IV- RESULTS AND DISCUSSION

This investigation was carried out with the aim of determining "the levelling uniformity coefficient" and the effect of levelling on the performance of machines at different types of levellers, different speeds of levelling, and different number of levelling passes.

The presentation of the results includes discussion on the following characters for each machine used in this study as :

1. The different component of the consumed time in performing the required field operation.
2. Field capacity and coefficient of useful time (field efficiency).
3. Seeding depth and germination capacity.
4. Harvesting efficiency.
5. The consumed energy in performing the required field operations.
6. Economical analysis.

The results related to effect of land levelling treatments on soil physical properties, irrigation efficiencies and crop productivily, as well as the economical evaluation of land levelling process, are successively.

This investigation was discussed in three parts as :

PART "I"

4.1. The levelling uniformity coefficient index "LUC":

Levelling the land is the most important agricultural process for seed-bed preparation. It consists of cutting ridges and filling small depression of the soil surface. In other words, reducing the degree of roughness of the soil surface.

The evaluation of 'levelling uniformity coefficient', LUC, was considered as an index of effectiveness with desired results can be achieved. It has been defined and used to evaluate the performance of the levelling treatments according to Tyagi and Singh (1979).

a- Effect of land levelling equipment on LUC :

The effect of different equipments of levelling on the levelling uniformity coefficient was studied by dividing the land into equal squares of sides equal 10 m. Elevations were obtained at the corners, and contour lines were plotted to indicate the uniformity pattern as shown in figs.5 and 6.

Figures show the effect of land levelling on redistribution and uniformity of contour lines by levelling the land prepared to cultivate berseem and maize crops.

Table 2, indicates the levelling uniformity coefficient "LUC" by using three types of equipment as: multi-steel-angle leveller (L_1), blade-box system leveller (L_2), and traditional-wooden leveller "zahhafa" (L_3), resulting the following descending order :

Blade L. $>$ angle L. $>$ zahhafa L. $>$ N.L. , in two cases of berseem and maize lands.

Table 2: Effect of land levelling equipment on the levelling uniformity coefficient "LUC".

	Levelling equipment			
	N.L.	L_1	L_2	L_3
Berseem land	46	80	81	56
Maize land	50	80	83	60
Mean	48	80	82	58

* N.L. = Non-levelled land.
L_1 = Multi-steel angle leveller.
L_2 = Blade-box system leveller.
L_3 = Traditional wooden-zahhafa.

This means that, using either blade L. (L_2) or angle L.(L_1) resulted in approximately the same value of LUC (84-81). Meanwhile, levelling by traditional wooden zahhafa (L_3) was not uniform enough, since the LUC was only 56% and 60%, resp. This is not higher than non

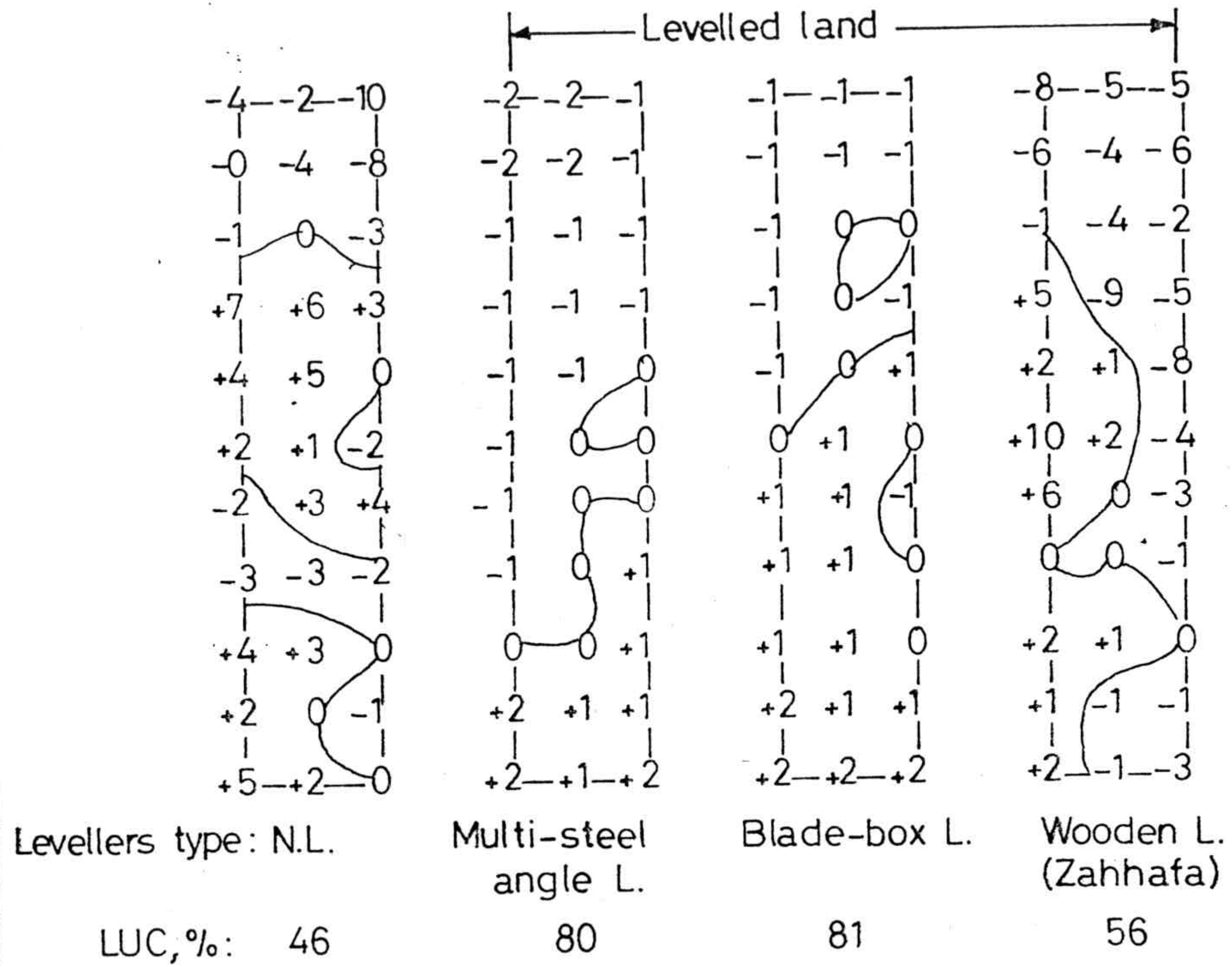

Fig.5: Effect of land-levelling equipment on the levelling uniformity coefficient, LUC (berseem-land). Contour lines represent zero deviation.

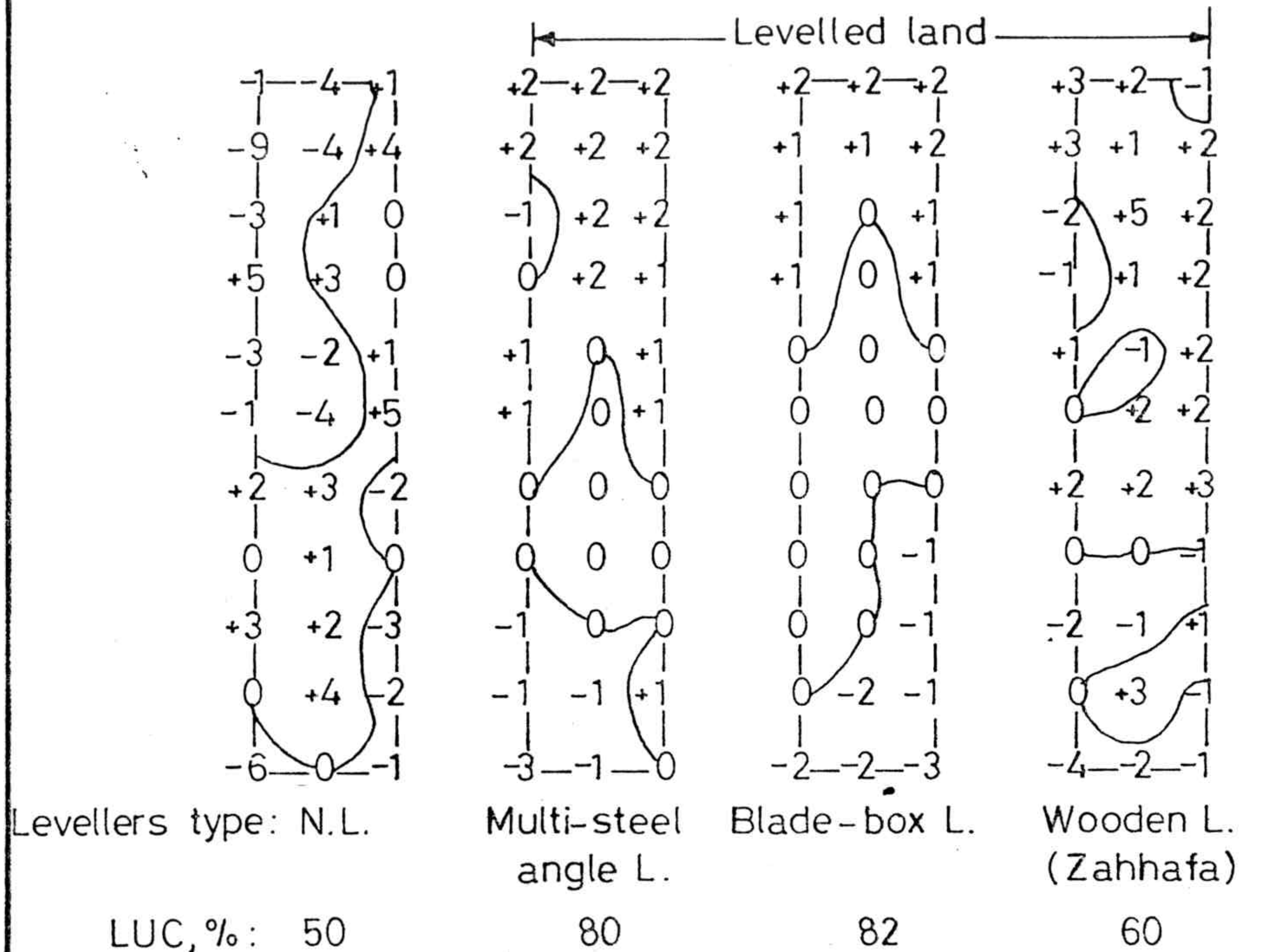

Fig.6: Effect of land levelling epuiqment on the levelling uniformity coefficient, LUC (maize-land).
Contour lines represent zero deviation.

