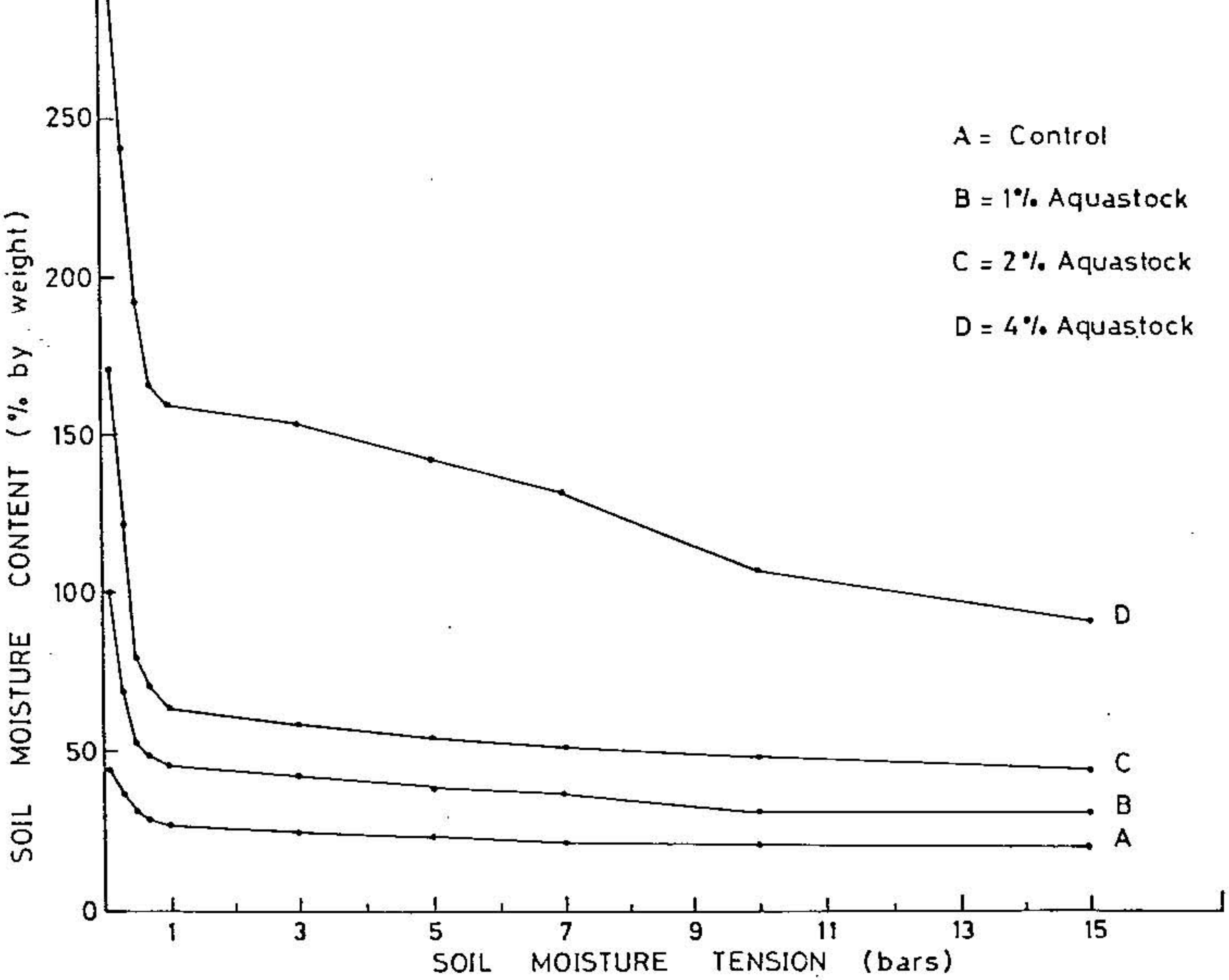

Figure 17: Soil moisture characteristics curves after four wetting-drying cycles for Ramtha clay loam soil as affected by different concentrations of Aquastock polymer, 1985.

Table 7 : Soil moisture desorption measurements (% by weight) of four different soils after four wetting-drying cycles as affected by different concentrations of Agri-SC., 1984.

Soils	Treatment	0.1	0.3	0.5 bars	0.7	1.0
Irbid	Control	58.67	48.24	40.90	33.20	31.85
	14.2 (1)	58.29	48.84	41.19	34.87	32.80
	28.4	58.91	48.33	41.16	34.18	32.25
	56.8	60.77	47.92	39.37	33.00	31.06
Ghour	Control	16.8	8.78	7.88	7.06	6.25
	14.2	16.93	8.95	8.43	7.62	6.57
	28.4	18.58	8.96	8.36	7.21	6.40
	56.8	19.04	8.48	7.77	7.06	6.25
Ramtha	Control	45.60	37.38	31.54	28.40	26.74
	14.2	43.66	37.58	31.90	29.40	27.60
	28.4	43.30	37.16	31.35	29.01	27.07
	56.8	43.41	36.88	30.57	27.16	25.95
Zizia	Control	35.14	29.75	25.59	22.91	22.52
	14.2	38.12	30.80	26.03	23.80	23.20
	28.4	38.38	30.40	25.68	23.20	22.88
	56.8	38.94	29.21	24.73	22.72	21.72

(1) grams/15 liters / dunum

Table 7: Continued ....

Soils	Treatments	3.0	5.0	7.0	10.0	15.0
			bars			
Irbid	Control	29.67	28.00	26.96	25.16	25.01
	14.2(1)	30.51	28.22	27.37	25.28	25.14
	28.4	30.17	27.90	26.61	25.04	24.91
	26.8	30.41	27.12	26.66	24.78	24.15
Ghour	Control	4.22	4.10	3.99	3.91	3.87
	14.2	4.54	4.31	4.44	4.10	3.96
	28.4	4.28	4.16	4.36	3.84	3.81
	56.8	4.17	4.04	4.02	3.72	3.56
Ramtha	Control	24.08	22.94	21.86	20.35	20.13
	14.2	24.30	23.14	21.53	20.46	20.25
	28.4	24.10	22.77	21.52	20.19	20.05
	56.8	23.58	21.92	21.80	20.04	19.89
Zizia	Control	20.74	19.04	18.52	17.68	16.21
	14.2	20.56	19.41	18.40	17.90	16.61
	28.4	20.83	18.88	18.66	17.62	16.51
	56.8	19.87	17.99	19.07	16.96	15.62

(1) grams/15 liters / dunum

bar with 4% Aquastock concentration was 5, 6.7 , 8.5, and 11 times that of untreated soils, and it reached 5,4.6, 5.3, and 12 times of the untreated soils at 15 bars for Irbid,Ramtha, Zizia, and Ghour soil,respectively . These results are supported by those obtained by Szczypa and Monies (1976);and Azzam(1983).It is clear from table 7 that the Agri-SC had no significant effect on the water retention of all soils. It could be decreased , or remain unchanged. These findings are consistant with Khoury et al. (1978) ; Mcgurine et al. (1978) ; and Jones et al. (1982) . It is obvious that Aquastock had increased the water retention much more that of Agri-SC .

Available water (FC-PWP)* after four wetting-drying cycles as affected by different concentrations of Agri-SC and Aquastock, are shown in table 8. Agri-SC had either increased or did not change the available water . The correlation between Agri-SC concentration and available water was significant for Ramtha soil and insignificant for other soils (Appendix). These findings are in agreement with the findings of (Khoury et al. (1978); and Jones et al. (1982)) .On the other hand , available water had increased by the addition of Aquastock.At the highest Aquestock concentration,the available water was 7.3,8.7,11.2 and 11.8 times that of the untreated soil, for Irbid,Ramtha,Ghour and Zizia soils, respectively.The available water had increased by the increase in Aquastock Concentration.

*) field capacity PWP: Permanent wilting point.

Table 8: Available water (% by weight, FC-PWP) after four wetting-drying cycles of Irbid, Ghour, Ramtha, and Zizia soil previously treated with different concentrations of Agri-SC. and Aquastock, 1984/1985.

Soils	Treatments	Available water % Agri-SC	Available water % Aquastock
Irbid	Control	23.21	18.21
	T1	23.77	40.14
	T2	23.36	61.47
	T3	23.14	132.55
Ghour	Control	13.01	13.01
	T1	12.58	35.98
	T2	14.78	65.43
	T3	15.48	146.02
Ramtha	Control	17.21	17.21
	T1	17.13	38.94
	T2	17.11	79.92
	T3	16.99	149.51
Zizia	Control	13.54	13.54
	T1	14.19	43.52
	T2	13.89	79.72
	T3	13.18	159.84

It is clear from table 8 table addition of Aquastock had made the available water in sandy soils high. The correlation between Aquastock concentrations and available water were highly significant for all soils (Appendix). Similar results were recently reported by (Szczypa and Monies (1976); sayegh et al.(1982) ; and Azzam (1983)).

The effect of different concentrations of Aquastock on the volume of water added to the four different soils planted with tomatoes are shown in figure 20. Table 9 whows the effect of different concentrations of Agri-SC polymer on the volume of water added to the four soils planted with,wheat.

It is clear from figure 20 that the decrease in the volume of water consumed by tomatoes grown in Irbid soil was 29.27 , 26.83 , and 31.71 % of the untreated soil at the first, second , and highest concentration of Aquastock , respectively. Aquastock had decreased volume of water consumed by tomatoes grown in Zizia soil by 29.27 % of the control at the first and second concentration , the decrease was 31.71 % of the control at the highest concentration of Aquastock . The decrease in the volume of water consumed by tomatoes grown in Ramtha soil was 30.95 % of the control at the first concentration and it was 33.33 % of the control at the second and highest concentrations of Aquastock.

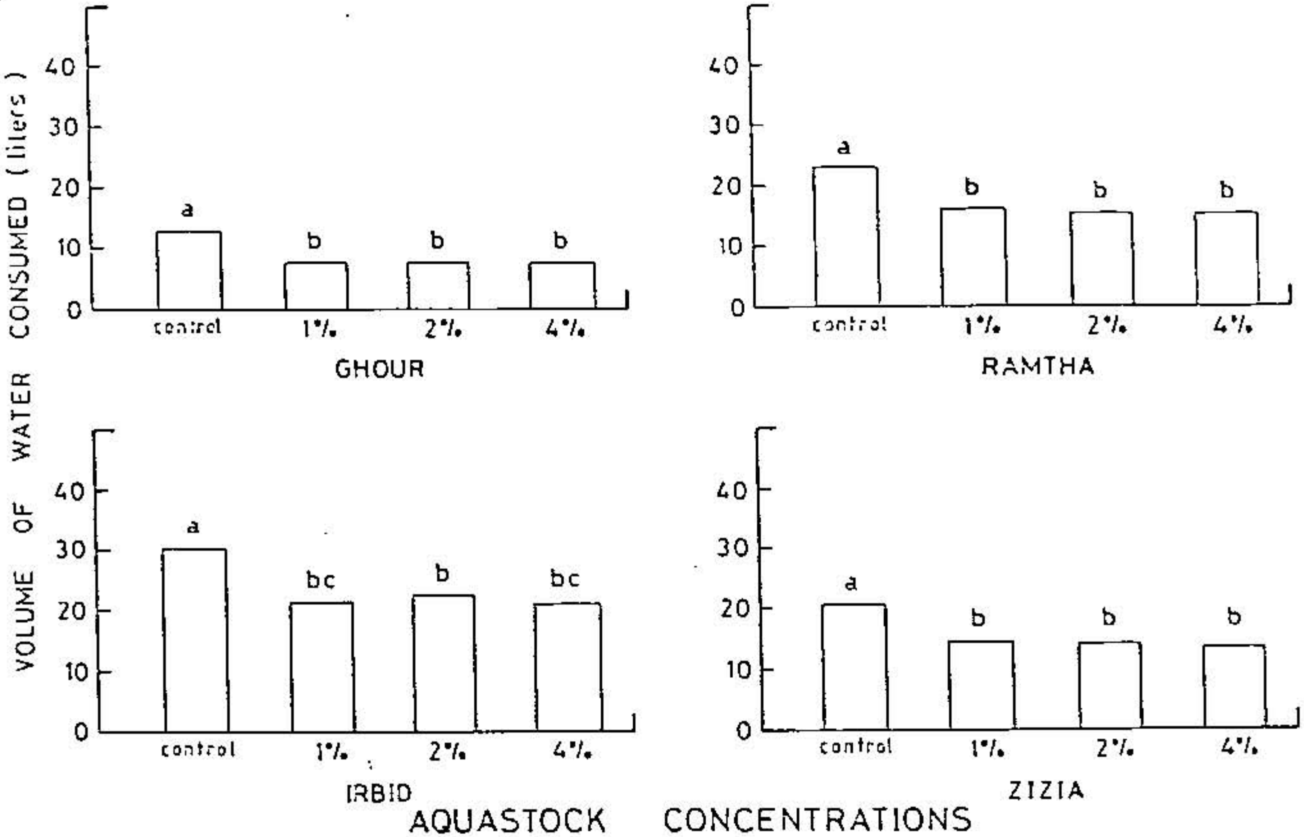

Figure 19 : Average volume of water consumed (liters) by tomato plant as affected by different concentrations of Aquastock polymer, 1985 (columns having different letters are significantly different at the 5% level according to Duncan's Multiple Range Test).

