EFFECT OF DIFFERENT METHODS OF SOIL PREPARATION ON SOIL MOISTURE LOSS, WEED GROWTH AND SOIL RESISTANCE TO PENETRATION[1]

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ABSTRACT - The effect of different methods of soil preparation on soil moisture loss, weed growth and soil resistance to penetration has been quantified for the Latosols of Bebedouro experiment station of CPATSA/EMBRAPA, Petrolina, PE, Brazil. The methods studied are manual preparation, preparation by animal drawn wheeled tool carrier and tractorized implements. The drying characteristics of three fields with different soil physical properties were studied prior to conducting the experiment. The different methods of soil preparation caused the soil moisture loss differently. The plot prepared by animal drawn tool carrier retained more moisture for longer time even at deeper layers. The soil resistance to penetration on the surface increased with time with little variation at deeper layers.

Index terms: latosol, irrigation, soil characteristics, crop emergence.

EFEITO DE DIFERENTES MÉTODOS DE PREPARO DO SOLO NA PERDA DE UMIDADE, DESENVOLVIMENTO DAS ERVAS E RESISTÊNCIA À PENETRAÇÃO

RESUMO - Experimento realizado no campo experimental do CPATSA-EMBRAPA, em Petrolina, PE, com o objetivo de quantificar a perda de umidade de três tipos de Latossolo do projeto irrigado de Bebedouro com diferentes características físicas e cobertura natural. Foram estudados os efeitos de diferentes métodos de preparo do solo (implemento manual, tração animal e tratorizado) na perda de umidade, no desenvolvimento das ervas e na resistência à penetração do solo, a fim de definir o número de dias requeridos para atingir o nível ótimo de teor de umidade para aração após a irrigação, e a eficiência de emergência da cultura quando plantada após vários métodos do preparo. A característica de perda de umidade dos três tipos de Latossolos é diferente, e os diferentes métodos de preparo resultaram na perda de umidade variável. Por outro lado, os diferentes métodos de preparo do solo não influenciaram significativamente o desenvolvimento das ervas e a resistência à penetração observados durante a experimentação.

Termos para indexação: latossolo, irrigação, emergência da cultura e características físicas do solo.

INTRODUCTION

In the semi-arid tropical region of the world, particularly in the drier belts of northeast Brazil, the soil moisture variation in the top few centimeters of the soil is a major concern to the farmers of subsistance dryland agriculture or with a commercial scale irrigated farming. The farmers within the vicinity of river San Francisco practising irrigated agriculture, generally irrigate their fields and wait for optimum soil moisture to facilitate land preparation operations.

In case of dryland agriculture, where crops are planted after rains, the delayed planting, many a times, leads to poor plant establishment due to insufficient moisture availability as a result of high evaporative losses. Therefore, quantification of "in-situ" soil moisture variation over time in the top few centimeters, becomes important. It would help to identitify optimum period of land preparation after irrigation or rain, in case of irrigated agriculture. And in case of dryland agriculture, it would help predict the performance of planting carried out on different days of rain. The effectiveness of different cultivation systems in reducing soil moisture loss, weed growth and soil resistance to penetration to facilitate crop establishment and initial growth can also be inferred from such a study.

The paper represents the results of an experiment conducted to quantify the effect of different methods of soil preparation (manual, animal-drawn and tractorized implements) on the soil moisture loss, weed growth and soil resistance to penetration, and also to study the soil moisture loss from three profiles of Latosol having different physical characteristics and crop cover, with following main objectives:

(a) to define the number of days required to achieve optimum moisture level in the upper 30 cm of soil layer for three profiles of Latosol to facilitate land preparation operation (plowing) for irrigated agriculture, and

[1] Accepted for publication on February 2, 1988.
The work was carried out at CPATSA/EMBRAPA, Petrolina, PE, Brazil, during the assignment of the author as mechanization specialist IICA/EMBRAPA-CPATSA (1979-85).

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(b) to compare three methods of soil preparation for their ability to sustain soil moisture, suppress weed growth and variation of resistance to penetration for rapid and effective emergence of the seedlings and supply moisture for their initial growth.