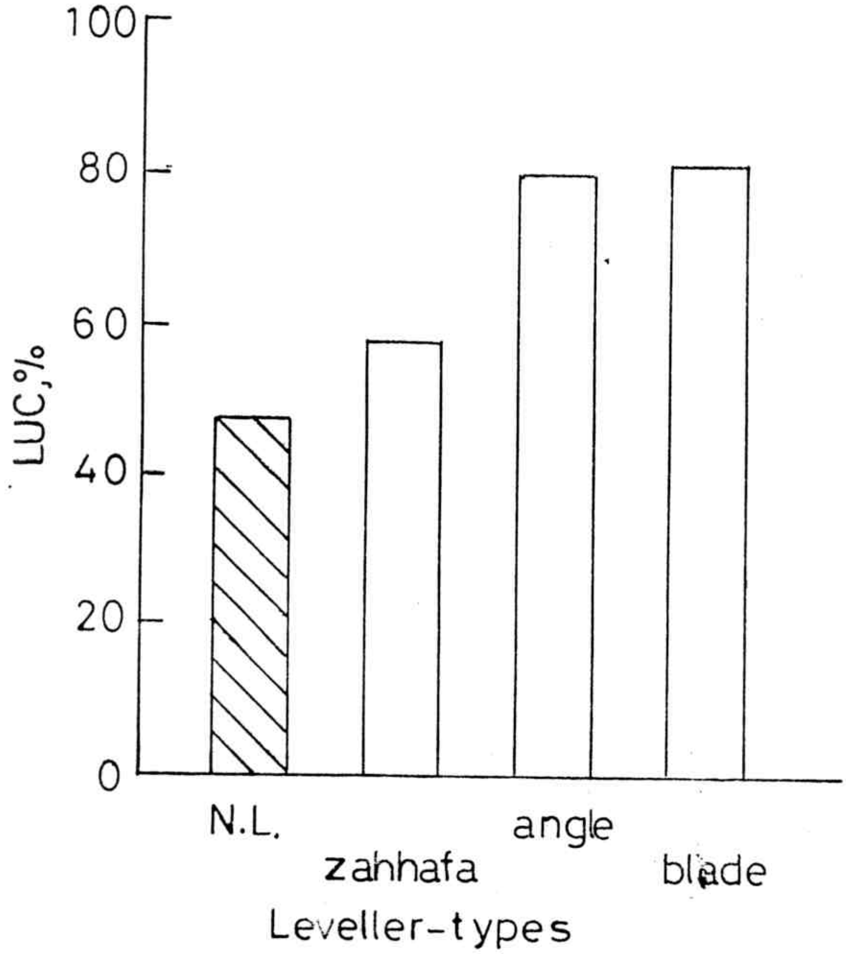

Fig.7: Levelling uniformity coefficient as a result of levelling types.

levelled (N.L.) value. The refor traditional wooden zahhafa should not be recommended. Fig. 7.

In principle, the levelling using multi steel angle leveller, the levelling bars are like a series of miniature buldozers working in train. These displacement the soil from ridges and deposit it in the depressions, leaving behined an exceptionally smooth level-surface, with an all over even compression.

But levelling using box system blade leveller, which cuts the high ridges and rolls the clods for a large and enough range to breaks down.

From the previous illustration, it should be recommended to level by box-steel-angle leveller, to perform better levelling with more uniformity.

b- Effect of levelling forward speeds on "LUC":

Levelling uniformity pattern for areas levelled by using box-blade system leveller (L_2), (which has been accepted previously and further usage in Egyptian fields), with different three forward speeds of about (average speeds): 3 (LSI), 4 (LS2) and 5 (LS3) km/h., are illustrated in fig. 8.

Levelling using forward speed of 4 km/h. resulted in more uniform land surface eminated by distribution and uniformity of contour lines.

From table 3, it is clear that, levelling uniformity coefficient has a descending order under the different levelling forward speeds as follows :

Levelling at 4 km/h. forward speed $>$ levelling at 3 km/h. forward speed. $>$ levelling at 5 km/h. forward speed, $>$ non-levelled land.

This means that, levelling land using box blade system leveller (L_2), with 4 km/h. forward speed increased LUC by 58.8% as compared with non levelled land, followed by 3 km/h. forward speed (47.1 over N.L.), followed by 5 km/h. forward speed (41.2 over N.L.), i.e. effect of 4 km/h. forward speed of levelling gave better LUC than other forward speeds.

This due to the fact that, the impact force resulting from the contact of medium speed ($\cong$ 4 km/h) with clods, was enough for rolling the large clods, breaking them down, filling the cavites, smoothing the surface with an all over uniformity.

As to speed ($\cong$5 km/h) a high impact force acting in a short time causing unbalancing and joging and scattering the clods without complete breaking.

Considering the law ($\cong$3 km/h.) the impact force, was un adequate for breaking and moving the clods to uniformed on the soil surface.

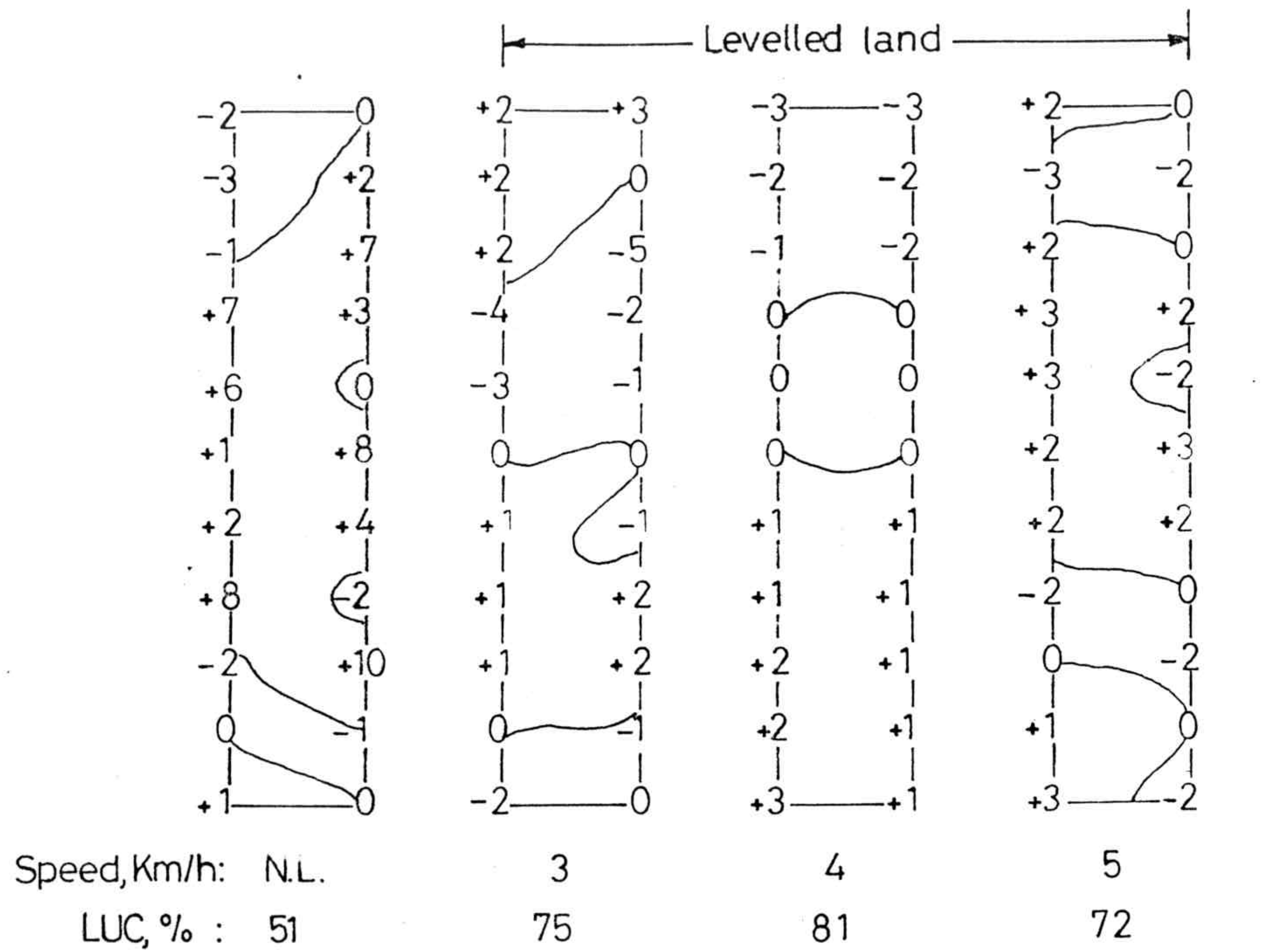

Fig.8: Effect of levelling forward-speeds on the levelling uniformity coefficient, LUC, using blade-box leveller.

Table 3: Effect of different forward-speeds of levelling, using blade-box system leveller, on the levelling uniformity coefficient "LUC", %.

	Levelling forward speeds, km/h.			
	N.L.	3	4	5
Land of sorghum	51	75	81	72

c- <u>Effect of times of levelling passes on "LUC":</u>

Effect of number of levelling passes on the levelling uniformity coefficient is shown in fig. 9.

The values of LUC as affected by times of passes (single, two and three passes) using blade-box system (L_2) at 4 km/h. levelling forward speed are given in table 4. The results indicate that levelling by three passes (LP_3) resulted in more uniform soil surface eminated by distribution and uniformity of contour lines. LUC has a descending order as follows :

Three passes (LP_3) $>$ two passes (LP_2) $>$ single pass (LP_1) $>$ N.L.

This means that, three passes resulted in increasing the LUC value by 137%, and two passes by 114%, while one pass lead to increase of 62.8% when compared with non levelled land (N.L.).

From the discussed mentioned above, it should be recommended that, for having soafter soil surface with fair aggregates distribution and improved levelling uniformity, it should be levelled using blade-box system leveller at 4 km/h. forward speed, with three passes only.

Increasing the passes time of levelling from one pass to two passes, the LUC increased by 51.2% and increasing the number of levelling passes from two passes to three passes, the LUC increased by 23% only. On the other hand, increasing the times of levelling passes from three to four passes, the expected increases of LUC not exceed than 8.7% only (from fig.10). It can be concluded that any increase of passes times above three passes lead to a small increasing of LUC (with a high increasing of levelling costs).

Table 4: Effect of times of levelling passes on the levelling uniformity coefficient "LUC", using blade-box system leveller at 4 km/h. forward speed.