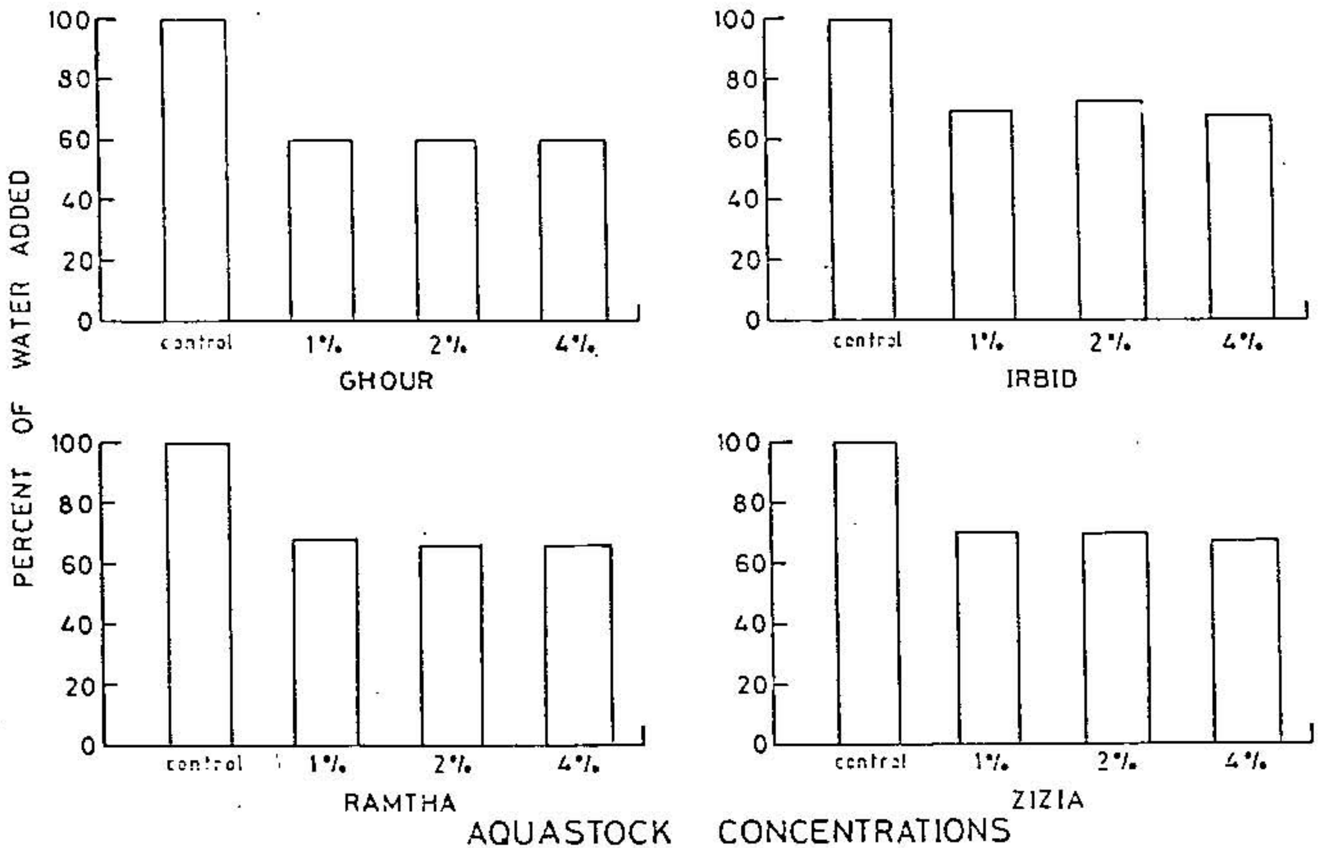

Figure 20 : Percent of water added (related to control) for tomato as affected by different concentrations of Aquastock polymer, 1985.

Table 9 : Average yield, Numbers of irrigation, Total volume of water applied and water use effeciency of wheat as affected by different concentrations of Agri-SC, 1984. 1984 .

Soils	Treatments	Average yield (gm/pot)	Number of Irrigations	Water applied (liter)	Water use effecience (gm/L)(1)
Irbid	Control	4.968 b(1)	23	43.355	0.114 b(2)
	14.2 (3)	5.463 b	21	39.585	0.138 b
	28.4	6.833 ab	21	39.585	0.172 b
	56.8	8.153 a	22	41.470	0.197 a
Ghour	Control	3.730 b	16	13.040	0.286 b
	14.2	4.090 b	16	13.040	0.334 b
	28.4	4.850 b	15	12.225	0.372 b
	56.8	5.530 a	16	13.040	0.424 a
Ramtha	Control	6.423 b	22	31.130	0.206 b
	14.2	6.308 b	20	28.300	0.223 b
	28.4	7.898 ab	20	28.300	0.279 b
	56.8	9.163 a	21	29.715	0.308 a
Zizia	Control	5.758 c	20	22.300	0.258 b
	14.2	6.955 ab	19	21/185	0.329 b
	28.4	6.623 b	19	21.185	0.313 b
	56.8	7.788 a	20	22.300	0.350 a

(1) F- test is not significant .

(2) Numbers having different letters are significantly different at the 5% level according to Duncans' Multiple Range Test.

(3) grams/15 liters / dunum

The decrease in the volume of water consumed by tomatoes grown in Ghour soil was about 40 % of the control for all concentrations of Aquastock .In addition, figure 19 shows that Aquastock had significantly decreased the volume of water consumed by tomatoes at all concentrations .It was noticed that the irrigation interval was extended from 4 to 7 days for all treated soils at all polymer concentrations. These findings were consistant with those reported by Dakshinamuri (1975);oades(1976); and Sayegh et al.(1982). It is clear from table 9 that Agri-SC had no effect on the amount of water consumed by wheat. There was a negative significant correlation between the volume of water added to tomatoes and Aquastock concentration, whereas, the correlation between water added to wheet and Agri-SC concentrations was not significant .

The effect of different concentrations of Aquastock on water use efficiency of tomatoes are shown in figure 21. Table 9 shows the effect of different concentrations of Agri-SC on water use efficiency of wheat.Figure 21 shows that the increase in water use effeciency of tomatoes grown in Aquastock treated soils was highly signigicant according to Duncan's Multiple Range Test for all soils . The increase in water use efficiency for tomatoes was greatest with the highest concentration of Aquastock.The increase in water use efficiency then started to decrease with decreasing Aquastock concentrations . These results agree with labib et al. (1983) findings . Table 9 shows that the

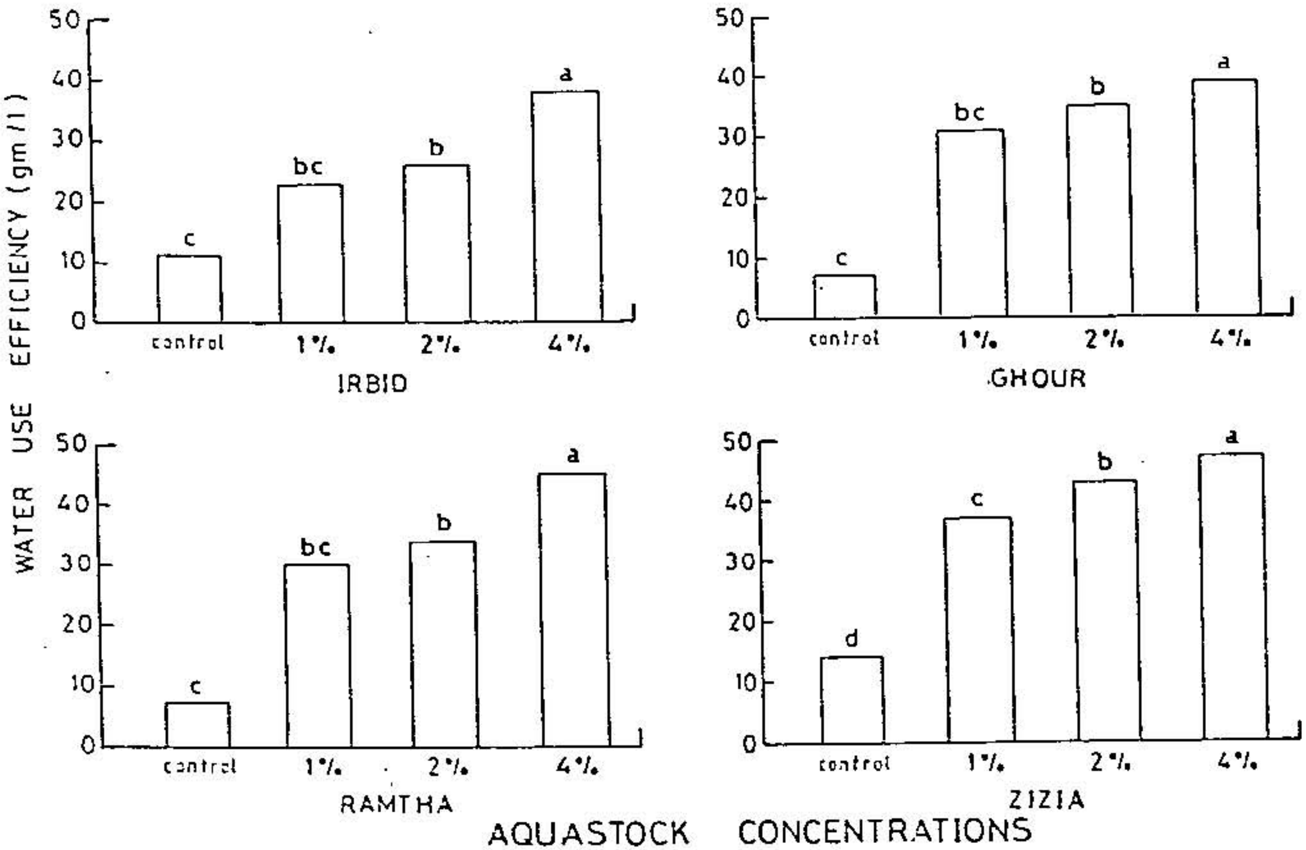

Figure 21: Water use efficiency (grams/liter) of tomato as affected by different concentrations of Aquastock polymer, 1985 (columns having different letters are significantly different at the 5% level according to Duncan's Multiple Range Test).

increase in water use efficiency of wheat grown in Agri-SC treated soils according to Duncan's Multiple Range Test was significant for all soils only at the highest concentration. In addition,the correlation between water use efficiency of wheat and Agri-SC concentration was insignificant. This finding was consistant with the finding of De-Boodt (1976).