MATERIALS AND METHODS

The experiment was conducted in two stages at the experiment station of CPATSA/EMBRAPA, Petrolina, PE, Brazil. The first stage was conducted in 1981 after a long dry season from June to November. Three locations with different soil profile characteristics were selected. Table 1 gives the soil physical characteristics of the three locations. The vegetation was eliminated by passing a tractor drawn chopper. At all three locations an irrigation of 80 mm was given to saturate the soil up to 80 cm depth of a premarked area of 24 x 36 sq. m. Prior to irrigation the stage of vegetation coverage at three locations was estimated by cross grid method. The coverage was classified into live vegetation, dead vegetation and bare soil. The Table 2 presents the percentage distribution of different types of vegetation observed at three locations.

The soil was allowed to dry and soil moisture observations in the perifery of predefined six points were taken using gravimeteric sampling technique on alternate days for five depths: 0 - 10, 10 - 20, 20 - 30 - 45 and 45 - 60 cm. Appendix A presents the dates of the experiment and soil moisture observed at the three locations.

The second phase of the experiment was conducted in December 1982 a year later to achieve environmental conditions similar to that of phase I. An area of 48 x 24 sq.m was selected and divided into three parcels of unequal size. The size of three parcels were fixed at 8 x 24 sq.m, 15 x 24 sq.m, and 25 x 24 sq.m, respectively for the soil preparation treatments with manual (spade), animal-drawn (single mould board plow attached to wheeled tool carrier) and tractorized implements (tractor mounted disc plow), respectively. After preparing the soil with respective implements a uniform irrigation with sprinkler was given to saturate the soil up to 80 cm for all the treatments. Hence after daily observations for soil moisture content on the periphery of ten predefined points in each parcel was taken over a cycle of fifteen days. On alternate days, the soil compaction on the surface at 15 cm soil depth and 30 cm soil depth was measured using Solo Teste (S-210) cone penetrometer. Ten samples (over the circular area with 1 m radius each) of weeds were collected to estimate the weed growth under each treatment. Seven of these samples were oven dried to estimate dry matter content of weed growth in each treatment.

RESULTS AND DISCUSSION

Soil-moisture loss without any preparation

Fig. 1 presents variation in the soil moisture in upper layer of 30 cm, during the drying cycle of fifteen days for the three locations. The soil moisture was observed to vary from 10.8 to 2.2, 10.9 to 3.2 and 9.8 to 4.2% in field I, field II and field III respectively. The drying characteristics of field I and field II seem quite similar. In the case of field III, the soil moisture loss during the first ten days was found rather steep and the curve flattened out during later days, thus indicating much higher rate of moisture loss during the first ten days as compared to last five days (Fig. 1).

TABLE 1. Physical characteristics of the soils of three locations of the experiment sites (Choudhury & Millar 1982).

Location	Soil depth cm	Particle size analysis (%)			Natural clay %	Density (gm/cc)	
		sand	silt	clay		real	apparent
Field I	0-30	90.6	4.0	5.3	2.3	2.64	1.56
	30-60	87.0	4.5	8.5	4.0	2.61	1.53
Field II	0-30	84.3	6.3	9.3	5.0	2.63	1.57
	30-60	83.5	6.0	10.5	5.0	2.64	1.66
Field III	0-30	88.3	4.6	7.6	3.5	2.63	1.58
	30-60	83.5	5.0	11.5	5.5	2.61	1.57

TABLE 2. Stage of natural vegetation at three locations of experiment 1 before irrigation.

Location	Date of experiment	Vegetation (% area)		
		Live	Dead	Bare soil
Field I	22.11 - 7.12, 1981	12	58	30
Field II	19.11 - 7.12, 1981	8	48	48
Field III	4.12 - 20.12, 1981	15	43	42