	Times of levelling passes			
	N.L.	single	two	three
Land of wheat	35	57	75	83

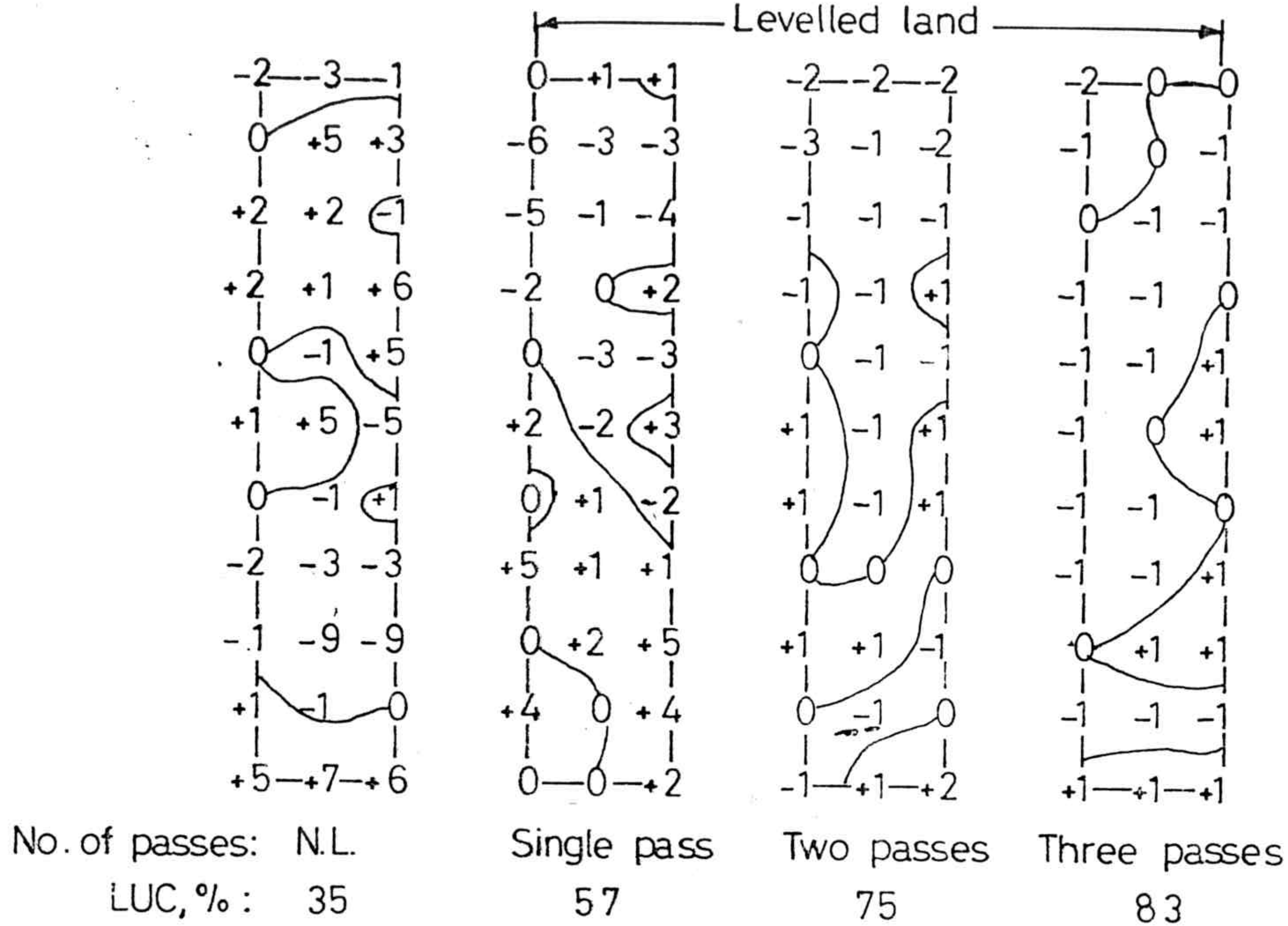

Fig.9: Effect of times of levelling passes on the levelling uniformity coefficient, LUC, using blade-box leveller at 4 km/h forward-speed.

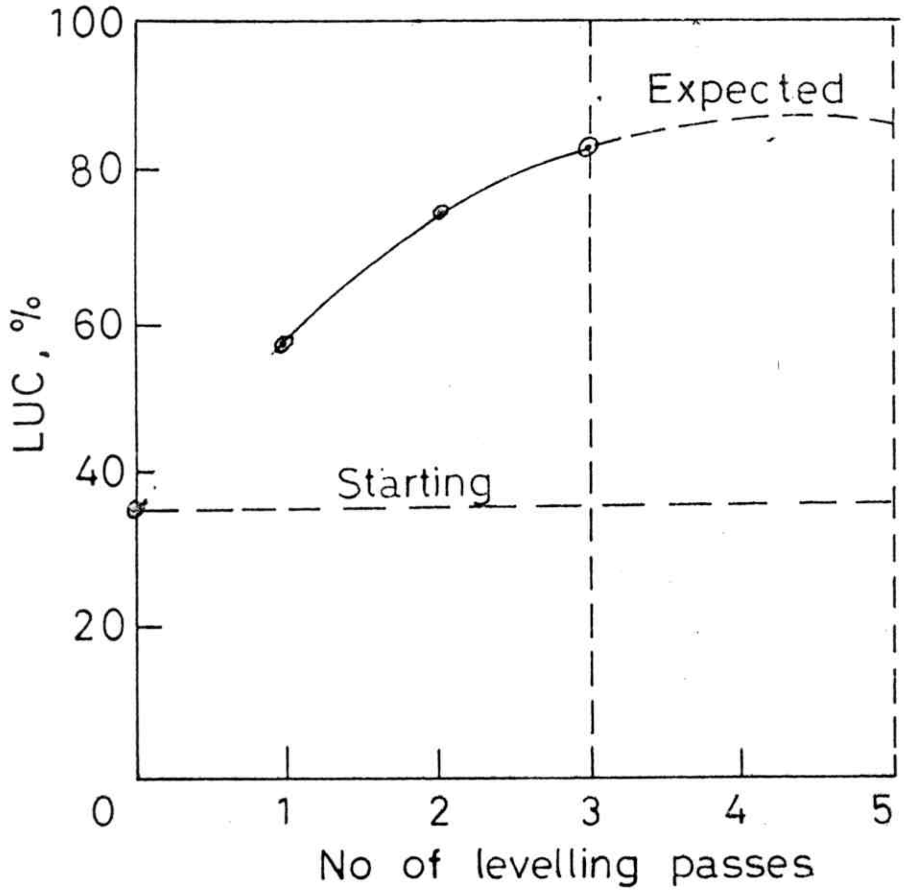

Fig.10:Levelling uniformity coefficient as a result of number of levelling passes.

4.2. Land levelling and soil physical properties:

Virtually, levelling is often done prior seeding as a regular land preparation practice, which is carried out for the purpose of developing soil structure favourable to plant growth by loosening and pulverizing soil particles to improve soil physical properties, i.e. bulk density, porosity, void ratio, aggregates., infiltration rate and compaction, and thus, high percentage of germination will be obtained.

a- Bulk density, porosity, and void ratio:

The discussion will cover the effect of levelling uniformity coefficient "LUC" on bulk density (ρ_b), total porosity (E) and void ratio (e). Bulk density and total porosity are the important factor for soil physical properties, considering its influence on the water holding capacity, hydraulic conductivity and aeration of soils.

Table 5 represents dry bulk density, total porosity, void ratio and moisture content of one layer of soil for different levelling treatments (different LUC values).

The obtained results show that, soil bulk density at soil layer depthes of 10 cm. was significantly increased by levelling operation. This increment could be attributed to the effect of land levelling on breaking, loosening and compacting of soil particles.

Table 5: Effect of land levelling on soil bulk density (ρ_b), porosity (E), void ratio (e) and moisture content (MC), through the 10 cm surface layer of soil.

LUC, %	ρ_b, g/cm^3	E, %	e	M.C., %
35	0.99	62.64	1.67	23.48
51	1.02	61.51	1.59	22.92
57	1.10	58.49	1.41	23.23
60	1.13	57.36	1.35	23.83
72	1.11	58.11	1.39	23.19
75	1.14	56.98	1.33	23.93
81	1.15	56.60	1.31	23.26
83	1.16	56.23	1.28	23.92

Also, it is evident from the same table that, the changeable in soil bulk density was more at the surface layer (from 0-10) fig. 11. This changeable may be due to effectiveness of working depth of land levellers usage, which actually does not exceed the first layer (0-10 cm.), while the load and compaction forces of the equipment usually influence deeper layers with damped effect causing an increase in soil bulk density.

According the previous change in bulk density, the total porosity shows a reverse behaviour at different levelling treatments.

It is clear that, the mean relative decrease in total porosity was due to the compaction effect resulting from land levelling, which increased soil bulk density and consequently, decreased soil porosity, table 5.

It was observed from this table that, as a result of the variable value of bulk density and constant value of real denisty of the same soil, that any variation of bulk density caused a corresponding variation in porosity.

The values of void ratio at this layer under different levelling uniformity coefficients indicate that void ratio was influenced by levelling operation, as it was decreased with different amounts depending upon the type of land levelling.

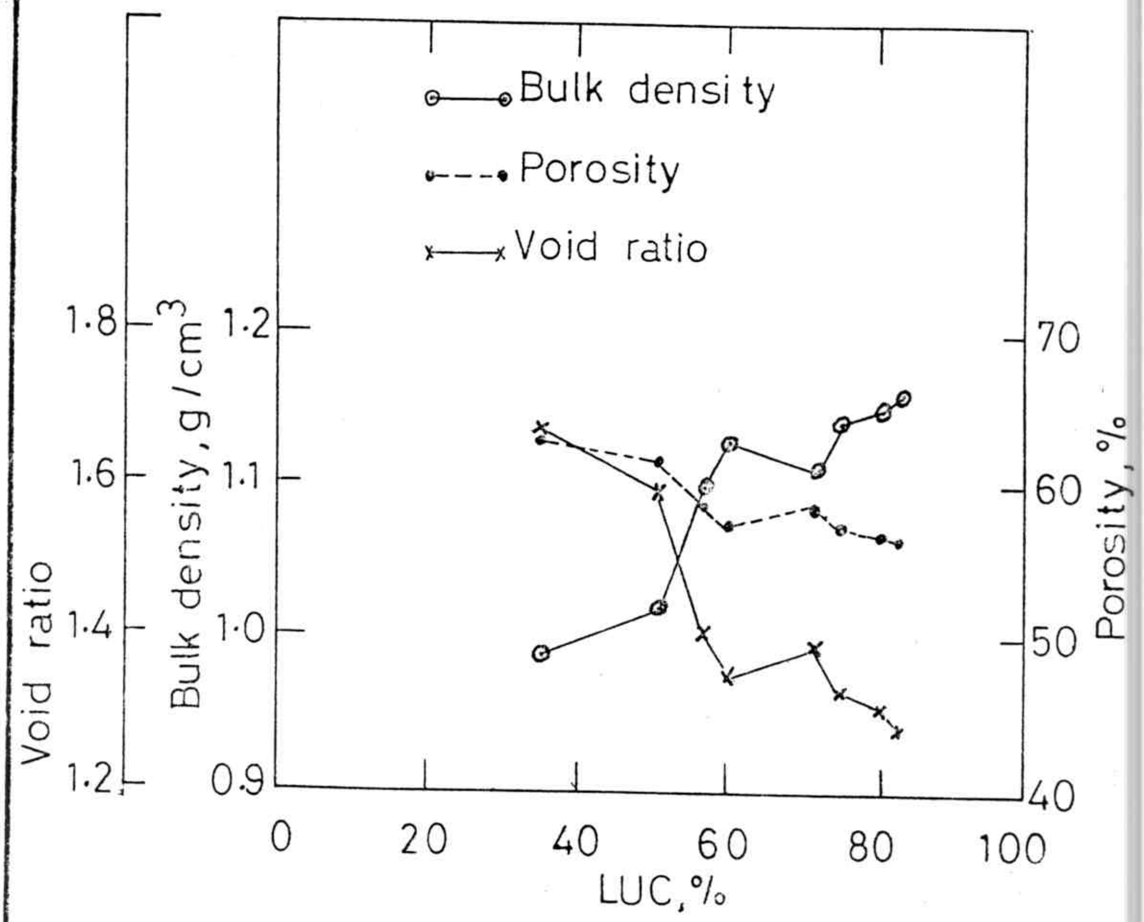

Fig.11: Bulk density, porosity and void ratio as affected by LUC.

This change is expected since void ratio is oppositely related to soil bulk density.

b- Soil granules distribution:

Soil structure can be evaluated by determining the size distribution of granules, that causes the steadiness of structure. These characteristics are changed with changing the surface layer of soil through different seedbed preparation practices.

The study of size distribution of granules was taken as one of the important parameters for evaluating land levelling, since cut and fill actions break-down soil granules.

Data presented in table 6. shows that, large granules (more than 100 mm. diameter) were broken down when LUC value increased from 60 up-to 83%.

Regarding the soil granules size distribution, it can be observed that granules of diameter of over 100 mm. were broken by levelling into sizes mostly smaller than 50 mm. diameter as shown in fig. 12.