Plastic and liquid limits after four wetting - drying cycles for Irbid, Ramtha, and Zizia soils as affected by different concentrations of Agri-SC and Aquastock are shown in table 10 .Plastic and liquid limits of Agri-SC treated soils did not change obviously and could be less, or remain unchanged for all soils .At the highest concentration , plastic limit had increased by the addition of Aquastock , and was 1.7 ,1.7, and 1.9 times more than that of untreated soils for Irbid , Ramtha and Zizia ,respectively. On the other hand , at the highest concentration of Aquastock the liquid limit had increased, and was 3.3, 3.8, and 4.9 times more than that of the untreated soils for Irbid, Ramtha, and Zizia soils, respectively. However, it is obvious that Aquastock had increased plastic and liquid limits more than that of Agri-SC . The correlation between plastic limit and Aquastock concentrations was insignificant for all soils. There was insignificant negative correlation between Agri-SC and plastic limit for all soils . The correlation between liquid limit and Aquastock concentrations

Table 10 : Plastic and liquid limits (% by weight) of three different soils after four wetting drying cycles previously treated with different concentrations of Agri-SC, and Aquastack , 1984/1985 .

Soils	Treatments	Plastic L. (Agri-SC.)	Liquid L. (Agri-SC.)	Plastic L. (Aquastock)	Liquid L. (Aquastock)
Irbid	Control	38.16	48.21	38.16	48.21
	T 1	35.10	48.91	44.17	67.20
	T 2	35.61	48.27	49.17	100.29
	T 3	32.81	47.86	64.92	157.45
Ramtha	Control	25.95	37.38	25.95	37.38
	T 1	25.12	37.58	39.16	66.92
	T 2	25.55	37.16	42.42	100.98
	T 3	25.20	36.88	44.22	143.69
Zizia	Control	23.58	29.75	23.58	29.75
	T 1	20.78	30.80	39.05	63.86
	T 2	21.55	30.40	42.00	98.42
	T 3	20.58	29.21	44.26	145.86

was significant for all soils, while it was insignificant with Agri-SC concentrations(Appendix).From previous discussions, it is clear that the increase in the soil water content in the most favorable range of tention to crops (0-1.0 bar).This increase will enable farmers to improve the management of their irrigation, expand their irrigation intervals by the respective increase in the water holding capacity of soils .

Nutritional Status as Affected by Polymers:

The effect of different concentrations of Agri-SC and Aquastock on the availability of certain micronutrients (Fe , Mn , Zn , and Cu) , PH, and the availability of phosphorous and potassium for the four soils are shown in table 11 and 12 . The availability of micronutrients (Fe, Mn, Zn, and Cu) had increased in soils treated with Agri-SC (table 11). The increase of iron availability at the highest concentration of Agri-SC was 24.6 , 134,134 , and 231% of the control for Ghour, Irbid, Ramtha, and Zizia soils , respectively . Aquastock as shown in table 12 had increased Iron availability . This increase at the highest concentration of Aquastock was 73, 152 , 175 , and 220 % of the untreated soils, for Ghour , Ramtha , Irbid , and Zizia soils , respectively . Manganese , Zinc , and copper availability were increased in both polymers .

Table 11: Micronutrients (Fe, Mn, Zn, and Cu), PH, and Macronutrients (P and K) of four different soils after four wetting-drying cycles previously treated with different concentrations of Agri-SC, 1984 .

Soils	Treatments	Fe	Mn PPm (1)	Zn	Cu	pH_{O} (2)	P PPm	K
Irbid	Control	22.6	280.1	11.2	37.2	8.3	4.0	580
	14.2 (3)	46.4	878.0	24.0	37.2	7.5	18	460
	28.4	44.2	686.0	19.8	43.4	7.7	18	500
	56.8	53.0	786.0	19.8	38.2	8.0	20	460
Ghour	Control	26.8	172.0	7.6	9.2	8.1	4.0	110
	14.2	37.8	184.0	9.4	7.4	7.5	9.0	110
	28.4	33.4	210.0	10.6	4.8	7.5	13.0	110
	56.8	33.4	328.0	9.4	Tr (4)	7.7	27.0	110
Ramtha	Control	22.6	240.0	10.6	31.2	8.2	6.0	540
	14.2	48.6	748.0	14.8	34.9	7.6	24	550
	28.4	53.0	770	18.8	33.8	7.7	24	570
	56.8	53.0	826.0	18.0	38.2	7.8	26	670
Zizia	Control	22.6	172.0	11.2	16.0	8.1	10	500
	14.2	68.2	640.0	12.4	27.6	7.8	33.8	630
	28.4	68.2	710.0	13.6	28.6	7.9	33.9	630
	56.8	74.8	754.0	19.6	26.8	8.1	30.1	680

(1) Part per million.

(2) Soil : Water ratio is 1 : 2.5 .

(3) grams /15 liters/dunum.

(4) Trace

Table 12: Micronutrients (Fe, Mn, Zn and Cu) PH, and Macronutrients (P and K) of four different soils after four wetting-drying cycles previously treated with different concentrations of Aquastock , 1985 .

Soils	Treatments	Fe	Mn	Zn	Cu	P^H (2)	P	K
			PPm(1)				PPm	
Irbid	Control	22.6	280.1	11.2	37.2	8.3	4.0	580
	1%	44.2	668.0	28.8	32.4	8.3	10	480
	2%	50.8	732.0	24.0	38.2	8.3	10	510
	4%	62.1	812.0	28.0	42.4	9.4	18	550
Ghour	Control	26.8	172.0	7.6	9.2	8.1	4.0	110
	1%	48.6	138.0	16.8	10.8	8.1	6.0	110
	2%	46.4	118.0	13.0	8.2	8.2	10.0	140
	4%	46.4	158.0	10.0	12.6	8.2	12.0	300
Ramtha	Control	22.6	240.0	10.6	31.2	8.3	6.0	540
	1%	53.0	662.0	18.6	33.8	8.3	21	640
	2%	55.2	740.0	23.4	42.6	8.4	18	680
	4%	57.0	790.0	26.2	46.8	8.5	21	710
Zizia	Control	22.6	172.0	11.2	16.0	8.2	10.0	500
	1%	66.0	458.0	17.4	37.2	8.3	9.0	650
	2%	68.2	482.0	18.0	40.0	8.3	20.0	750
	4%	72.4	510.0	18.6	46.0	8.4	23.0	984

(1) Part per million

(2) Soil : Water ratio is 1 : 5 .

The increase in Mn availability at the highest concentration of Agri-SC was 90.7 , 181, 244 , and 338 % of the control for Ghour, Irbid, Ramtha, and Zizia soils , respectively, and was - 9 , 190 , 196 , and 229 % of the control for Ghour, Irbid, Zizia, and Ramtha soils treated with Aquastock , respectively. Zinc availability in Aquastock treated soils had increased at the highest concentration the increase was 32 , 66, 147 and 150 % of the control for Ghour, Zizia,Ramtha, and Irbid soils. In Agri-SC treated soils, the increase in zinc availability at the highest concentration was 23.7,69.9, 75 , and 76.8% of the control for Ghour,Ramtha,Zizia,and Irbid soil, respectively.Copper availability in Agri-SC treated soils had increased. At the highest concentration the increase was zero, 16,22, and 67.5 % of the control for Ghour,Irbid , Ramtha, and Zizia soil, respectively . In Aquastock treated soils, the increase in copper availability at the highest concentration was 14, 37, 50, and 187 % of the control for Irbid ,Ghour , Ramtha, and Zizia soils , respectively . In general, from tables 11 and 12 it can concluded that the micronutrients availability had increased by increasing these two polymers. The availability has increased with the increase in the polymer concentrations . The correlation between Fe , Mn , Zn , and Cu availability and Aquastock and Agri-SC concentrations were insignificant for all soils (Appendix) .

- Soil p^H

The effect of Agri-SC on soil p^H is shown in table 11. It is clear that this polymer had slightly decreased the soil p^H for all soils. The increase in the micronutrients availability could be contributed to the effect of this polymer on the soil p^H . Table 12 shows that Aquastock had slightly increased the soil P^H for all soils although the micronutrients availability had increased.This unusual effect might be explained by the nature of the Aquastock polymer itself which helped in increasing the micronutrients availability in a mechanism not affected by soil p^H.

- Phosphorous

Agri-SC had increased phosphorous availability as shown in table 11 .At the highest polymer concentration the increase was 200, 333, 400, and 575 % of the control for Zizia, Ramtha, Irbid, and Ghour, respectively .It is clear from table 12 that Aquastock application had increased phosphorous availability . At the highest concentration the increase was 130, 200, 250, and 350 % of the control , for Zizia, Ghour , Ramtha, and Irbid soils , respectively . The correlation between Aquastock and Agri-SC concentrations and phosphorous availability was not significant for all soils except for Ghour soil treated with Agri-SC

- Potassium

Table 12 shows that potassium availability had increased by using Aquastock .It was- 5,31,97,and 172 % of the control at the highest concentration,for Irbid,Ramtha,Zizia, and Ghour respectively.The potassium availability increase using Agri-SC were -20,zero, 24,and 36% of the control at the highest concentration, for Irbid,Ghour,Ramtha, and Zizia soils, respectively.The correlation between potassium availability and Aquastock concentrations was significant for all soils, while this correlation between Agri-SC concentrations and potassium availability was not significant except for Ramtha soil(Appendix).

<u>Micronutrients Uptake:</u>

The effect of different concentrations of Agri-SC on the uptake of Fe,Mn,Zn, and Cu by wheat grains is shown in table 13 Table 14 shows the effect of different concentrations of Aquastock on the uptake of Fe,Mn,Zn, and Cu by tomato leaves.It is clear from table 9 that wheat grains uptake of Fe, Zn,Cu, and Mn from Agri-SC treated soils was either slightly increased or remained unchanged.Copper uptake was the same for all soils at all concentrations(76 ppm).Fe uptake by tomato leaves from Aquastock treated soils was slightly decreased with increasing Aquastock concentration for Ghour and Zizia soils as shown in table 9,while in Irbid and Ramtha soils the Fe uptake had slightly increased. Manganese and zinc had the same trend like Iron for all soils . Copper uptake was not affected by Aquastock for all soil. The Correlation between Fe , Zn , Mn and

Table 13: Iron Manganese, Zin and Copper uptakes (ppm [1]) by wheat plants as affected by different concentrations of Agri-SC, 1984 .

Soils	Treatments	Fe	Mn	Zn	Cu
			PPm		
Irbid	Control	254	44	44	76
	14.2 [2]	276	54	86	76
	28.4	298	66	80	76
	26.8	276	66	56	76
Ghour	Control	276	64	80	76
	14.2	298	60	56	76
	28.4	232	64	73	76
	26.8	232	64	66	76
Ramtha	Control	276	58	44	76
	14.2	254	64	62	76
	28.4	276	66	62	76
	56.8	232	68	68	76
Zizia	Control	254	64	56	76
	14.2	298	56	62	76
	28.4	298	66	44	76
	26.8	276	64	56	76

(1) Part per million

(2) grams/15 liters / dunum

Table 14 : Iron, Manganese, Zinc, and Copper uptakes (ppm[1]) by tomato leaves as affected by different concentrations of Aquastock , 1985.

Soils	Treatments	Fe	Mn	Zn	Cu
			PPM		
Irbid	Control	526	1368	338	Tr[2]
	1%	562	1628	123	Tr.
	2%	650	1548	322	Tr.
	4%	606	1718	353	Tr.
Ghour	Control	608	1608	277	Tr.
	1%	859	1164	345	Tr.
	2%	504	1176	202	Tr.
	4%	575	772	138	Tr.
Ramtha	Control	775	1096	362	Tr.
	1%	754	646	189	Tr.
	2%	691	1246	189	Tr.
	4%	879	978	202	Tr.
Zizia	Control	506	1234	246	Tr.
	1%	483	732	151	Tr.
	2%	525	944	153	Tr.
	4%	462	1188	236	Tr.