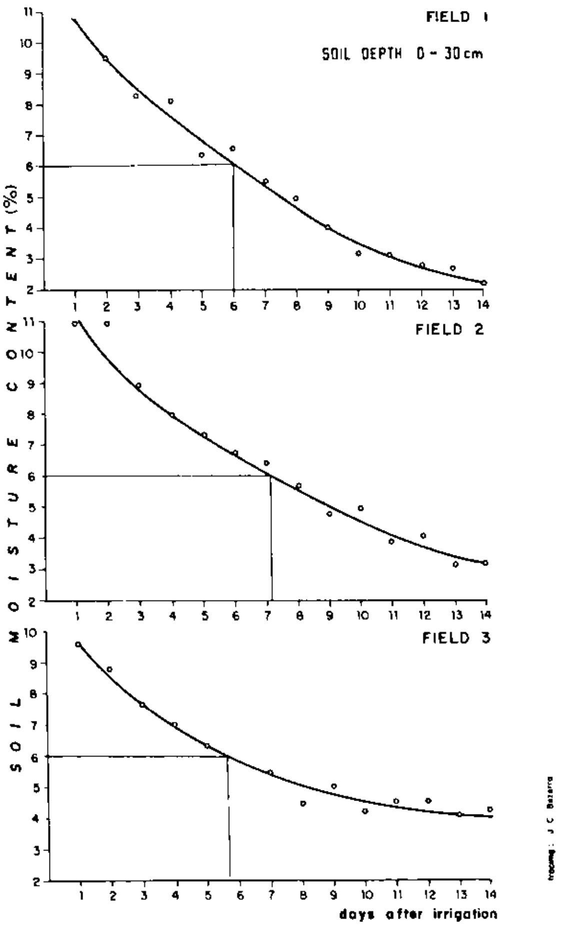

FIG. 1. Soil moisture variation in upper 30 cm of three profiles of Latosol of Bebedouro experiment station of CPATSA/EMBRAPA, Petrolina, PE, Brazil.

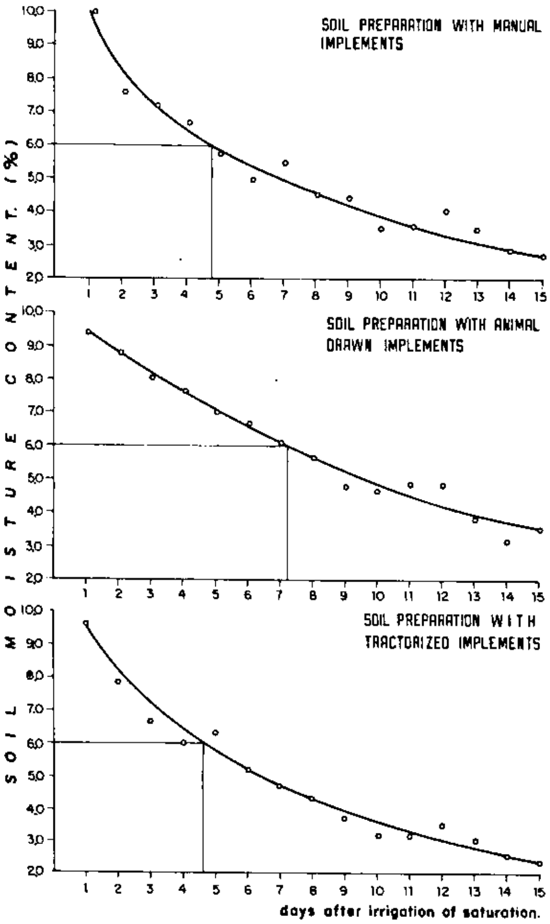

FIG. 2. Soil moisture variation in upper 15 cm as affected by different methods of soil preparation.

This information can be useful in estimating the number of days required to achieve optimum moisture level for plowing after irrigation. Supposing the soil moisture of 6% is optimum for plowing, this condition would reach on the 6th day in field I, between 7th and 8th day in field II and between 5th and 6th day in field III.