Comparing data presented in table 6 indicates that, increasing land levelling (LUC value) increases the percentage of medium granules size (50-20 mm.), and the fine granules size (less than 10 mm.).

The difference in size distribution of soil granules at different levelling uniformity coefficients may be attributed to the differences in design, specifications, forward speeds and times of levelling passes of the used levellers which have different effective loads.

Generally, it can be concluded that, good land levelling (large value of LUC) breaks soil granules and redistributes these granules after reducing their diameters, smoothes land surface, and produces a better soil surface compatible with further mechanized field operations, and surface crust becomes less effective on emergence of seeds and infiltration rate increases. Ibrahim (1974), good structure results in soils. Baver (1965) and Vucic (1968), and the yield of wheat is increased, Braunack and Dexter (1988).

c- Soil compaction:

Soil compaction, increases the resistance of soil to penetration by roots and seedlings emergence. It limits oxygen and carbon dioxide exchange between the root-zone and the atmosphere. It reduces the rate of water infiltration into the soil. It is caused by agricultural equipment traffic on the soil.

Crop production and yield are adversely affected by soil compaction.

Soil compaction is defined as packing together of soil particles resulting in an increase in bulk density and a decrease in void ratio; and consequently worse properties exist.

Table 6: The percentage of soil distribution under different LUC values, %.

LUC %	Diameter range, mm.											
	200	200-150	150-100	100-50	50-20	20-10	10-8	8-6	6-4	4-2	2-1	I
35	12.14	22.46	20.18	15.25	13.89	3.29	2.94	2.41	2.03	1.85	1.96	1.60
51	18.72	21.89	19.32	15.43	6.17	5.43	3.01	1.19	2.63	1.76	2.18	1.91
57	-	-	17.80	20.27	17.62	10.55	5.05	4.15	4.04	2.98	2.48	2.02
60	-	-	13.04	37.62	22.13	6.41	5.17	2.38	5.01	3.02	2.89	2.33
72	-	-	-	19.11	36.92	14.66	5.31	7.03	3.93	4.62	5.87	2.80
75	-	-	-	15.06	34.40	15.81	6.15	7.20	4.55	6.18	6.37	3.71
81	-	-	-	6.72	29.62	8.16	11.23	4.50	13.57	10.42	9.51	6.27
83	-	-	-	4.53	25.77	9.04	13.19	5.78	13.96	12.10	9.13	6.50

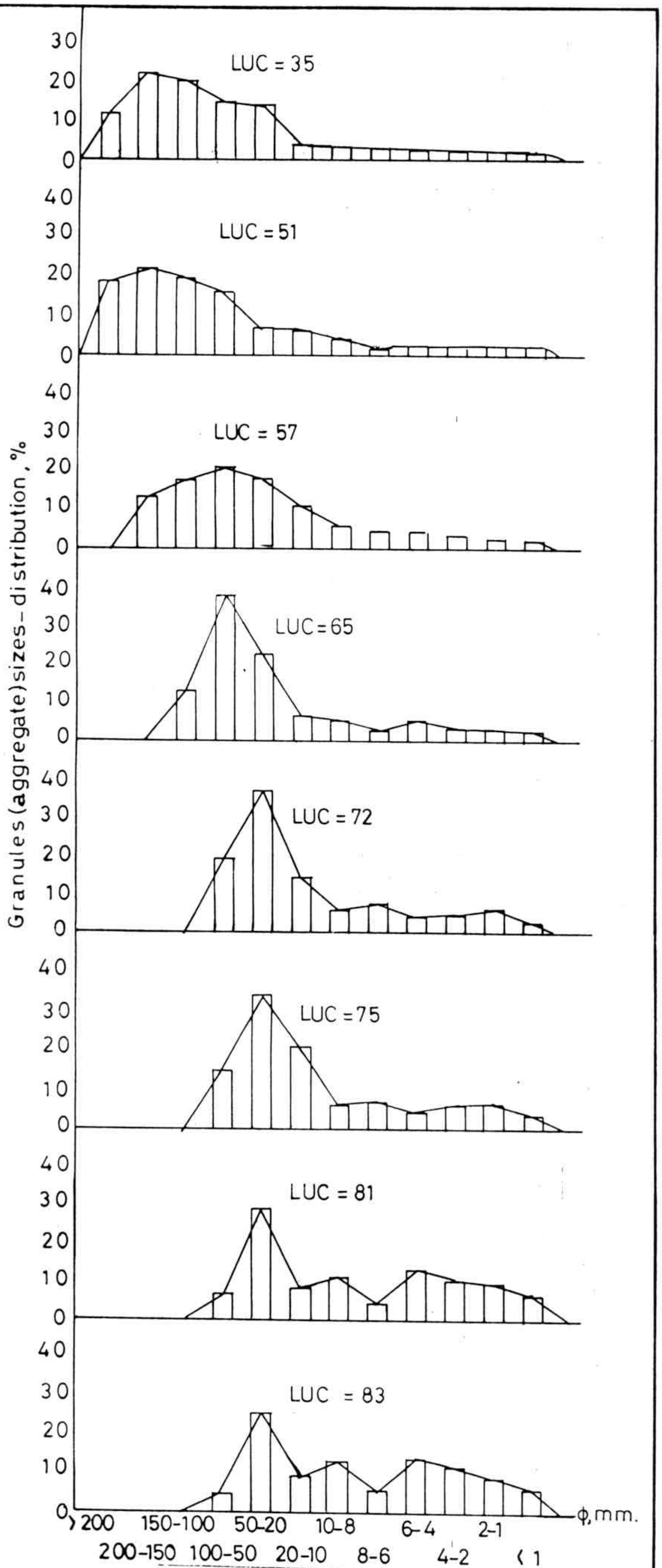

Fig.12: Soil granules distribution under different "LUC" values, (results are taken from all treatments).

Soil compaction was measured by using a pentrometer gauge shown in fig. 4.

The measurement was carried out before and after the levelling treatments in case of multi passes effects (one, two and three passes of land leveller).

Data represented in table 7 shows the effect of land levelling (multi passes effect) on the compaction in KN./ cm^2 (using penetrometer gauge) at soil layer of 20 cm depth. The trend noticed from the table 7 indicates that, the compaction increases as LUC value increases, especially at higher LUC value (83%) which was obtained from the three passes of land levelling. The effect of the successful passes on soil compaction may attributed to the load of the tractor used rather than the levelling action, fig.13.

Therefore, it could be recommended that, land levelling should be carried out with minimum times of passes to minimize soil compaction.

Table 7: Effect of land levelling on the compaction, using penetrometer gauge, at soil layer of 20 cm.depth.

	LUC, %			
	35	57	75	83
Moisture content,	27.22	27.75	26.70	26.85
Compaction, kN/cm.	0.230	0.248	0.255	0.304
L.S.D., 0.05	(0.029)			

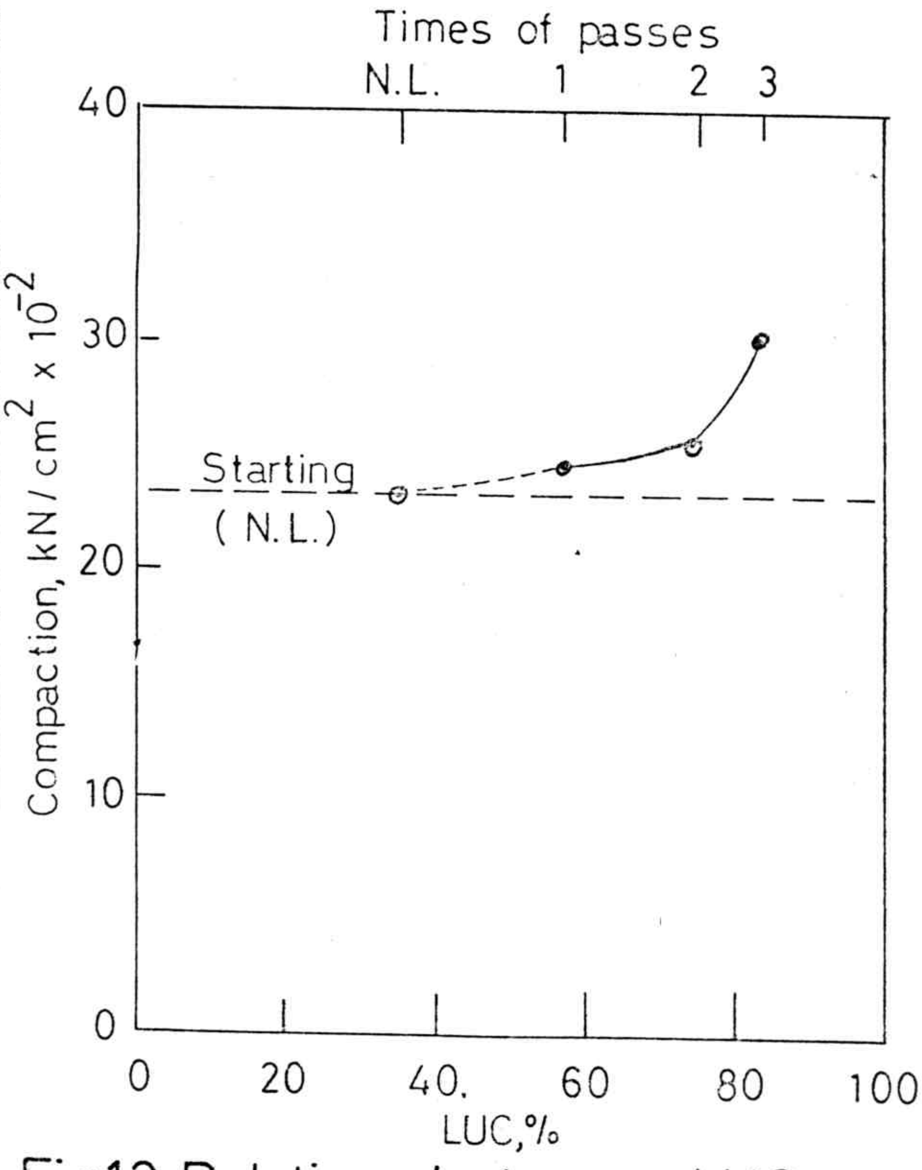

Fig.13: Relation between LUC and soil compaction.

4.3. Land levelling and irrigation-efficiencies:

Land levelling must be accurate for successful surface irrigation specially, the border or basin irrigation.

The principle of surface irrigation is to allow all parts of the field to water nearly equal periods of time, hence, high and low spots must be minimized. In addition to unequal distribution, high spots are subject to excessive erosion and low spots may become salty and dry prematurely.

According to the above more general statements, land levelling becomes very important factor affecting irrigation efficiencies.

Overall irrigation efficiency is known as a combination of various efficiencies expressed by the following relations, according to Israelesen and Hansen (1962):

$$E_{ov.} = \frac{E_a}{100} \times \frac{E_s}{100} \times \frac{E_d}{100}$$

where :

$E_{ov.}$ = Overall-irrigation efficiency , %

$E_{a.}$ = Water-application efficiency , %

$E_{s.}$ = Water-storage efficiency , %

$E_{d.}$ = Water-distribution efficiency , %

Determining the application efficiency and distribution uniformity of irrigation can be helpful in evaluating the irrigation management procedures.

One of the most important procedures for irrigation management is the levelling and preparing soil surface for good water distribution and high application efficiency.

A sketch of the water stored at successive soil layers of root-zone throughout the field length will help to evaluate the adequacy of land levelling operation and the effect of high and low areas on the actual distribution of water through the irrigated area.