(1) Part per million

(2) Trace

Cu uptake and Aquastock and Agri-SC concetrations were not significant (Appendix). These results agree with other findings of (Sepakah (1980) ; El-Hady (1983) and abib (1983)).

Germination and Growth as Affected by Polymers :

The emergence of wheat in Zizia and Ramtha soils was affected by Agri-SC application . After 6 days the emergence was complete in the treated and untreated Irbid and Ghour soils and the treated Zizia and Ramtha soils . The emergence of the untreated Zizia and Ramtha soil after 6 days was 74 and 71% of the treated soils , respectively . After eight days the emergence was 87, and 80 % of the treated soils for Zizia and Ramtha soils , respectively .

Aquastock had great effect on germination of tomato seeds. Germination was 5 days erlier in all treated soils , for all soils at all concentrations . Similar results were reported by (Labib and Awad (1981) ;El-Hady (1983) ; and Labib (1983)). Beneficial effect of Agri-SC on Zizia and Ramtha , and Aquastock on all soils could be related to their effect on soil structure , thus preventing the formation of surgace crust which is considered the main obstacle in cultivating these soils .

It was noticed that the growth of tomato seedlings continued higher at higher concentrations , these finding were similar to the results of Azzam (1983) .

The effect of different concentrations of Agri-SC on the average yield of wheat for the four different soils are shown in table 9 . Agri-SC gave significant increase in wheat yield according to Duncan's Multiple Range Test only at the highest concentration of polymer. The increase in wheat yield at the highest concentration was 35 , 43 ,48, and 64 % of the untreated soils , for Zizia, Ramtha, Ghour and Irbid soils , respectively . There was a significant increase in yield of wheat for Zizia soil only . The effect of different concentrations of Aquastock on avarage yield of tomato for the four soils are shown in figure 22. Aquastock polymer gave a highly significant increase in yield in all soils . The increase in yield at the highest concentration was 120 , 130 , 218 , and 303 % of the control , for Zizia , Irbid , Ghour , and Ramtha soils ; respectively . Simillar findings were indicated by De-Boodt (1976) ; Sakr and Iman (1978) ; Sayagh (1982) ; Labib (1983) ; and El-Hady (1983) .

The effect of different concentrations of Aquastock on tomato length for the four different soils are shown in figure 23 . According to Duncan's

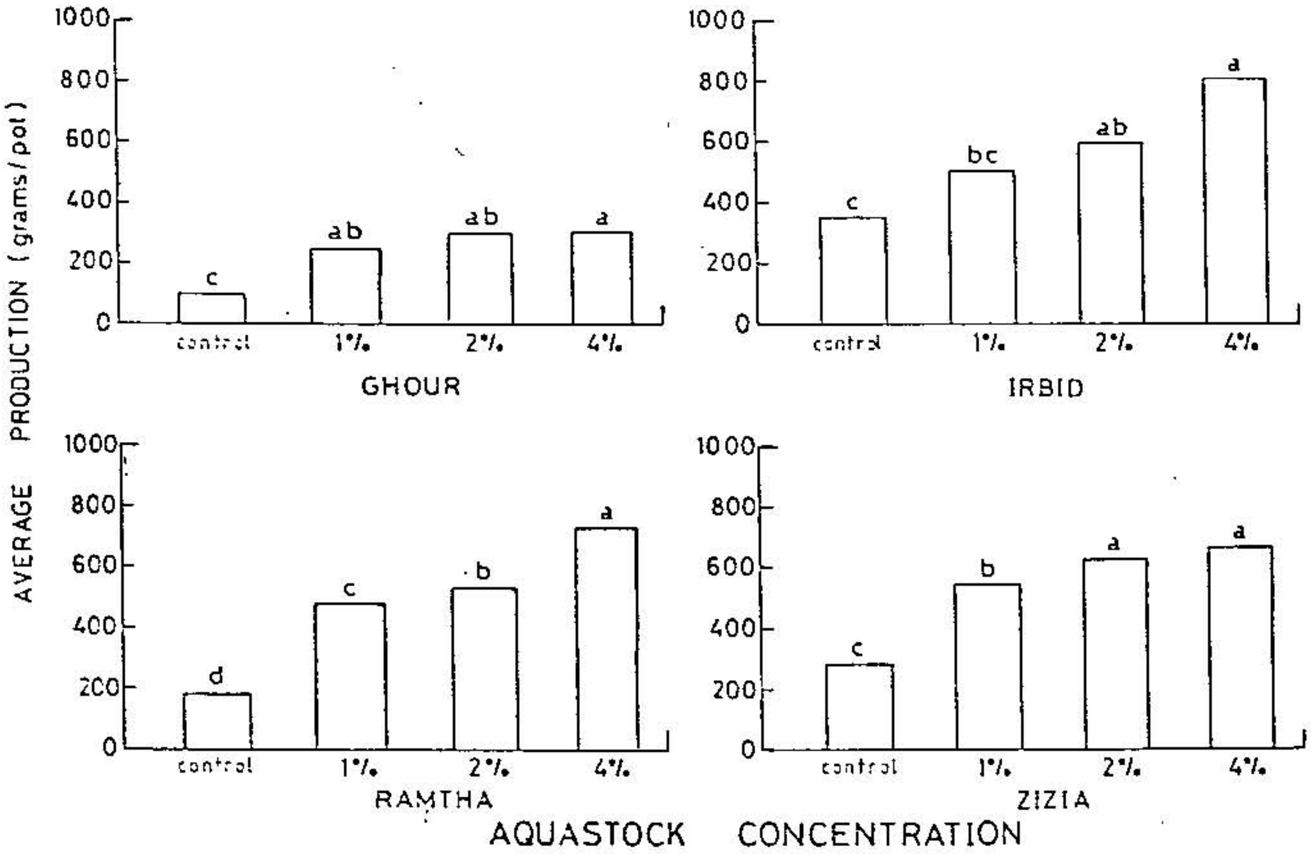

Figure 22 : Average yield (grams/pot) of tomato as affected by different concentrations of Aquastock polymer, 1985 (columns having different letters are significantly different at the 5% level according to Duncan's Multiple Range Test).

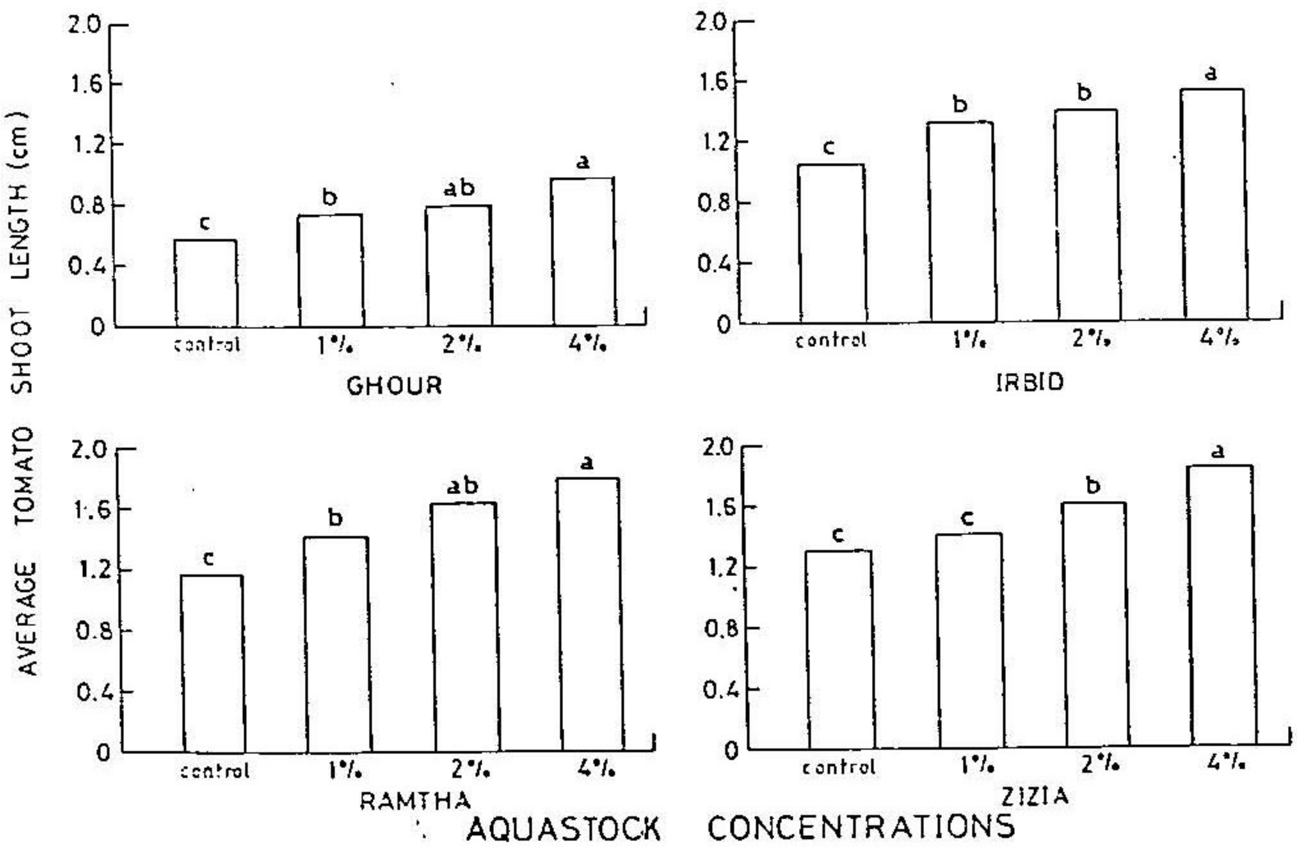

Figure 23 : Average tomato shoot length (cm) as affected by different concentrations of Aquastock polymer, 1985 (columns having different letters are significantly different at the 5% level according to Duncan's Multiple Range Test).

Multiple Range Test this effect was highly significant at the highest polymer concentration . The increase in tomato Lengths were 41.9 , 45.7 , 55.2 and 60.3 % of the control for Zizia, Irbid , Ramtha, and Ghour soils , respectively. The higher the concentration of Aquastock the more the increase in tomato length . The correlation between polymer concentration and yield and tomato length were significant (Appendix) for all soils .

Average root length of tomato as affected by different concentrations of Aquastock are shown in figure 24 . Aquastock gave a highly significant increase in root lengths for all soils at all concentrations . The increase at the highest concentration was 125 , 184 , 194 , and 258% of the untreated soils , for Ghour , Zizia , Irbid , and Ramtha soils , respectively . Aquastock gave statisticaly significant increase in tomato root weight according to Duncan's Multiple Range Test for all soils at all concentrations . These findings agree with the findings of Azzam (1983). The correlation between Aquastock concentration and root Length was significant for all soils(Appendix).