Soil moisture loss (upper layer 0-15 cm)

The retention of soil moisture in the upper layer after planting is critical for seedling emergence. Fig. 2 presents the soil moisture variation in upper 15 cm, for the three methods of soil preparation. Over a period of fifteen days cycle the soil moisture in upper 15 cm was observed to vary from 10.0 to 2.8, 9.4 to 3.6 and 9.7 to 2.4% respectively for the treatments of soil preparation by manual, animal--drawn and tractorized implements. The soil moisture reduced rapidly in the plots prepared using manual and tractorized implements as compared to the plot prepared using animal-drawn implements. The cloddy surface due to mould board plowing at slow speed with animal traction could be attributed for this behavior in the second treatment. The curves in Fig. 2 can be used in estimating the percentage of crop emergence when planted on different days after irrigation or rainfall of saturation. If the planting techniques have a satisfactory performance (in terms of percentage of crop emergence) up to 6% soil moisture content in upper 15 cm layer, then it would lead to satisfactory results till the 5th day in the case of manually and tractorized prepared seedbed, and till the 8th day in case of animal-drawn implements.

Vertical soil-moisture profile

The soil moisture variation in different layers when it is prepared using different tillage implements is presented in Fig. 3. The Fig. 3(a) presents the soil moisture profile on one day and on fifteen days after irrigation of saturation; and Fig. 3(b) presents the same on two, five, eight and eleven days after irrigation of saturation.

It is interesting to note that soils prepared by animal-drawn mould board plow could retain higher moisture from beginning till end in the deeper layers too. This clearly shows that under the conditions of the experiment the soil preparation using animal-drawn implements will not only facilitate the seedling emergence but would provide better conditions in terms of supplying moisture for the initial growth of the emerged seedlings.

Soil resistance to penetration

Table 3 presents the mean values of soil resistance to penetration observed on various days at three layers (surface, 15 cm depth and 30 cm depth) under different soil preparation treatments. An increasing trend of soil resistance to penetration with time can be noted on the surface. At deeper layers (15 cm and 30 cm depth) there is practically no variation. Not much difference in the overall mean values was observed among the various tillage treatments. The soil resistance to penetration of deeper layers was considerably higher as compared to the surface values. This is mainly because the tillage treatments did not disturb the soil at the deeper layers specially at 30 cm.

Weed growth

Suppression of weed growth is the third important objective of tillage. Table 4 presents mean values of green weight and dry weight of weed material in different treatments. Not much difference