Tables 8 and 9 show a detailed evaluation of soil moisture stored at 20, 40, and 60 cm. depths of the root-zone. Also, the distribution pattern and efficiency for the sum of water stored in the 60 cm soil layer along field length are shown in fig. 14 for furrows, and fig. 15 for strips as affected by levelling uniformity coefficient (different land levellings).

It is evident that the best water distribution pattern throughout the field length was obtained in treatments levelled with the high value of LUC.

The distribution efficiency of water stored in 60 cm. soil layer along the furrows length was 91.80% at LUC value of 84.

Values of average water depth stored in the 60 cm. root-zone were higher at low values of LUC with up to 50% (un-levelled land) over other LUC values. This was because

20-30 min. more time was needed for water to reach the end of the un-levelled field.

High distribution uniformity does not necessarily correspond to high application efficiency. The application efficiency must be evaluated based on data of the available root-zone storage which is also affected by the soil surface irregularities and/or spatial variability of soil physical properties.

Therefore, water distribution efficiency (E_d), water storage efficiency (E_s), and water application efficiency (E_a) were evaluated under different levelling conditions with different levelling uniformity coefficients "LUC".

The evaluation data are shown in table 10 and fig.16 for furrow irrigation, and, table 11 and fig.17 for strip irrigation.

For both of furrow and strip irrigations, the efficiencies of distribution (E_d), storage (E_s) and application (E_a), as well as the overall irrigation efficiency (E_{ov}), were higher with greater LUC values.

Correlating data in tables 10 and 11 with the corresponding LUC values may create a direct linear relationships in the form of :

E_i = A + B (LUC) ....

for furrow and strip irrigations, table 12.

Figs. 16 and 17 indicate the relation obtained between irrigation efficiencies: E_d , E_s, E_a, and E_{ov} with the levelling uniformity coefficient (LUC).

The $E_{ov.}$ for furrow and strip irrigations are :

$$E_{ov.}(\text{furrow}) = -270.6387 + 14.6620(LUC) - 0.2335(LUC^2) + 0.00128(LUC^3), \quad (r^2 = 0.919)$$

$$E_{ov.}(\text{strip}) = -139.4859 + 9.0256(LUC) - 0.1508(LUC)^2 + 0.0009(LUC^3), \quad (r^2 = 0.957).$$

From these relations, it could be neglected the last part of two formulas, which was very small and consequently its effect was very small two, thus the relations becomes as follows :

$$E_{ov.}(\text{furrow}) = -270.6387 + 14.6620(LUC) - 0.2335(LUC^2)$$

$$E_{ov.}(\text{strip}) = -139.4859 + 9.0256\ (LUC) - 0.1508(LUC)^2$$

From the above relationships, it can be concluded that, water-distribution, water-application and water-storage efficiencies, as well as the overall efficiency, are highly depended on the levelling uniformity coefficient and increase with it.

Table 8: Water depth stored during furrow irrigation, in cm., and water distribution efficiency (E_d), %.

LUC, %	depth cm	Length, m. 0	20	40	60	80	100	$\bar{X}$, cm water	E_d, %
50	20	2.52	1.91	3.39	2.06	2.23	4.09		
	40	3.34	3.71	4.06	3.92	2.39	5.71		
	60	4.02	3.85	5.62	4.42	4.05	5.99		
	$\sum$	9.88	9.47	13.07	10.40	8.67	15.79	11.21	69.25
60	20	1.32	2.15	2.43	2.36	2.23	1.91		
	40	2.64	3.19	2.89	4.25	2.85	3.04		
	60	3.37	4.78	4.74	5.24	4.40	5.10		
	$\sum$	7.33	10.12	10.06	11.85	9.48	10.05	9.82	80.96
80	20	1.40	1.58	1.97	2.49	2.18	1.64		
	40	2.77	2.57	2.83	3.38	3.29	3.08		
	60	3.55	3.57	3.76	4.12	4.37	3.83		
	$\sum$	7.72	7.71	8.56	9.99	9.84	8.55	8.73	88.14
82	20	1.45	1.66	1.80	1.57	1.35	1.43		
	40	2.54	2.81	2.59	2.72	2.92	3.06		
	60	3.87	3.82	3.65	3.97	4.24	3.77		
	$\sum$	7.86	8.29	8.04	8.26	8.51	8.26	8.20	91.80

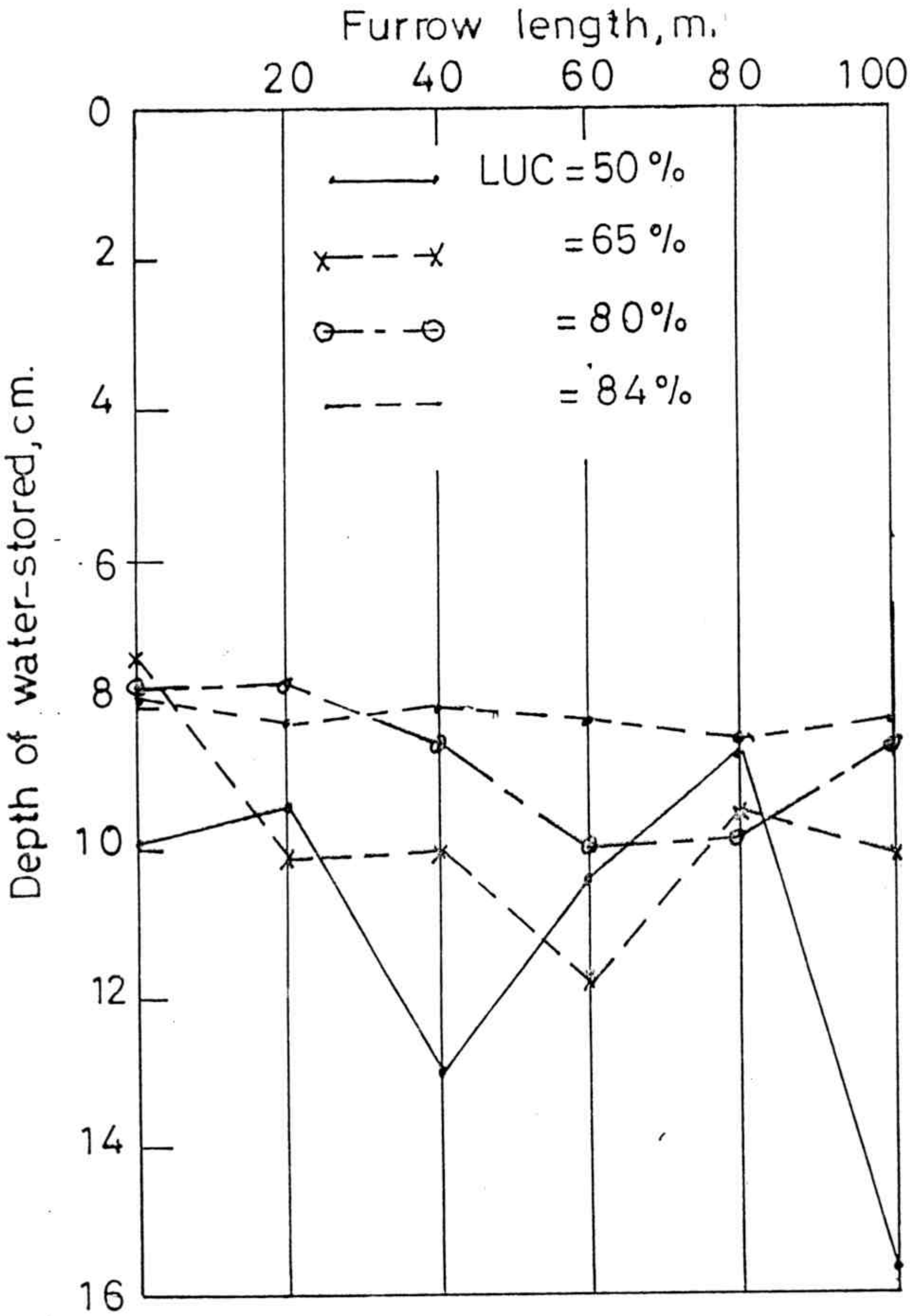

Fig.14: Effect of "LUC" on the sum of water depth stord in the 60cm soil layer during furrow irrigation.

Table 9: Water depth stored during strip irrigation, in cm., and water distribution efficiency (E_d), %.

LUC, %	Depth, cm,	Length, m. 0	20	40	60	80	100	$\overline{X}$ cm water	E_d, %
51	20	2.06	1.56	2.18	2.29	1.99	2.44		
	40	2.74	2.52	2.88	2.21	2.74	3.04		
	60	3.63	3.09	2.66	3.21	2.46	2.74		
	$\sum$	8.43	7.17	7.72	7.71	7.19	8.22	7.74	73.98
57	20	1.41	3.46	1.45	2.12	2.02	2.40		
	40	2.82	3.02	3.51	1.86	2.77	2.70		
	60	2.20	3.15	3.30	2.36	2.15	3.81		
	$\sum$	6.43	9.63	8.26	6.34	6.94	8.91	7.75	79.93
72	20	2.51	2.10	2.76	2.10	1.14	2.27		
	40	3.90	2.74	2.81	2.94	2.53	2.32		
	60	3.95	2.55	3.64	3.99	3.21	3.03		
	$\sum$	10.36	7.39	9.21	9.03	6.88	7.62	8.42	86.72
75	20	2.31	2.39	2.16	2.35	2.48	2.27		
	40	2.85	2.91	2.88	3.08	2.88	2.99		
	60	3.04	3.10	3.10	3.24	3.23	3.09		
	$\sum$	8.20	8.40	8.14	8.67	8.59	8.35	8.39	88.32
81	20	1.79	1.75	1.95	1.92	1.90	1.54		
	40	2.39	2.48	2.77	3.07	3.03	2.92		
	60	3.23	3.61	3.53	3.71	3.69	3.85		
	$\sum$	7.41	7.84	8.25	8.70	8.62	8.30	8.19	93.22
83	20	2.52	2.54	2.50	2.45	2.51	2.57		
	40	2.88	2.90	2.91	2.94	2.90	2.98		
	60	3.34	3.28	3.21	3.23	3.22	3.29		
	$\sum$	8.76	8.72	8.62	8.64	8.64	8.84	8.70	94.94