Generally, an important key to the promotion of crop growth lies in the management of soil structure , which has a considerable influence on water and air relations of the soil - plant system . The direct effects of the soil

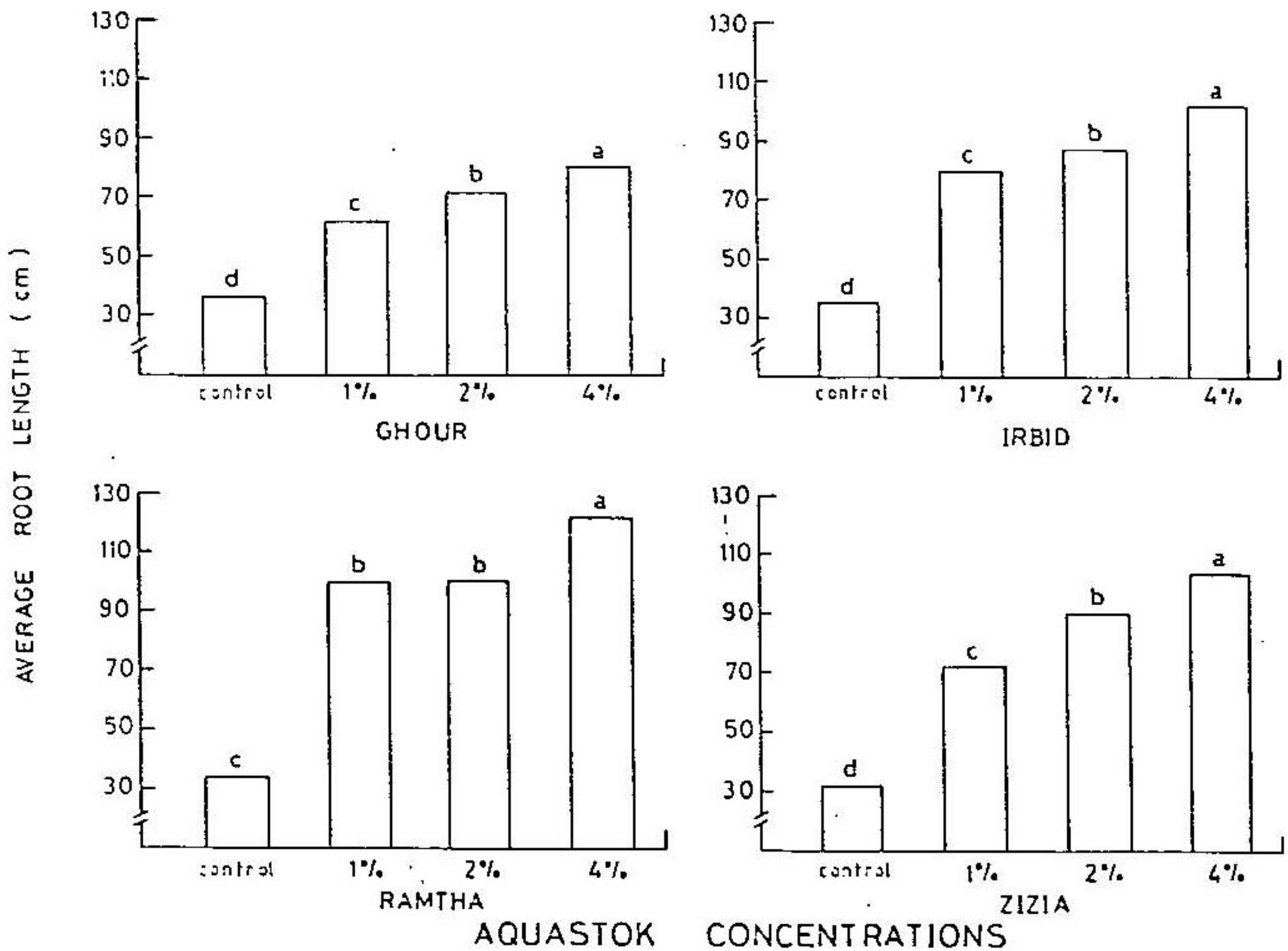

Figure 24 : Average root length (cm) of tomato as affected by different concentrations of Aquastock polymer, 1985 (columns having different letters are significantly different at the 5% level according to Duncan's Multiple Range Test).

structure on crop nutrition exists mainly in the area of root extension and root contact.

The effect of different concentrations of Aquastock for the four different soils on the fresh and dry matter weight of tomato are shown in figures 25 and 26,respectively. It is clear from figures 25 and 26 that Aquastock effect on the fresh matter and dry weigh of tomato were highly significant .

The increase in fresh weight of tomato at the highest concentration was 98 ,11, 189, and 219 % of the control for Irbid, Zizia, Ghour , and Ramtha, respectively. Dry matter increase was 60 , 96,100, and 149 % of the control at the highest concentration , for Irbid , Zizia , Ghour, and Ramtha soils , respectively . The increase in both, fresh and dry matter was highly significant for all soils according to Duncan's Multiple Range Test . These results were in agreement with the results of Azzam (1983). The correlation between fresh and dry matter weight and Aquastock concentrations was highly significant for all soils (Appendix) Fresh and dry matter increased more with the increase in Aquastock concentration .

Average dry root weight of tomato as affected by different concentrations of Aquastock for the four different soils are shown in figure 27 . It is obvious that Aquastock polymer effect on dry root weight was highly significant for Irbid soil only (Appendix).

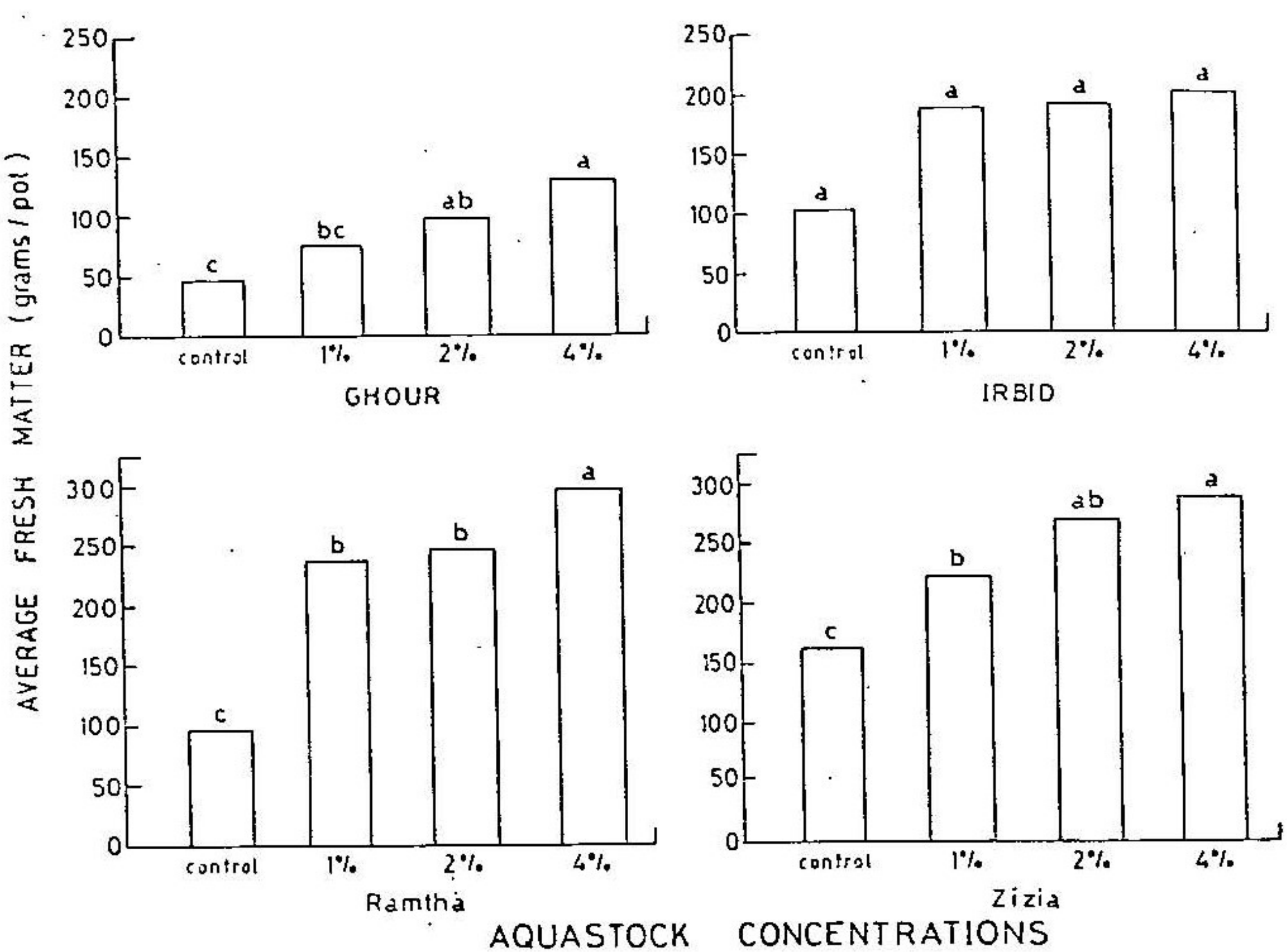

Figure 25 : Average fresh matter (grams/pot) of tomato as affected by different concentrations of Aquastock polymer, 1985 (columns having different letters are significantly different at the 5% level according to Duncan's Multiple Range Test).

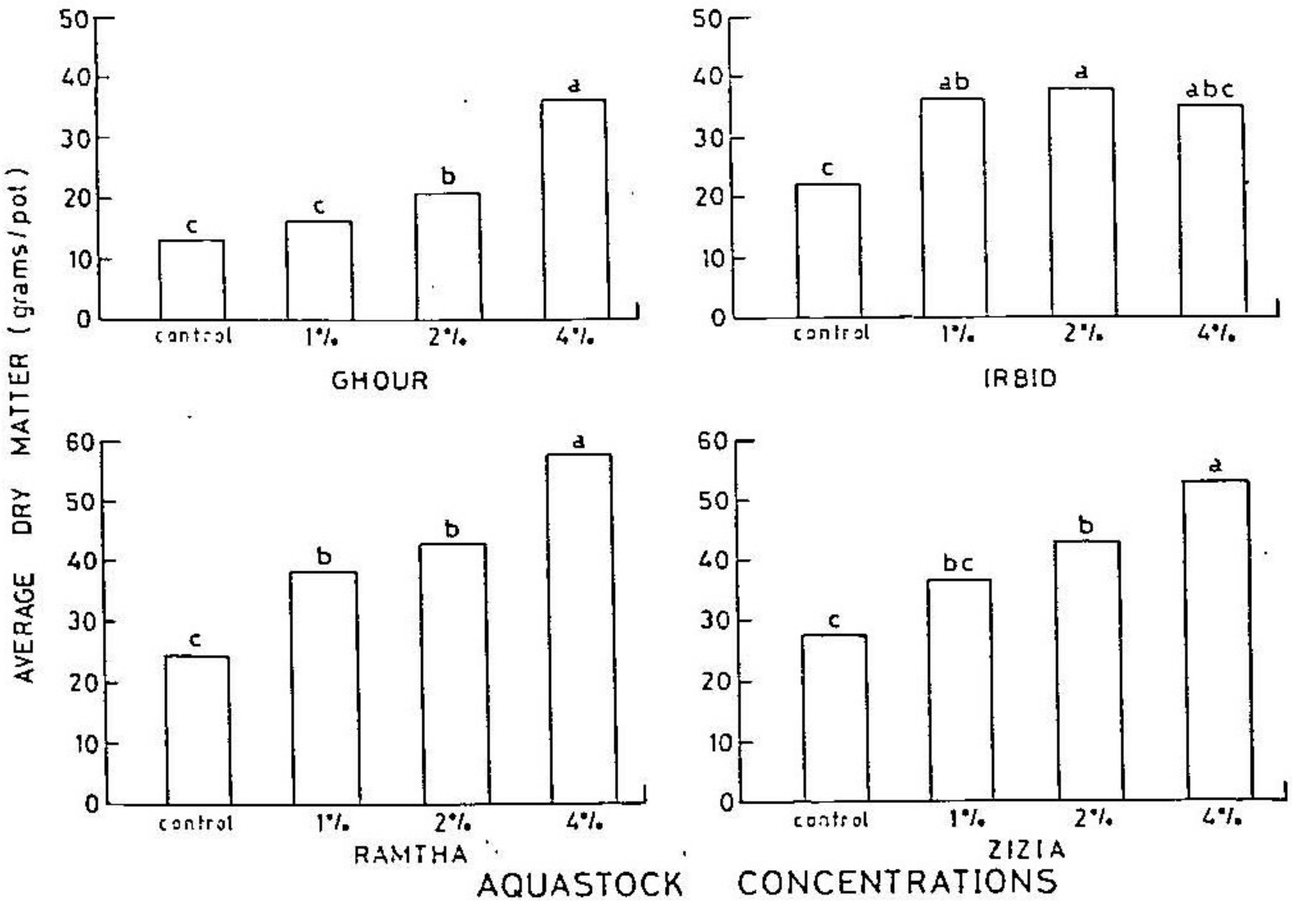

Figure 26: Average dry matter (grams/pot) of tomato as affected by different concentrations of Aquastock polymer, 1985 (columns having different at the 5% level according to Duncan's Multiple Range Test).