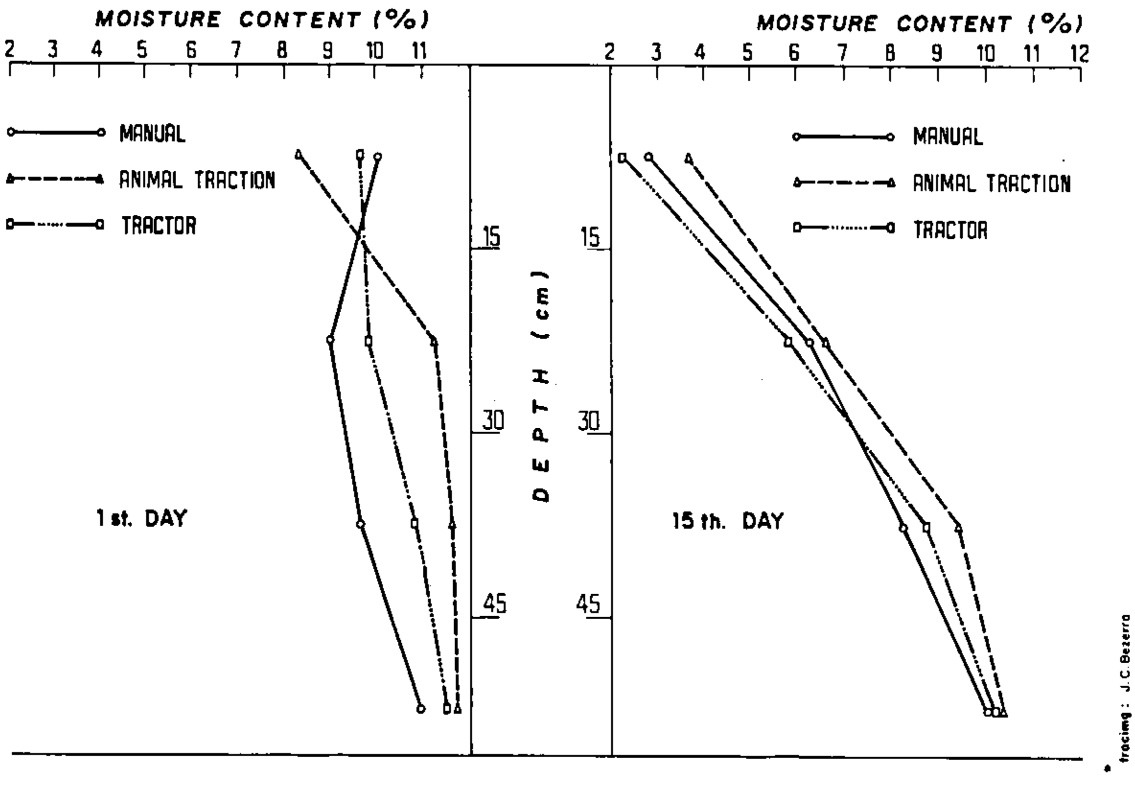

FIG. 3a. Soil moisture content in various layers on 1st and 15th day after irrigation as affected by different methods of soil preparation.