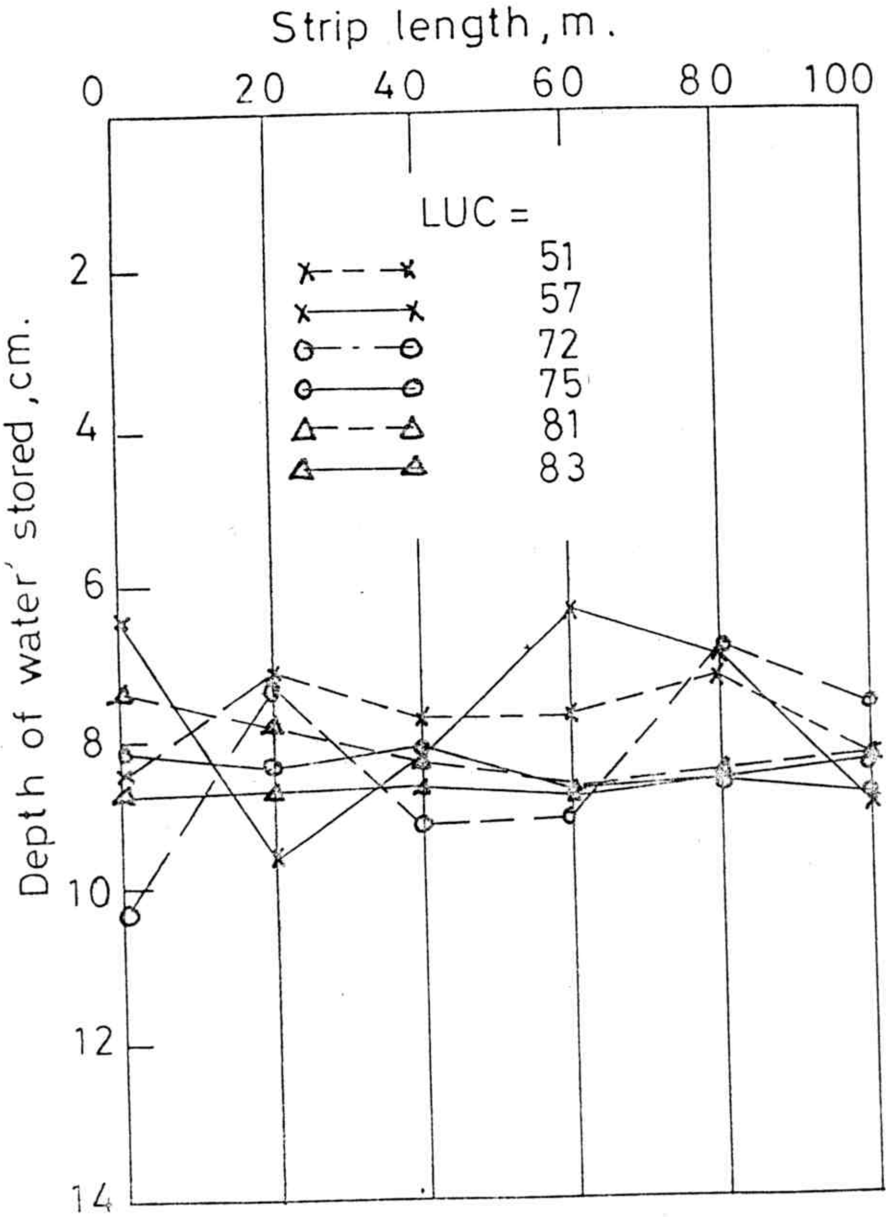

Fig.15: Effect of LUC on the sum of water depth stored in the 60 cm soil layer during strip irrigation.

Table 10: Effect of land levelling "LUC" on the furrow irrigation efficiencies, %.

Irrigation efficiencies, %	LUC, %				L.s.d. 0.05
	50	60	80	82	
E_d	69.25	80.96	88.14	91.80	(5.082)
E_s	76.64	76.67	82.43	85.83	(1.234)
E_a	72.88	77.27	89.60	91.30	(2.814)
$E_{ov.}$	38.68	47.86	65.13	71.94	

$$E_{ov.} = -270.6387 + 14.6620(LUC) - 0.2335(LUC)^2 + 0.00128(LUC)^3$$

Table 11: Effect of land levelling "LUC" on the strip irrigation efficiencies, %.

LUC	Irrigation efficiencies, %			
	E_d	E_s	E_a	E_{ov}
51	73.98	77.65	69.20	39.75
57	79.93	81.38	78.23	50.89
72	86.72	84.44	81.27	59.51
75	88.32	86.20	88.09	67.07
81	93.23	88.30	90.91	74.84
83	94.94	95.23	91.76	82.96

$$E_{ov.} = -139.459 + 9.0256(LUC) - 0.1508(LUC)^2 + 0.0009(LUC)^3$$

Table 12: The constant values of the regression linear equations for furrow and strip efficiencies.

Efficiencies, %	Furrow irrigation			Strip irrigation		
	A	B	r^2	A	B	r^2
E_d	38.99	0.64	0.988	47.20	0.56	0.969
E_s	61.99	0.26	0.894	54.91	0.44	0.934
E_a	42.79	0.58	0.957	39.36	0.63	0.968

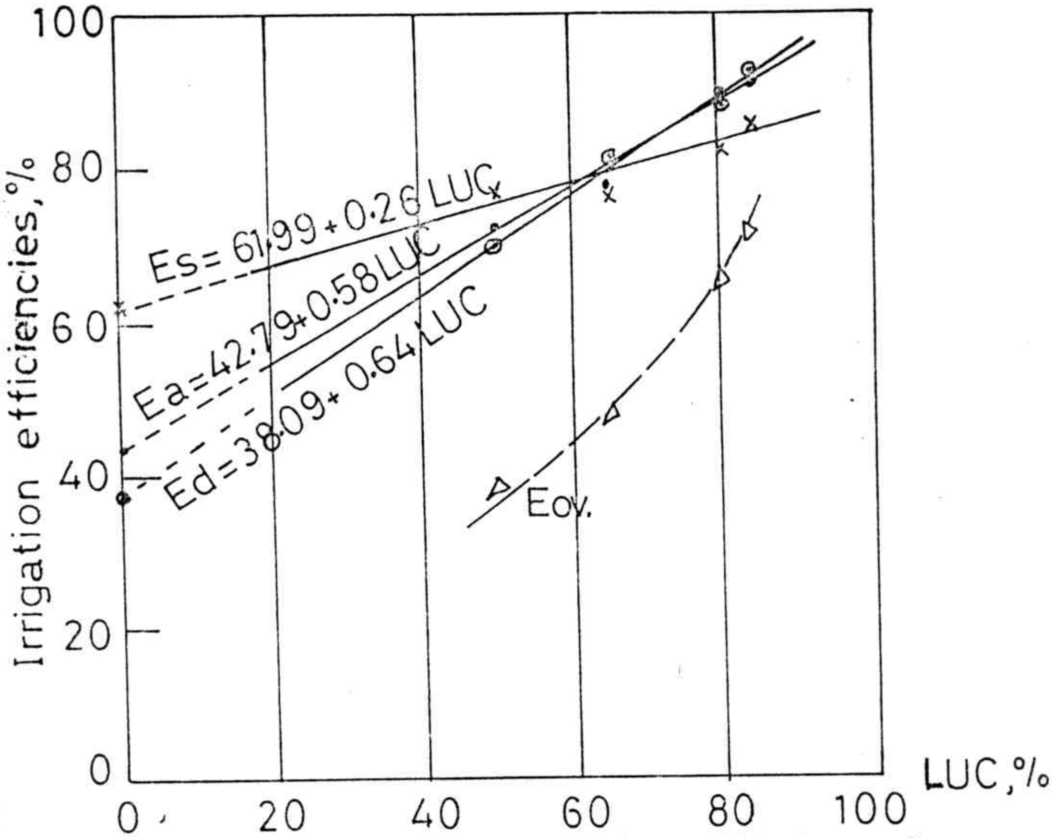

Fig.16: Furrow irrigation-efficiencies as affected by LUC values.

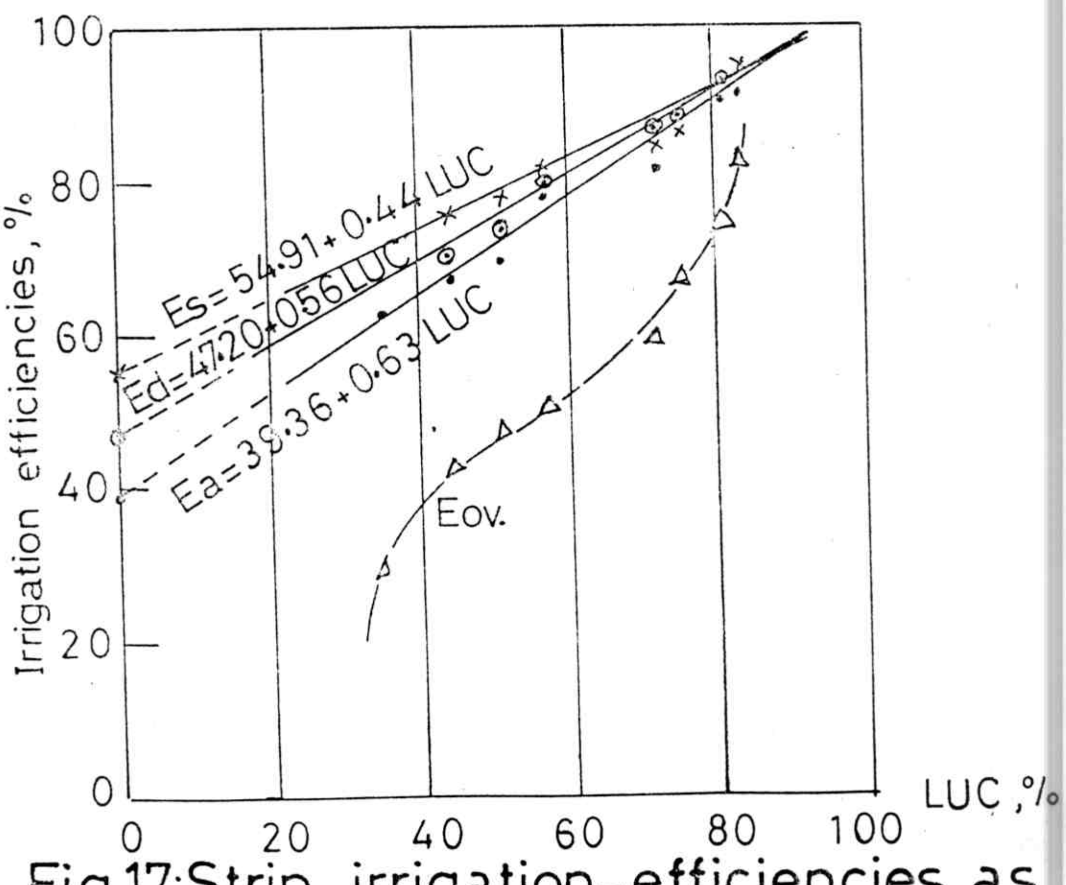

Fig.17: Strip irrigation-efficiencies as affected by LUC values.

4.4. Land levelling and seeding-machine performance:

Different time components of planting operation may help in analysis both the total losses in time (T_{pa}) and the actual working time (T_A, which is useful time), the consumed time per feddan, total field efficiency (coefficient of useful time, cut), and consequently field capacity (F.C.), which indicates how well adapted a specific field is for machinery use.

These concepts were experimentally measured and calculated in modified formulas according to Mckibben and Dressel (1943), under land levelling treatments, LUC (levelling uniformity coefficient).

Tables 13 and 14 show the effect of land levelling in a form of LUC, on the performance of seeder and planter machines.

Tables clarify that, the total losses time (T_{pA}) decreases by increasing LUC, and then, total time (T_t) decreases with increasing the LUC. This result is due to the effect of levelling on the smooth and level surface of the land which increases the speed of machine operation, and consequently, the coefficient of useful time, and field capacity.

As a result of land levelling, increases of the C.u.t. and F.C. were 13.55 % and 11.2% for seeder machine, and

9.76% and 8% for planter machine at the same circumstances.

The relations obtained between levelling uniformity coefficient with coefficient of useful time "Cut", and field capacity "F.C." were linear as shown in figs. 18 and 19.

The effects of land levelling on planting machines seed-depth and germination capacity were studied.

As a result of the effect of land levelling on soil physical properties and uniformity distribution of irrigation with constant seed depth, more germination of seeds and yields were observed.