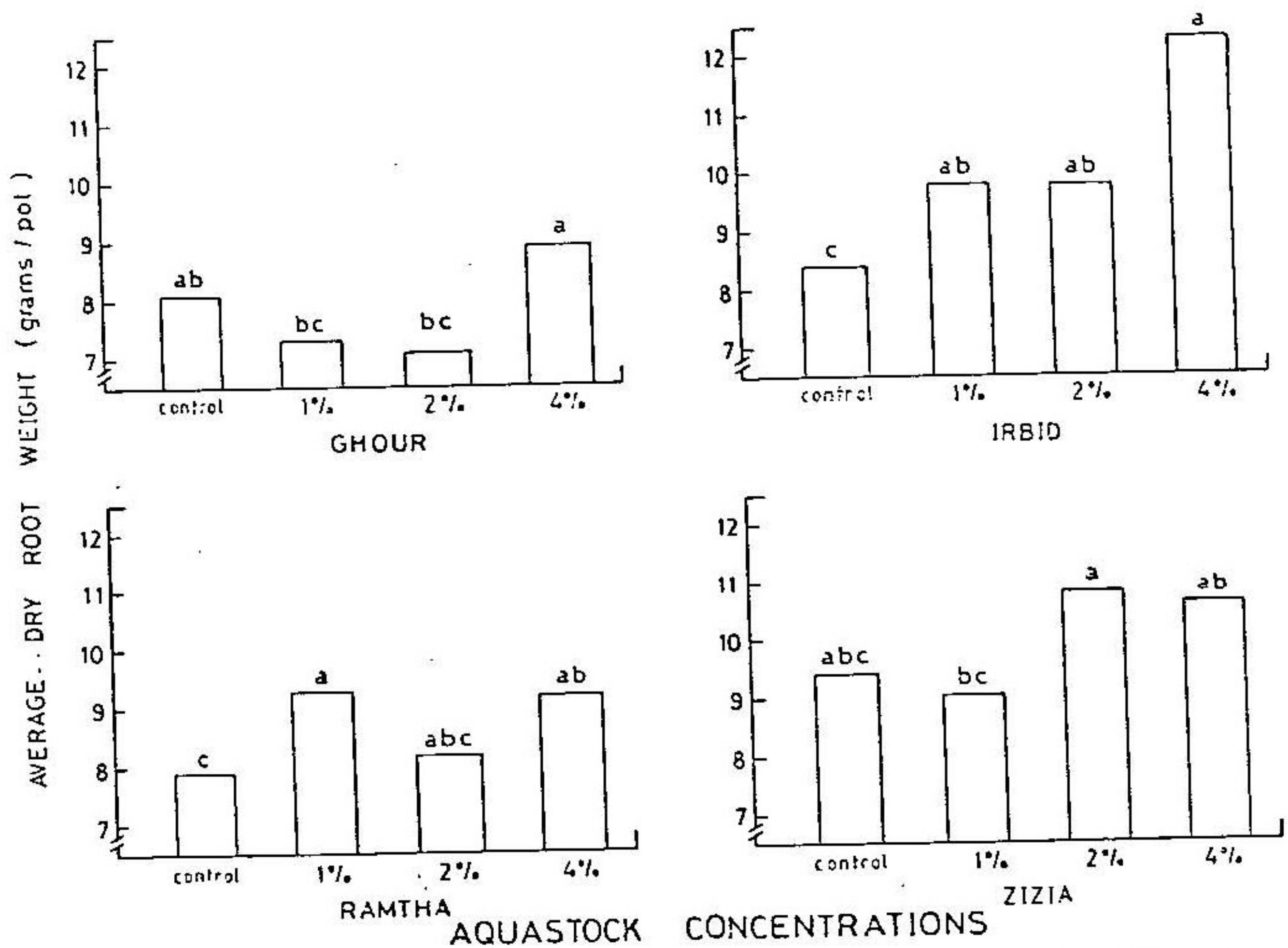

Figure 27 : Average dry root weight (grams / pot) of tomato as affected by different concentrations of Aquastock polymer, 1985 (columns having different letters are significantly different at the 5% level according to Duncan's Multiple Range Test).

The increase in dry root weight at the highest concentration was 9 , 12, 16 , and 46 % of the untreated soils , for Ghour , Zizia , Ramtha and Irbid soils , . respectively . The increase in dry root weight was relatively insighificant for all soils at all concentrations according to Duncan's Multiple Range Test .

The chemical properties of tomato juice, including p^H, percent total soluble solids and percent titritable acid as related to different concentrations of Aquastock polymer for the four soils are shown in lable 15 . It is clear that Aquastock had increased the P^H . Value of the tomato Juice and decreased titritable acid in all soils at all concentrations . Juice p^H of all soil at higher concentrations reached 4.2 . In addition , percent total soluble solids (TSS %) was increased with increasing polymer concentrations for all soils . Percent titritable acid increased with increasing polymer concenration for Ramtha and Zizia soils , In contrast it decreased with increasing polymer concentrations for Irbid and Ghour soils.

Table 15 : PH, total soluble solids (%) and Titratable acid (%) of tomato fruit as affected by different concentrations of Aquastock 1985.

Soils	Treatment	PH	%TSS	%TA
Irbid	Control	3.9	5.5	0.3816
	1%	4.0	6.0	0.3912
	2%	4.0	6.2	0.3709
	4%	4.2	7.5	0.2999
Ghour	Control	3.5	5.0	0.4122
	1%	4.0	5.8	0.3921
	2%	4.1	6.0	0.3311
	4%	4.2	6.2	0.3662
Ramtha	Control	3.8	5.5	0.3492
	1%	4.0	6.0	0.3885
	2%	4.1	6.8	0.3708
	4%	4.2	7.4	0.3670
Zizia	Control	3.9	5.0	0.3529
	1%	4.0	6.1	0.3722
	2%	4.0	6.8	0.3812
	4%	4.2	7.2	0.3791

SAMMARY AND CONCLUSION

Green house experiments were conducted in Jordan University site to study the effect of two soil conditioners namely Agri-SC. and Aquastock polymers on the yield of wheat and tomato, respectively , on four different soils of extreme textures in Jordan . Some physical properties, water conservation , and micronutrients availability were also studied in the laboratory .

Results obtained revealed that Aquastock application had significantly increased aggregate water stability, aggregation size, water retention , available water, plastic and liquid limits, for all soils . This polymer had significantly decreased bulk density and significantly increased porosity for all soils. Availability of Zinc, Copper, Iron , and manganese was also insignificantly for all soils. Tomato yield , length, root length , and fresh and dry matter weight were significantly increased for all soils, whereas , dry root weight was not significantly affected in all soils.

Agri-SC. polymer had improved aggregate water stability and aggregation size for Ramtha clay loam and Zizia silt loam soils . Bulk density was significantly decreased and porocity was significantly increased for Irbid clayey and Zizia silt loam soils only . Agri-SC. application did not affect water retention and available water for all soils . It increased availability of Zinc, Manganese, Iron and Copper for all soils . Wheat yield was not significantly affected by Agri-SC.

It is , therefore , recommended that Aquastock polymer be used under conditions similar to this investigation to improve plant growth and production , water conservation , water air soil system, and soil aggregation . However , further field studies are needed for different crops.

ملخــــــــص

أجريت تجربتين في البيوت الزجاجية في موقع الجامعة الاردنيـــــة ، لدراسة تاثير اثنين من المواد المبلمرة كمحسنات للتربة : هما أجـــــري اس سي (.Agri-SC) والأكواستوك (Aquastock) على أربعـــة انواع من الاراضي الاردنية مختلفة الصفات ، حيث وضعت في أصص بلاستيكيـــق وتم زراعة الاراضي المعاملة بالأجري اس سي (.Agri-SC) بالقمح والاراضـــي المعاملة بالأكواستوك بالبندورة ، ولقد حللت ودرست مخبريا بعض الخصائـــص الفيزياثية ، حفـــظ التربة للماء ووفرة العناصر الدقيقة لهذه الاراضـــي باستخدام هاتين المادتين .

اظهرت النتائج ما يلـــي :

زاد الأكواستوك (Aquastock) من تشبيت حبيبات التربـــة وزيادة حجمها وزيادة الماء المتيسر وذلك لكل انواع الأراضي ، وكذلـــك نقصت قيمة الكثافة الظاهرية وزادت المسامية لجميع الترب باستخدام الأكواستوك. لوحظ أيضا زيادة بسيطة في توفر كل من الزنك والحديد والنحاس والمنغنيـــز، كذلك فقد ازداد انتاج البندورة وطول النبات وطول جذرها ووزن النبـــات الخضري الجاف والطازج دون حصول زيادة في وزن الجذور الجاف وذلك لكـــل الاراضي .

أما أجري اس سي (.Agri-SC) فقد حسّن تشبيت حبيبـــات التربة وحجم الحبيبات لأراضي الرمثا وزيزيا فقط . ولم يكن هناك تاثيـــر للأجري اس سي (.Agri-SC) على زيادة الماء المتيسر لكل الاراضـــي. والاجري اس سي (.Agri-SC) زاد المسامية وأنقص الكثافة الظاهرية لأراضـــي اربد وزيزيا فقط . كما أن انتاج القمح لم يتأثر باستخدام هذه المادة .

لذلك ومن النتائج السالفة ينصح باستخدام الأكواستوك (Aquastock) في مثل ظروف هذه التجارب وذلك لتحسين نمو النبات ، وزيادة الانتـــاج،

وحفظ المياه للتربة ، وعلاقة التربة بالماء والهواء ، وتثبيت حبيبات التربة منعا للأنجراف ، ولذلك ينصح ايضا باجراء المزيد من التجارب وخصوصا في الحقل وعلى مختلف المحاصيل .

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Word or sentence	Columns
Polymer concentration	1
Soil apparant specific gravity	2
Soil porosity	3
Soil available water	4
Soil aggregate stability	5
Yield of crop	6
Length of tomato	7
Fresh weight of tomato	8
Dry weight of tomato	9
Root length of tomato	10
Root Dry weight of tomato	11
Quantity of water added for irrigation	12
Water use effeciency	13
Soil plastic limit	14
Soil liquid limit	15
Soil Zinc	16
Soil Copper	17
Soil Manganese	18
Soil Iron	19
Soil Phosphorous	20
Soil Potassium	21
Soil PH	22
tomato leaves zinc	23
tomato leaves Manganese	24
tomato leaves Iron	25
Wheat Zinc	26
Wheat Copper	27
Wheat Manganese	28
Wheat Iron	29

Table 1 : List of columns used in correlation coeficients analysis.

Table 2 : Correlation coefficient between matrix of items list in table 1 for Irbid clayey soil as affected by different concentrations of Aquastock, 1985 .