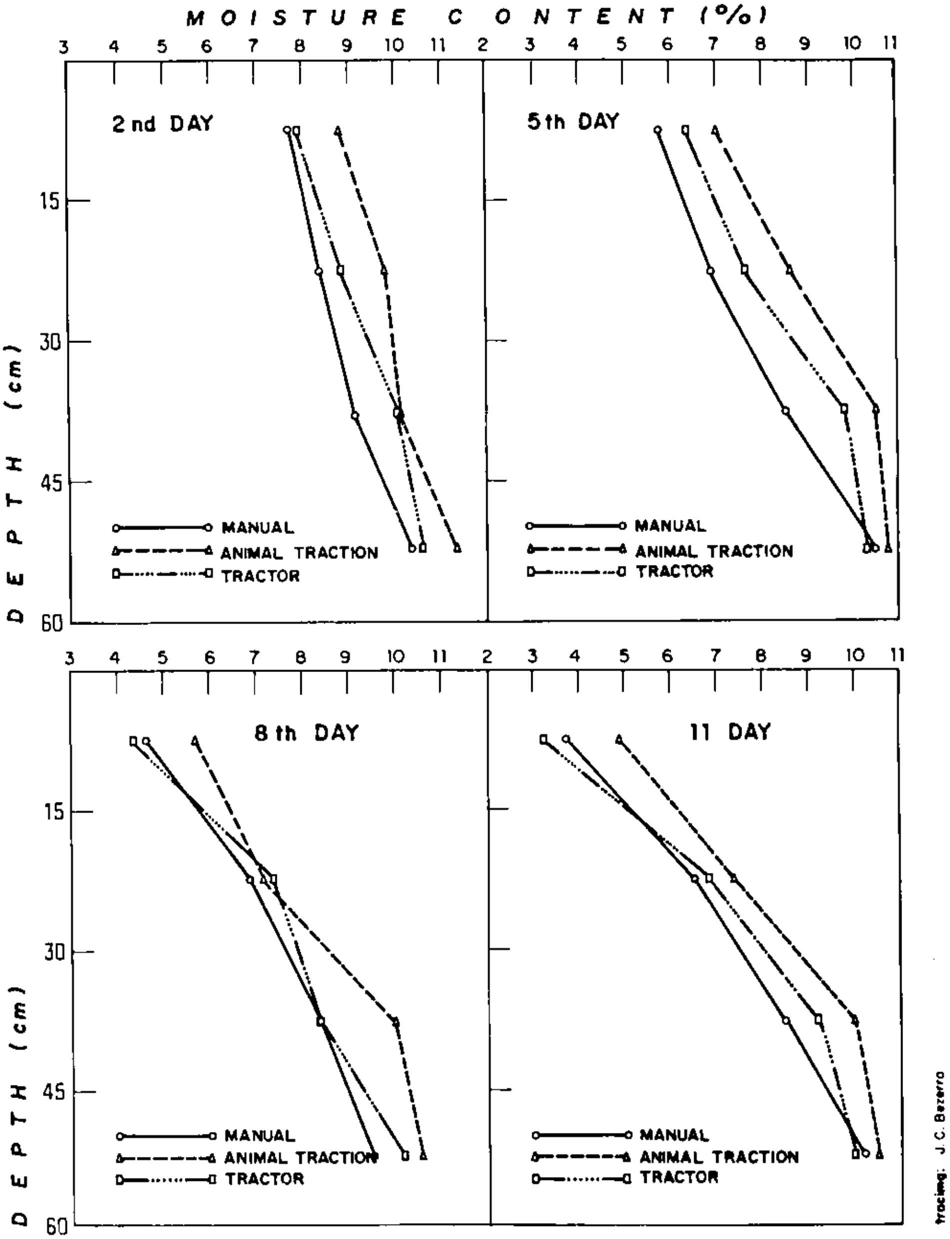

FIG. 3b. Soil moisture content in various layers on various days after irrigation as affected by different methods of soil preparation.

TABLE 3. Soil resistance to penetration Kgf/sq.cm under different tillage treatments.

Days after irrigation	Method of soil preparation*								
	1	2	3	1	2	3	1	2	3
	Surface			15 cm depth			30 cm depth		
1	1.52	1.09	1.16	7.09	3.46	5.97	8.98	6.54	7.60
3	2.68	1.68	2.29	5.30	7.85	7.67	8.44	7.04	7.40
5	2.62	3.13	2.45	7.98	9.15	6.94	8.88	7.84	8.67
7	4.02	3.40	3.57	9.24	10.24	9.07	8.98	9.13	9.37
9	4.13	3.22	6.65	8.17	8.13	7.77	9.04	9.24	9.34
11	2.64	5.53	4.18	8.09	10.73	9.14	7.84	9.59	9.88
13	4.08	5.04	2.89	8.22	7.69	5.83	6.83	8.42	6.29
15	2.14	6.88	4.20	10.46	9.21	9.69	9.02	8.08	8.29
Overall mean	2.98	3.75	3.42	8.06	8.31	7.76	8.49	7.26	8.48

* Measured by cone penetrometer of "Solo Teste - S210", Rua Conselheiro Carrão 275 (Bela Vista), São Paulo, Brazil.

1. Manual soil preparation
2. Preparation with animal-drawn mould board plow
3. Preparation with tractor mounted disk plow

TABLE 4. Weed growth (fresh weight and dry matter) under different tillage treatments.

Soil preparation treatment	Number of observations										mean
	1	2	3	4	5	6	7	8	9	10	
				fresh weight (kg/ha)							
Manual	1321	450	734	1207	147	396	975	1124	500	251	711
Animal drawn	1000	545	2012	1304	131	818	519	1750	69	722	887
Tractor	525	1085	1201	1644	574	490	230	653	468	833	770
				dry weight (kg/ha)							
Manual	NR	NR	NR	349	56	133	263	195	136	69	172
Animal drawn	NR	NR	NR	358	45	228	132	322	014	185	183
Tractor	NR	NR	NR	463	136	122	52	228	160	199	194

NR: Not recorded.

was observed among the treatments showing little effect of different tillage treatments and confirming that the variation of soil moisture was mainly due to different tillage treatments.

CONCLUSIONS

1. The drying characteristics of the three profiles of Latosols of Bebedouro experiment station of CPATSA/EMBRAPA, Petrolina, PE, are different. The soil moisture loss from upper layers after saturation during the first ten days is rapid.

2. By integrating information about the plowing characteristics at various moisture regimes, one could easily find the optimum period for land preparation based upon soil moisture drying characteristics developed.

3. The different methods of soil preparation caused the soil moisture loss differently. The preparation with animal-drawn mould board plow could

retain higher moisture from beginning till end. It would facilitate the emergence of seed and would provide better conditions for the initial development of emerged seedlings.

4. The soil resistance to penetration on the surface increased with time for all tillage treatments. At deeper layers (15 cm and 30 cm) it was consistently higher than that of surface values and was not found varying with time.

REFERENCES

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Appendix A: Soil moisture variation at various depth after irrigation of saturation at three locations of Bebedouro experiment station of CPATSA/EMBRAPA, Petrolina, PE, Brazil.