From the tables 13 and 14 indicate that by increasing LUC from 35 to 83 (for seeder), the germination capacity increased 13.48%, and, 18.62% for planter machine.

The relation between LUC and germination capacity (G.C.) is resulting as shown in fig. 20, which was a linear regression equations as follows :

$$G.C. = 68.9255 + 0.2667(LUC) \qquad (r^2 = 0.8846)$$

Table 13: Effect of land levelling (LUC) on the seeder machine performance.

Performance	LUC, %							
	35	46	51	57	72	75	81	83
T_{PA} (min./fed.)	20.2	19.76	18.97	18.52	17.09	16.48	15.63	15.40
T_A (" ")	27.8	27.48	27.91	27.99	27.68	27.96	27.84	27.78
T_t (" ")	48.0	47.24	46.88	46.51	44.78	44.44	43.48	43.17
Speed (Km./h.)	3.21	3.26	3.41	3.74	4.68	4.81	4.85	4.85
C.u.t., %	56.67	58.16	59.54	60.18	61.83	61.92	64.04	64.35
F.C.,(fed/h.)	1.25	1.27	1.28	1.29	1.34	1.35	1.38	1.39
Germination capacity, %	79.4	80.8	82.8	83.6	85.7	86.9	89.1	90.1

Table 14: Effect of land levelling (LUC) on the planter machine performance.

Performance	LUC, %			
	50	60	80	82
T_{PA} (min./fed.)	20.0	18.8	16.88	16.8
T_A (min./fed.)	29.0	28.1	27.90	27.8
T_t (min./fed.)	49.0	46.9	44.78	44.6
Speed (km/h.)	3.21	3.92	4.51	4.65
C.u.t, %	58.09	59.91	62.30	63.76
F.C., (fed/h.)	1.25	1.28	1.34	1.35
Germination capacity, %	78.4	80.4	92.0	93.0

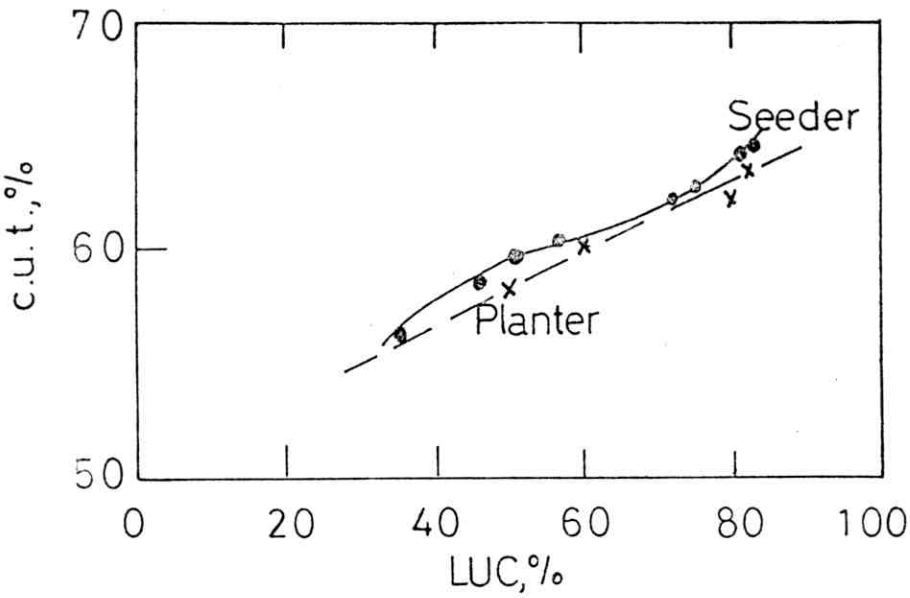

Fig.18:Relation between LUC and coefficient of useful time for planting machines.

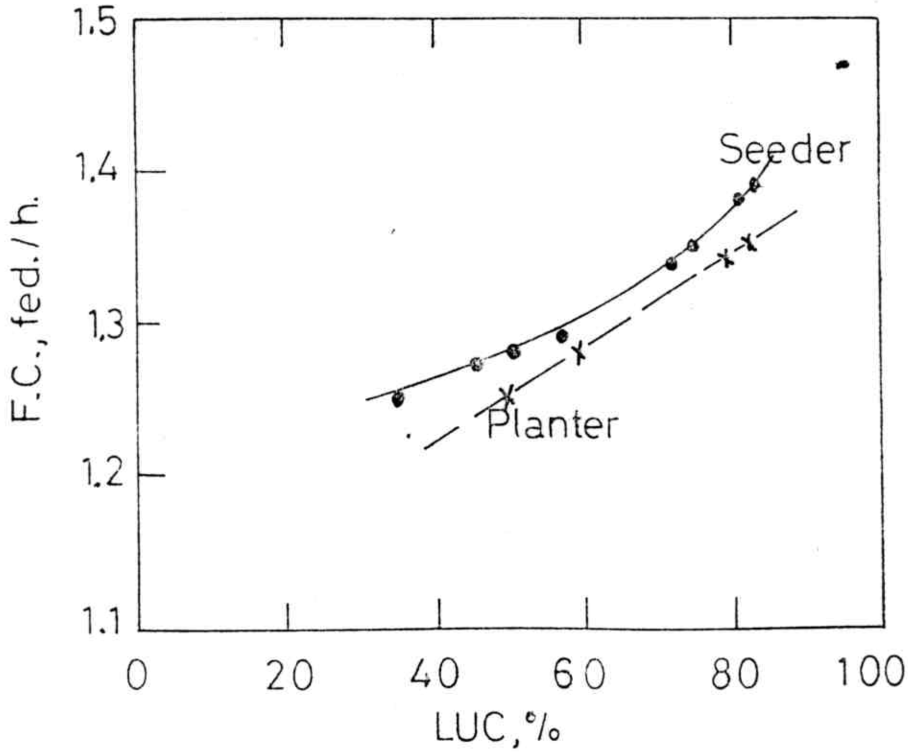

Fig.19:Relation between LUC and field capacity.

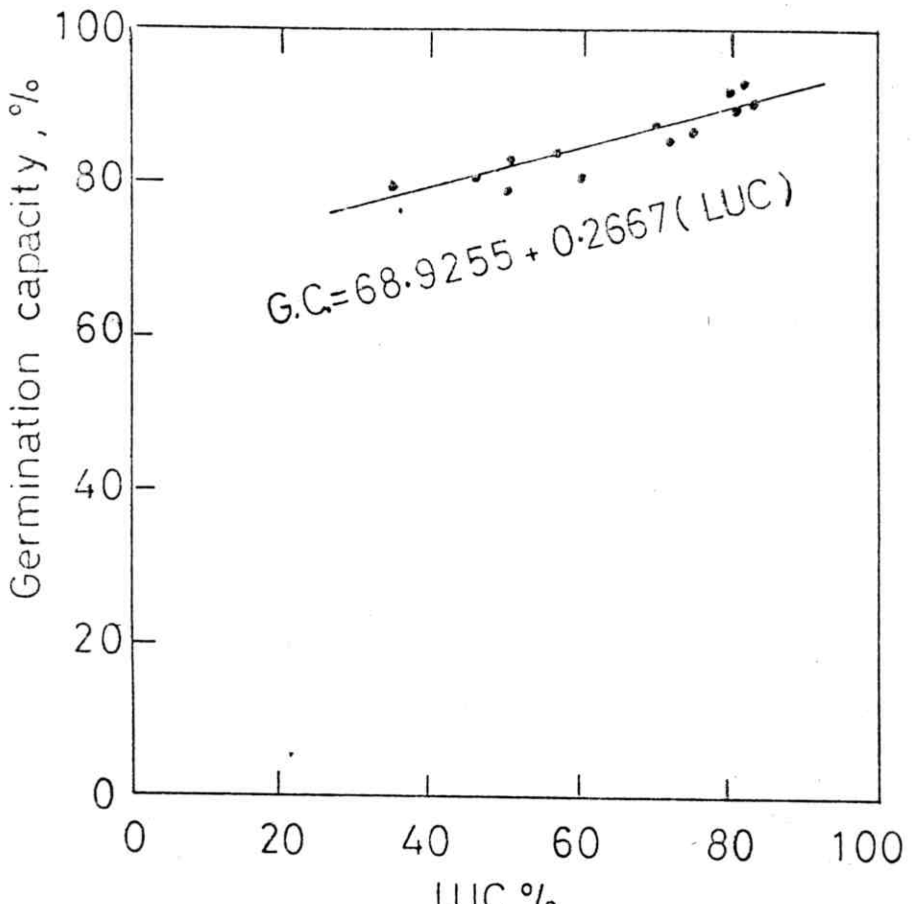

Fig.20:Relation between LUC and germination capacity.

4.6. Land levelling and harvesting machine performance:

The performance of harvesting machine includes the coefficient of useful time, and field capacity as affected by land levelling.

Performance is represented in table 15 for harvesting berseem and wheat, and in table 16 for maize and sorghum crops.

It is noticed from the tables that, by increasing LUC, the total parasitic time (T_{PA}) decreases from 25.25 min./fed. to 15.49 min./fed., i.e., reducing the total parasitic time by 63.01%, table 15, and this reduction equales to 100%, from table 16.

The changeable on the total parasitic time (T_{PA}) causes by: time spent in turning at the end of the field, short period rest time for workers during operation, time spent in interruptions and simple field repair and adjustments of the mowers but in little change. Also, this changeable was due to, by a great degree, the time consumed in re-executing the misorded works depending on the effect of land levelling on the level and smooth the soil surface with reduce the roughness.

This result reflects that, the total time consumed per fed., and consequently the coefficient of useful time and field capacity, with increasing forward speed of machine due to effects of levelling on smoothing the surface of the soil.

As a result of land levelling the increasing of the C.u.t. and F.C. were: 10.00 and 26.98, resp. (for harvesting berseem and wheat), and, 23.26 and 28.85% (for harvesting maize and sorghum).

The relation between levelling uniformity coefficient "LUC" and coefficient of useful time (C.u.t.) and field capacity (F.C.) were linear as shown in figs.21 and 22.

The effect of land levelling on the technical performance of harvesting is investigated as efficiency of mechanical harvesting (η_h), which can be estimated as a function of both the stand yield and the harvested yield. The difference between these two values indicates the lost amount of crops.

The efficiency of mechanical harvesting η_H was calculated and represented in tables 15 and 16.

The effect of land levelling on harvesting efficiency has linear relation as shown in fig. 23.

Land levelling resulted in high harvesting efficiency, as it increased by 17.22 and 14.82%, due to reduction of shattering on loss.

This means that levelling of the land increases the yield by about 32.44% as a result of increasing efficiency only.

In general, the effect of land levelling, in a form of LUC, on the harvesting efficiency (η_H) and losses has the relationships as follows :

$$\eta_H = 70.8321 + 0.2639(LUC) \qquad (r^2 = 0.9522)$$

$$Losses = 29.1679 - 0.2639(LUC) \qquad (r^2 = 0.9522)$$

Table 15: Effect of land levelling (LUC) on the harvesting machine performance (berseem & wheat).

	LUC, %					
	35	46	57	75	81	83
T_{PA} (min/fed.)	25.25	21.08	17.78	16.67	16.8	15.49
T_A (min/fed.)	69.70	60.66	61.76	61.86	60.10	60.78
T_t (min/fed.)	94.95	81.84	79.57	78.53	76.90	75.27
Speed (km/h.)	2.75	3.99	4.02	4.37	4.51	4.57
C.u.t., %	73.41	74.12	77.61	78.77	78.95	80.75
F.C.(fed./h.)	0.63	0.73	0.75	0.77	0.78	0.80
η_H, %	80.08	82.50	87.10	89.09	93.12	93.87
Losses, %	19.92	17.50	12.90	10.91	6.88	6.13

Table 16: Effect of land levelling (LUC) on the harvesting machine performance (maize & sorghum).