* Significant at 5 %

** Significant at 1 % or less .

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	-0.87	0.87	0.98**	0.96*	0.99**	0.92*	0.78	0.64	0.83*	0.97*	-0.74	0.98**	0.99**	0.99**	0.67	0.74	0.84	0.93*	0.97*	-0.04	0.99**	0.34	0.84	0.67
		-1.0**	-0.79	-0.82	0.91*	0.99**	-0.99**	-0.92*	-1.0**	-0.86	0.97*	-0.94*	-0.84	-0.83	0.67	-0.34	0.99**	-0.99**	0.91*	0.52	0.91*	0.09	-0.95*	-0.76
			0.79	0.82	0.9*	0.99**	0.99**	0.92*	0.99**	0.87	-0.97*	0.94*	0.84	0.83	-0.93*	0.34	0.99**	0.99**	0.91*	-0.53	0.91*	-0.09	0.95*	0.76
				0.92*	0.97*	0.85	0.68	0.51	0.80	0.97*	-0.64	0.94*	0.99**	0.99**	0.93*	0.80	0.75	0.87	0.96*	0.09	0.95*	0.40	0.79	0.54
					-0.94*	0.88	0.73	0.63	0.84	0.86	0.67	0.92*	0.93*	0.97*	0.58	0.80	0.81	0.90*	0.87	-0.004	0.97*	0.49	0.7	0.81
						0.95*	0.82	0.69	0.91*	0.93**	-0.79	0.99**	0.99**	0.99**	0.55	0.68	0.89	0.96*	0.98**	-0.12	0.99**	0.27	0.67	0.68
							0.96**	0.88*	0.99**	0.91*	-0.94	0.97*	0.89	0.89	0.72	0.44	0.93**	0.99**	0.94*	-0.43	0.45*	0.02	0.93*	0.77
								0.97*	0.98**	0.78	-0.99**	0.87	0.74	0.73	0.88	0.19	0.93**	0.95*	0.84	-0.65	0.83	-0.22	0.93*	0.76
									0.92*	0.62	-0.97*	0.75	0.58	0.59	0.96*	0.04	0.95*	0.87	0.69	-0.78	0.71	-0.31	0.82	0.83
										0.06	-0.96*	0.95*	0.85	0.85	0.93*	0.37	0.99**	0.99**	0.91*	-0.51	0.92*	-0.06	0.94*	0.78
											-0.77	0.95**	0.98**	0.96*	0.92*	0.63	0.63	0.92*	0.99**	-0.09	0.95*	0.18	0.91*	0.51
												-0.85	-0.71	-0.69	0.73	-0.11	0.97*	-0.92*	-0.82	0.70	-0.79	0.31	-0.94*	-0.69
													0.97*	0.96*	-0.98**	0.59	0.92*	0.98**	0.99**	-0.22	0.98**	0.16	0.92*	0.67
														0.99**	0.80	0.75	0.80	0.91*	0.97*	0.01	0.98**	0.35	0.83	0.59
															0.64	0.79	0.80	0.91*	0.95*	0.03	0.99**	0.42	0.79	0.66
															0.61	-0.01	0.93*	0.86	0.79	-0.74	0.70	-0.45	0.95*	0.56
																	0.30	0.48	0.58	0.60	0.70	0.86	0.26	0.43
																		0.98**	0.88	-0.56	0.85	-0.11	0.92*	0.79
																			0.95*	-0.39	0.95*	0.06	0.93*	0.77
																				-0.18	0.96*	0.12	0.94*	0.56
																					-0.12	0.80	-0.49	-0.38
																						0.31	0.84	0.74
																							-0.22	0.25
																								0.51

Table 3 : Correlation coefficient between matrix of items list in table 1 for Ghour sandy soil as affected by different concentrations of Aquastock. 1985.

* Significant at 5 % only

** Significant at 1 % or less

1	2	3	4	5	6	7	8	9	10	11	12	13	16	17	18	19	20	21	22	23	24	25
	-0.92*	0.91*	0.99**	0.95*	0.84	0.97*	0.99**	0.99**	0.91*	0.46	-0.68	0.82	-0.00	0.63	-0.16	0.62	0.0	0.93*	0.84	-0.83	-0.95*	-0.36
		-1.0**	-0.86	-0.76	-0.92*	-0.96*	-0.96*	-0.94*	-0.99**	-0.07	0.86	-0.94*	-0.27	-0.4	0.54	-0.81	-0.32	-0.71	-0.90*	0.72	0.91*	0.34
			0.86	0.76	0.95	0.97*	0.96*	0.94*	0.99**	0.08	-0.87	0.44*	0.27	0.37	-0.54	0.81	0.33	0.71	0.89	-0.71	0.91*	-0.34
				0.98**	0.77	0.92*	0.96*	0.99**	0.85	0.57	-0.60	0.74	-0.1	0.68	-0.04	0.54	-0.11	0.97*	0.81	-0.85	-0.92*	-0.37
					0.65	0.85	0.90*	0.93*	0.74	0.71	-0.45	0.62	-0.25	0.73	0.14	0.39	-0.27	0.99**	0.74	-0.85	-0.86	-0.39
						0.95*	0.90*	0.85	0.98**	-0.03	-0.97*	0.99**	-0.52	0.45	-0.60	0.94*	0.54	0.60	0.72	-0.48	-0.93*	-0.05
							0.99**	0.96*	0.98**	0.26	-0.85	0.94*	0.26	0.60	-0.36	0.81	0.26	0.82	0.80	-0.68	-0.99**	-0.19
								0.99**	0.96*	0.33	-0.77	0.89	0.12	0.57	-0.30	0.72	0.14	0.87	0.86	-0.79	-0.96*	0.33
									0.39*	0.39	-0.7	0.84	0.01	0.54	-0.23	0.64	0.03	0.90*	0.89	-0.85	-0.93*	-0.42
										0.08	-0.92*	0.93**	0.37	0.46	-0.53	0.87	0.40	0.70	0.81	-0.62	-0.95*	-0.19
											0.22	-0.06	-0.64	0.75	0.80	-0.26	-0.74	0.75	0.13	-0.5	-0.3[illegible]	-0.17
												-0.98*	-0.71	-0.35	0.72	0.99**	-0.73	-0.4	-0.58	0.27	0.8[illegible]	-0.12
													0.56	0.43	-0.63	0.96*	0.58	0.57	0.7	-0.45	-0.91*	-0.02
														0.02	-0.73	0.77	0.98**	-0.29	-0.1	0.47	-0.28	0.64
															0.4	0.35	-0.11	0.75	0.12	-0.28	-0.71	0.31
																-0.72	-0.84	0.21	-0.41	-0.01	0.27	0.04
																	0.78	0.34	0.49	-0.17	-0.80*	0.22
																		-0.32	0.0	0.41	-0.26	0.51
																			0.7	-0.84	-0.83	-0.37
																				-0.91*	-0.7	0.72
																					0.61	0.81
																						0.06

Table 4 : Correlation coefficient between matrix of items list in table 1 for Ramtha Clay Loam soil as affected by different concentrations of Aquastock 1985 .

* Signidicant at 5 % only

** Significant at 1 % or less

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	0.9*	0.89*	0.99**	0.93*	0.94*	0.92*	0.87*	0.95**	0.84	0.54	-0.72	0.93*	0.83	0.99**	0.92*	0.96*	0.81	0.75	0.69	0.9*	0.96*	-0.63	0.08	0.57
		-1.0**	-0.87	-0.96*	-0.96*	0.96*	-0.96**	-0.94*	-0.95*	-0.53	0.92*	-0.97*	-0.98**	-0.94*	1.0**	0.93*	-0.97*	-0.94*	-0.66	-0.99**	-0.99**	0.87	-0.08	-0.18
			0.87	0.96*	0.96*	0.99**	0.96*	0.94*	0.95*	0.53	-0.93*	0.97*	0.98**	0.93*	0.99**	0.93*	0.97*	0.94*	0.86	0.99**	0.98**	-0.87	0.07	0.17
				0.93*	0.91*	0.89	0.83	0.96*	0.79	0.48	-0.66	0.9*	0.79	0.99**	0.89*	0.96*	0.77	0.69	0.63	0.87	0.93*	-0.57	0.15	0.59
					0.9*	0.92*	0.86	0.92*	0.84	0.34	-0.78	0.91*	0.88	0.97*	0.96*	0.99**	0.86	0.80	0.68	0.93*	0.96*	-0.70	0.31	0.26
						0.99**	0.98**	0.99**	0.97*	0.71	-0.9*	1.0*	0.99**	0.95*	0.97*	0.89	0.94*	0.92*	0.90*	0.98**	0.98**	-0.84	-0.13	0.41
							0.99**	0.98*	0.98*	0.65	-0.93*	0.99**	0.98**	0.94*	0.99**	0.90*	0.98*	0.95*	0.90*	0.99**	0.99**	-0.88	-0.07	0.30
								0.95*	0.99**	0.74	-0.56	0.59	0.98**	0.89	0.97*	0.83	0.99**	0.97*	0.95*	0.98**	0.96*	-0.92**	-0.19	0.27
									0.94*	0.66	-0.83	0.99**	0.92*	0.97**	0.96*	0.92*	0.91*	0.86	0.83	0.96*	0.98**	-0.77	-0.06	0.49
										0.75	-0.97*	0.98**	0.98**	0.87	0.95*	0.80	0.98**	0.98*	0.97*	0.97*	0.94*	-0.94*	-0.24	0.24
											-0.68	0.70	0.64	0.51	0.56	0.33	0.66	0.7	0.83	0.61	0.57	-0.69	-0.79	0.49
												-0.91*	-0.98**	-0.76	-0.91*	-0.72	-0.99**	-0.99**	-0.97*	-0.94*	-0.88	0.99**	0.21	-0.01
													0.97*	0.95*	0.98**	0.89	0.96*	0.93*	0.90*	0.98**	0.96**	-0.86	-0.12	-0.37
														0.87	0.97**	0.84	1.0**	0.98**	0.94*	0.99**	0.96*	0.95*	-0.09	0.13
															0.95*	0.96**	0.85	0.79	0.72	0.93*	0.97*	-0.68	0.13	0.48
																0.93*	0.96*	0.92*	0.86	0.99**	0.99**	-0.86	0.05	0.24
																	0.61	0.74	0.63	0.90*	0.95*	-0.63	0.32	0.36
																		0.99**	0.95*	0.98**	0.94*	-0.96*	-0.13	0.11
																			0.97*	0.95*	0.90*	-0.98**	0.21	0.06
																				0.90*	0.83	-0.97*	-0.43	0.15
																					0.99**	-0.89	-0.02	0.22
																						-0.81	0.04	0.34
																							0.27	0.07
																								-0.26

Table 5 : Correlation coefficient between matrix of items list in table 1 for Zizia silt loam soil as affected by different concentrations of Aquastock, 1985 .

* Significant at 5 % only .

** Significant at 1 % or less .

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	-0.86	0.91*	0.99**	0.99**	0.85	0.99**	0.90*	0.99**	0.91*	0.74	-0.73	0.85	0.83	0.99**	0.78	0.86	0.77	0.76	0.90*	0.99**	0.95*	0.10	0.17	-0.55
		-0.99**	-0.83	-0.89	-0.99**	-0.86	-0.99**	-0.93*	-0.99**	-0.69	0.95*	-0.99**	-0.99**	-0.91*	-0.97*	-0.98**	-0.97*	-0.97*	-0.78	-0.88	-0.95*	0.42	0.31	0.29
			0.88	0.93*	0.99**	0.90*	0.99**	0.96*	1.0**	0.71	-0.94*	0.99**	0.98**	0.94*	0.96*	0.98**	0.96*	0.96*	0.81	0.93*	0.98*	-0.33	-0.23	-0.36
				0.99**	0.82	0.99**	0.88	0.98*	0.88	0.74	-0.69	0.82	0.79	0.99**	0.74	0.83	0.74	0.72	0.90*	0.99**	0.93*	0.16	0.22	-0.57
					0.89	0.99**	0.92*	0.99**	0.94*	0.71	-0.79	0.89	0.87	0.99**	0.83	0.90*	0.82	0.81	0.87	1.0**	0.97*	0.02	0.08	-0.56
						0.85	0.99**	0.92*	0.99**	0.65	-0.97*	1.0**	0.99**	0.89	0.98	0.99**	0.98**	0.98**	0.75	0.88	0.95*	-0.44	-0.34	-0.32
							0.90*	0.98**	0.90*	0.79	-0.71	0.84	0.81	0.99**	0.76	0.85	0.76	0.74	0.93*	0.99**	0.93*	0.10	0.20	-0.49
								0.96*	0.99**	0.73	-0.93*	0.98**	0.83	0.92*	0.96**	0.97*	0.95*	0.99*	0.83	0.92*	0.96*	-0.33	-0.21	-0.31
									0.96*	0.93*	-0.83	0.92*	0.90*	0.99**	0.87	0.93*	0.86	0.85	0.88	0.99**	0.98*	-0.06	0.02	-0.51
										0.70	-0.94*	0.99**	0.98**	0.94*	0.96*	0.98**	0.96*	0.95*	0.81	0.92*	0.97*	-0.32	-0.22	-0.36
											-0.45	0.62	0.59	0.77	0.52	0.58	0.52	0.49	0.95*	0.71	0.61	0.02	0.31	0.13
												-0.97*	-0.98**	0.78	-0.99**	0.98*	-0.99**	0.99**	-0.56	-0.77	-0.90*	0.57	0.54	0.34
													0.99**	0.89	0.99**	0.99**	0.99**	0.93**	0.72	0.88	0.96*	-0.44	-0.36	-0.35
														0.87	0.99**	0.99**	0.99*	0.99**	0.70	0.86	0.95*	-0.47	-0.40	-0.34
															0.82	0.89	0.82	0.81	0.91*	0.99**	0.96*	0.00	0.10	-0.48
																0.98**	1.0**	1.0**	0.63	0.81	0.93*	-0.54	-0.48	-0.33
																	0.98**	0.98**	0.71	0.89	0.97*	-0.41	-0.35	-0.42
																		1.0**	0.62	0.81	0.93	-0.54	-0.49	-0.34
																			0.60	0.80	0.92*	-0.55	-0.50	-0.34
																				0.88	0.78	0.11	0.33	-0.16
																					0.96*	0.04	0.1	-0.56
																						-0.18	-0.15	-0.56
																							0.93*	-0.36
																								-0.16

Table 6 : Correlation coefficient between matrix of items list in table 1 for Irbid clay soil as affected by different concentrations of Agri-SC , 1984 .