Location and duration	Days after irrigation	Soil moisture (% dry weight basis) soil depth (cm)				
		0 - 10	10 - 20	20 - 30	30 - 45	45 - 60
Field I	1	10.03	10.90	10.52	8.95	8.81
	3	8.76	7.98	8.24	8.94	8.04
	5	6.72	6.27	6.27	8.17	7.64
	7	5.00	5.28	6.25	7.19	7.66
	9	3.27	3.91	5.03	6.67	6.99
	11	2.39	2.70	4.26	6.48	6.85
	13	2.04	2.38	3.70	5.27	6.49
	15	1.22	2.13	3.20	5.05	5.95
Field II	1	10.65	10.37	10.97	10.48	9.74
	3	8.88	8.45	9.45	8.81	8.38
	5	6.67	6.92	8.38	8.57	7.61
	7	5.43	6.11	7.74	8.27	7.33
	9	2.98	4.77	6.67	7.95	8.54
	11	2.52	3.71	5.65	6.68	6.77
	13	1.75	3.08	4.79	5.93	6.37
	15	1.67	2.17	3.92	5.33	5.76
Field III	1	9.12	9.48	10.14	10.09	11.16
	3	6.99	8.04	8.02	9.92	9.86
	5	4.58	6.44	8.03	9.24	9.17
	7	3.64	5.84	7.01	8.68	8.95
	9	3.15	5.36	6.83	7.66	8.54
	11	2.34	5.10	6.33	7.87	8.20
	13	2.17	4.10	6.05	7.73	8.00
	15	1.94	3.29	5.22	6.96	7.62

Appendix B: Soil-moisture variation at various depths after irrigations of saturation on three treatments of soil preparation using different levels of mechanization.

Date	Manual implement				Animal-drawn				Tractorized			
	Soil depth (cm)				Soil depth (cm)				Soil depth (cm)			
	0 - 15	15 - 30	30 - 45	45 - 60	0 - 15	15 - 30	30 - 45	45 - 60	0 - 15	15 - 30	30 - 45	45 - 60
09.12.82	10.02	8.96	9.63	10.90	9.36	11.22	11.55	11.58	9.73	9.88	10.79	11.49
10.12.82	7.64	8.36	9.18	10.33	8.85	9.95	10.14	11.46	7.89	8.85	10.12	10.77
11.12.82	7.22	7.94	9.22	10.39	8.07	8.86	10.56	10.77	6.71	8.49	9.49	10.37
12.12.82	6.72	7.79	7.95	8.88	7.64	9.20	10.47	10.75	6.07	7.36	9.70	10.64
13.12.82	5.79	6.93	8.56	10.50	7.06	8.61	10.51	10.75	6.39	7.65	9.84	10.32
14.12.82	5.08	6.94	8.71	10.29	6.70	7.73	10.27	10.98	5.15	7.53	8.86	10.69
15.12.82	5.57	7.26	8.75	10.40	6.16	7.79	10.06	10.84	4.75	7.50	9.53	10.37
16.12.82	4.62	6.92	8.38	9.53	5.69	7.22	9.98	10.54	4.36	7.42	8.34	10.19
17.12.82	4.49	5.91	8.30	9.66	4.82	6.75	9.62	10.32	3.72	7.19	9.12	10.11
18.12.82	3.63	6.61	8.63	10.20	4.69	7.42	9.52	10.35	3.20	7.08	9.09	9.86
19.12.82	3.76	6.57	8.52	10.15	4.90	7.39	10.05	10.48	3.21	6.90	9.15	10.04
20.12.82	4.35	6.46	8.09	9.49	4.90	7.17	9.15	10.27	3.58	6.90	8.24	9.77
21.12.82	3.66	6.64	8.73	10.03	3.85	7.24	9.19	10.29	3.07	6.98	8.74	10.22
22.12.82	3.07	6.25	8.30	10.03	3.26	6.97	9.24	10.94	2.57	6.67	8.48	10.15
23.12.82	2.82	6.23	8.22	10.15	3.57	6.54	9.38	10.32	2.31	5.82	8.86	10.14