* Significant at 5% only

** Significant at 1 % or less

1	2	3	4	5	6	12	13	14	15	16	17	18	19	20	21	22	26	27	28	29
	-0.92*	0.92*	-0.37	-0.51	-0.98	-0.25	0.98**	-0.92*	-0.58	0.43	0.25	0.59	0.82	0.77	-0.69	-0.12	0.04	0.0	0.88	0.48
		-1.0**	0.48	0.31	-0.87	-0.06	-0.83	0.86	0.64	-0.25	0.12	-0.43	-0.67	-0.55	0.57	-0.13	0.24	0.0	-0.62	-0.10
			-0.47	-0.31	0.87	0.05	0.83	-0.86	-0.63	0.25	-0.12	0.43	0.67	0.55	0.57	0.12	-0.24	0.0	0.62	0.10
				-0.60	-0.45	-0.69	-0.28	0.02	0.97*	0.67	-0.1	0.53	0.21	0.29	-0.41	-0.83	0.82	0.0	-0.21	0.23
					-0.44	0.90*	-0.60	0.75	-0.39	-0.99**	-0.24	-0.99**	-0.90*	-0.93*	0.95*	0.90*	-0.84	0.0	-0.61	-0.71
						-0.23	0.98*	-0.86	-0.65	0.35	0.37	0.50	0.77	0.72	-0.60	-0.07	0.01	0.0	0.92*	0.53
							-0.49	0.45	-0.52	-0.40*	-0.52	-0.83	-0.70	-0.80	0.74	0.97*	-0.97*	0.0	-0.54	-0.85
								-0.91	-0.50	0.52	0.40	0.65	0.87	0.84	-0.73	-0.26	0.20	0.0	0.95*	0.63
									0.24	-0.70	-0.07	-0.83	-0.95*	-0.90*	0.90	0.40	-0.29	0.0	-0.78	-0.47
										0.48	-0.18	0.32	-0.03	0.05	-0.19	-0.69	0.70	0.0	-0.43	0.06
											0.17	0.98**	0.86	0.89	-0.94*	-0.93*	0.86	0.0	0.52	0.65
												0.13	0.24	0.36	-0.08	-0.31	0.41	0.0	0.67	0.85
													0.94*	0.95*	-0.99**	-0.84	0.75	0.0	0.61	0.63
														0.99**	-0.97*	-0.64	0.56	0.0	0.81	0.67
															-0.96*	-0.73	0.67	0.0	0.83	0.77
																0.74	-0.64	0.0	-0.65	-0.58
																	-0.99*	0.0	-0.39	-0.70
																		0.0	0.34	0.74
																			0.0	0.0
																				0.82

Table 7 : Correlation coefficients between matrix of items list in table 1 for Ghour Sandy soil as effected by different concentrations of Agri-SC,1984.

* Significant at 5 % only .

** Significant at 1 % or less .

1	2	3	4	5	6	12	13	16	17	18	19	20	21	22	26	27	28	29
	0.29	-0.24	0.51	0.42	0.99**	-0.10	0.92*	0.54	-0.99**	0.96*	0.35	0.99**	0.0	-0.41	-0.29	0.0	0.29	-0.75
		-0.81	0.65	0.76	0.38	-0.33	0.46	-0.03	-0.34	0.37	-0.73	0.29	0.0	0.47	0.83	0.0	1.0**	-0.78
			-0.59	-0.28	-0.38	0.83	-0.57	-0.41	0.26	-0.14	0.38	-0.16	0.0	0.01	-0.67	0.0	-0.81	0.81
			0.58	0.58	0.95*	-0.33	0.95*	0.49	-0.93*	0.88	0.02	0.59	0.0	-0.21	0.12	0.0	0.65	-0.95*
					0.40	0.30	0.33	-0.42	-0.47	0.62	-0.65	0.46	0.0	0.65	0.53	0.0	0.78	-0.53
						-0.25	0.97	0.62	-0.99**	0.92*	0.31	0.96*	0.0	-0.43	-0.19	0.0	0.38	-0.84
							0.46	-0.73	0.00	0.13	-0.09	0.02	0.0	0.47	-0.28	0.0	-0.33	0.56
								0.71	-0.92	0.82	0.26	0.83	0.0	-0.47	-0.07	0.0	0.46	-0.91*
									-0.51	0.29	0.69	0.45	0.0	-0.91*	-0.4	0.0	-0.08	-0.51
										-0.97*	-0.30	-0.99**	0.0	0.37	0.24	0.0	-0.34	0.77
											0.17	0.98**	0.0	-0.16	-0.19	0.0	0.37	-0.69
												0.31	0.0	-0.91*	-0.93*	0.0	-0.73	0.14
													0.0	-0.33	-0.29	0.0	0.29	-0.70
														0.0	0.0	0.0	0.0	0.0
															0.71	0.0	0.47	0.16
																0.0	0.83	-0.34
																	0.0	0.0
																		-0.75

Table 8 : Correlation coefficients between matrix of items list in table 1 for Ramtha clay loam soil as affected by different concentration of Agri-SC, 1984 .

* Significant at 5 % only

** Significant at 1 % or less

1	2	3	4	5	6	12	13	14	15	16	17	18	19	20	21	22	26	27	28	29
	-0.64	0.62	-0.99**	0.85	0.96*	-0.25	0.96*	-0.60	-0.86	0.81	0.96*	0.77	0.75	0.75	0.96*	-0.43	0.84	0.0	0.90*	0.76
		-1.0**	0.73	-0.84	-0.41	0.79	0.51	0.97*	0.18	-0.74	-0.75	-0.95*	-0.92*	-0.96*	-0.49	0.93*	-0.94*	0.0	-0.36	0.68
			-0.71	0.82	0.39	-0.82	0.49	-0.97*	-0.15	0.74	0.72	0.95*	0.92*	0.96*	0.45	-0.94*	0.94*	0.0	095	-0.65
				-0.94*	-0.90*	0.30	-0.90*	0.71	0.78	-0.79	-0.99**	-0.81	-0.78	-0.80	-0.95*	0.50	-0.69	0.0	-0.92*	0.48
					0.70	-0.36	0.71	-0.87	-0.55	0.66	0.97*	0.81	0.76	0.81	0.85	-0.60	0.89	0.0	0.85	-0.95*
						-0.09	0.98*	-0.34	-0.97*	0.77	0.85	0.60	0.61	0.58	0.92*	-0.21	0.68	0.0	0.79	-0.59
							-0.25	0.67	-0.13	-0.70	-0.27	-0.81	-0.83	-0.82	0.02	0.96*	-0.70	0.0	-0.64	0.09
								-0.41	-0.93*	0.87	0.84	0.71	0.72	0.68	0.88	-0.36	0.76	0.0	0.87	-0.54
									0.12	-0.59	-0.75	-0.87	-0.82	-0.88	-0.5	0.85	-0.88	0.0	-0.77	-0.78
										-0.62	-0.73	-0.39	-0.41	-0.36	-0.89	-0.02	-0.49	0.0	-0.63	0.48
											0.73	0.91*	0.94*	0.89	0.61	-0.73	0.89	0.0	0.95*	-0.29
												0.79	0.75	0.78	0.94*	-0.49	0.88	0.0	0.88	-0.90
													0.99**	1.0**	0.58	-0.91*	0.99**	0.0	0.95*	-0.59
														0.99**	0.53	-0.90*	0.97*	0.0	0.96*	-0.52
															0.56	-0.92*	0.98**	0.0	0.95	-0.59
																-0.20	0.69	0.0	0.75	-0.83
																	-0.84	0.0	-0.76	0.36
																		0.0	0.98*	-0.70
																			0.0	0.0
																				-0.64

Table 9 : Correlation coefficients between matrix of items list in table 1 for Zizia Silt loam soil as affected by different concentrations of Agri-SC , 1984 .

* Significant at 5 % only

** Significant at 1 % or less .

1	2	3	4	5	6	12	13	14	15	16	17	18	19	20	21	22	26	27	28	29
	-0.92*	0.92*	-0.54	-0.49	0.90*	0.17	0.82	-0.73	-0.51	0.97*	0.62	0.79	0.77	0.59	0.86	0.0	-0.19	0.0	0.29	0.25
		-1.0**	0.30	-0.21	-0.79	0.15	-0.76	0.73	0.26	-0.82	-0.78	-0.88	-0.84	-0.74	-0.88	0.22	0.48	0.0	-0.35	-0.50
			-0.31	-0.21	0.78	-0.13	0.76	-0.72	-0.27	0.82	0.77	0.89	0.83	0.73	0.87	-0.21	-0.49	0.0	0.38	0.49
				0.99**	-0.28	-0.59	-0.06	-0.11	0.99**	-0.69	0.32	0.08	0.12	0.36	-0.05	-0.84	0.07	0.0	-0.61	0.67
					-0.27	-0.94	-0.06	-0.12	0.99**	-0.65	0.38	0.14	0.15	0.41	-0.01	-0.85	-0.09	0.0	-0.49	0.72
						-0.01	0.98**	-0.92*	-0.26	-0.89	0.73	0.86	0.88	0.73	0.94	-0.26	0.16	0.0	-0.16	0.43
							-0.22	0.39	-0.92*	0.37	-0.65	-0.46	-0.47	-0.68	-0.30	0.95*	0.23	0.0	0.39	-0.90*
								-0.99**	-0.04	0.76	0.85	0.92*	0.95*	0.85	0.97*	-0.47	0.45	0.0	-0.28	0.61
									-0.12	-0.65	-0.91*	-0.94*	-0.97*	-0.92*	-0.97*	0.62	-0.13	0.0	0.36	-0.73
										-0.66	0.35	0.12	0.15	0.39	-0.02	-0.86	0.02	0.0	-0.57	0.70
											0.45	0.65	0.64	0.42	0.77	0.18	-0.04	0.0	0.27	0.05
												0.97*	0.97*	0.99**	0.91*	-0.77	-0.22	0.0	-0.19	0.91*
													0.99**	0.96*	0.98**	-0.61	-0.21	0.0	-0.08	0.79
														0.97*	0.98**	-0.64	-0.10	0.0	-0.18	0.80
															0.91*	-0.81	-0.16	0.0	-0.26	0.93*
																-0.49	-0.07	0.0	-0.12	0.68
																	0.0	0.0	0.58	-0.95*
																		0.0	-0.81	-0.21
																			0.0	0.0
																				-0.35