	LUC, %					
	50	60	72	75	80	83
T_{PA} (min./fed.)	23.00	20.30	14.10	12.90	11.90	11.50
T_A (min./fed.)	35.00	34.00	35.40	34.40	34.00	33.40
T_t (min./fed.)	58.00	54.30	49.50	47.30	45.90	44.90
Speed (km/h)	3.51	3.95	4.31	4.43	4.52	4.53
C.u.t, %	60.35	62.96	71.52	72.73	74.07	74.39
F.C.(fed./h)	1.04	1.12	1.21	1.27	1.31	1.34
η_H, %	81.22	87.12	88.60	89.14	91.41	93.25
Losses, %	18.78	12.88	11.40	10.86	8.59	6.75

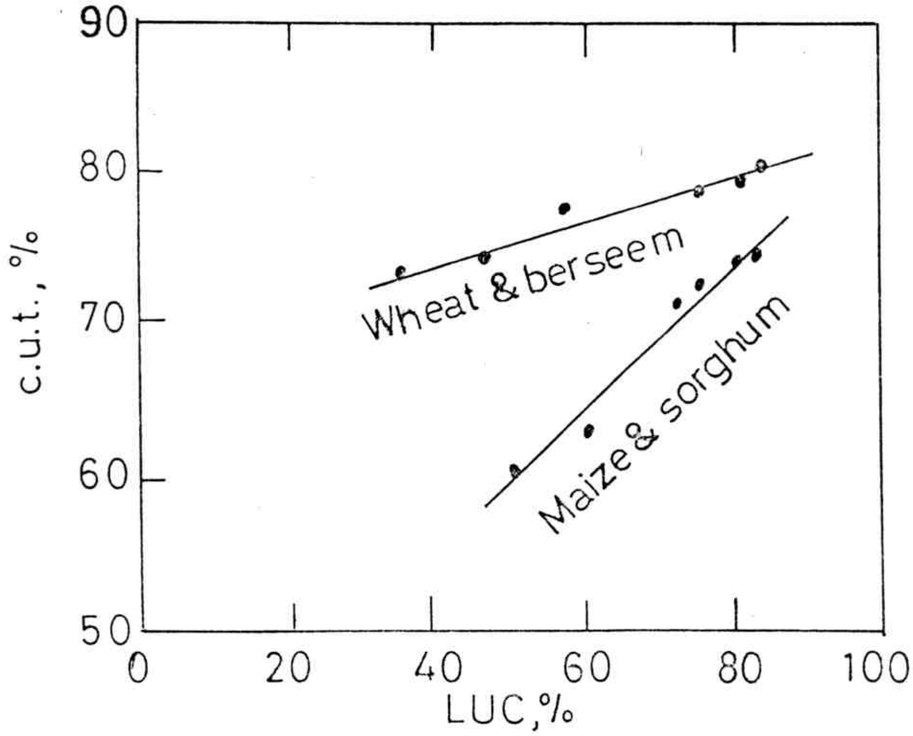

Fig.21:Relation between LUC and coefficient of useful time for harvesting machine.

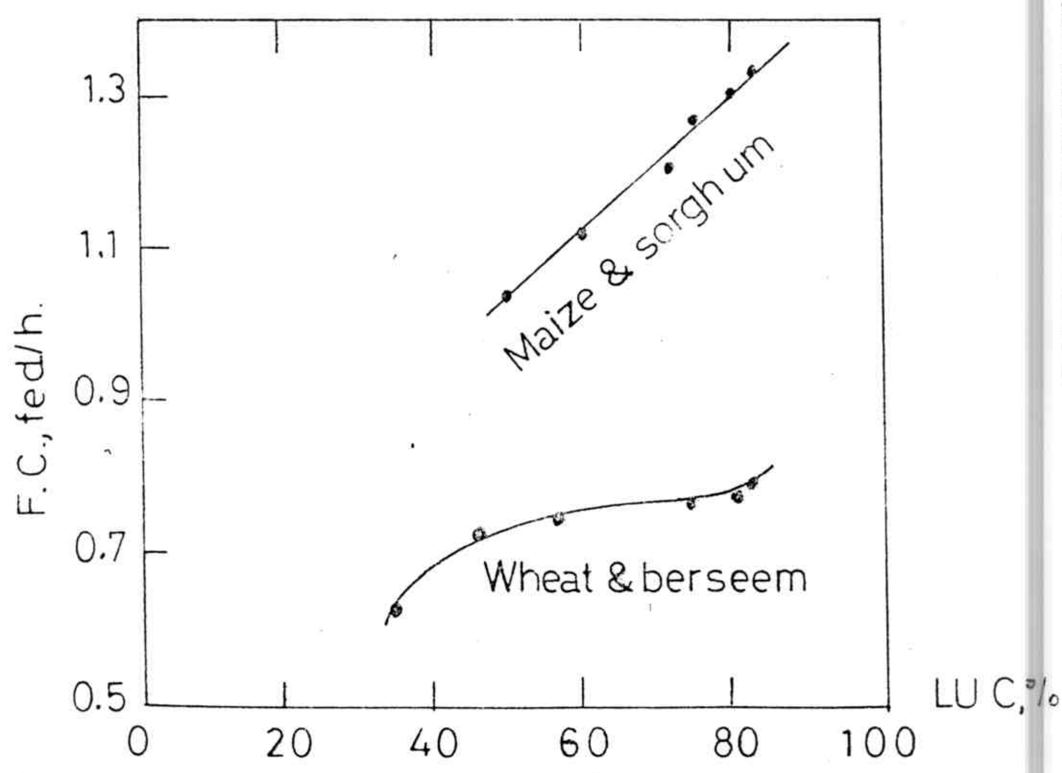

Fig.22:Relation between LUC and field capacity.

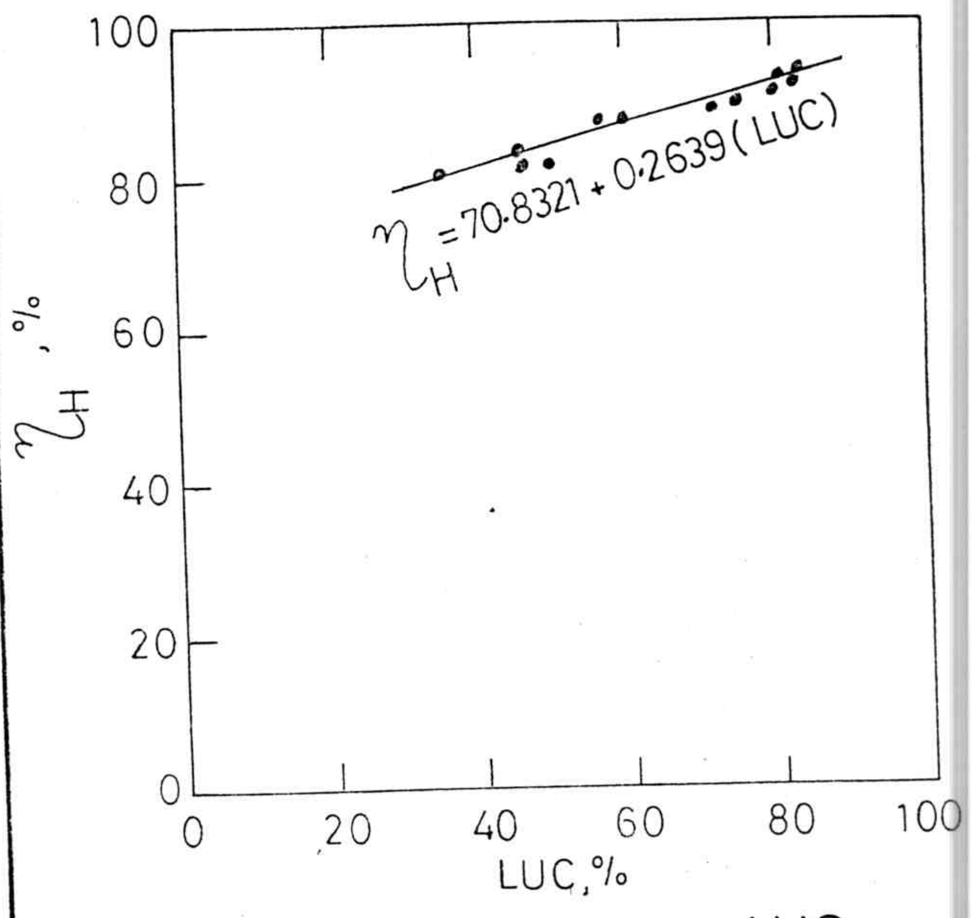

Fig.23: Relation between LUC and harvesting efficiency.

PART "2"

Effect of land levelling on crop yields :

Seed-bedpreparation by levelling, may be improve soil physical properties, soil surface uniformity and smoothening the land, water distribution and storage efficiencies; and consequently, permit maximum germination of seeds and, this in turn resulted in increasing the yield.

This study was designed to investigate the effect of levelling forward speeds in a form of LUC on the crop potentiality of forage sorghum yield, and the effect of the number of levelling passes on the productivity of wheat crop.

a- Forage sorghum yield :

1. Fresh and dry weights per plant:

Data in table 17 show that, any of levelling forward speed treatments (LS_1, LS_2 and LS_3) produced significantly higher fresh and dry weights of forage sorghum yield per plant, than the non-levelling treatment (LUC = 51). These results were obtained for the three subsequent cuts.

It is also clear that, the levelling speed of 4 km/h. forward speed (LUC=83) significantly produced higher fresh and dry forage sorghum yields per plant that the other forward speeds of levelling.

Similar results were true for the three subsequent cuts.

These results were obtained due to the good distribution of water on the land surface which resulted from the good levelling and plants can be mature more uniformity, Sewell (1970).

Meanwhile, the lowest forage sorghum fresh and dry yields per plant were obtained when the land was not levelling (LUC= 51) as comparison with the other treatments with significant difference for the first, second and third cuts. Similar results were true either after 30 days from seeding (or cutting) or at harvesting.

In conclusion, treatments that produced forage sorghum yield per plant could be arranged as follow in assending order :

$$\text{N.L.} < LS_3 < LS_1 < LS_2.$$

2. Fresh and dry weight of roots per plant:

The results in table 18 show the effect of levelling forward speed treatments (LS_1, LS_2 and LS_3) on the fresh and dry weight of roots/plant of forage sorghum, either 30 days from seeding (or cutting) or at harvesting.

In general, any of the levelling speeds, produced significantly lower fresh and dry weight of roots per plant than non-levelling treatment.

Similar results were obtained either after 30 days from seeding (or cutting) or at harvesting for the different cuts.

Table 17: Effect of levelling forward speeds "LUC" on fresh and dry weights of sorghum forage yield per plant, in 1986 season.

LUC values	Fresh weight, g./plant			Dry weight,g./plant		
	Cutting number					
	1st	2nd	3rd	1st	2nd	3rd
	After 30 days from seeding or cutting					
51	11.77	19.69	16.79	2.52	6.64	6.15
72	13.62	22.39	18.46	2.68	7.33	6.61
75	14.75	25.84	24.66	3.14	8.39	8.29
83	17.13	28.17	27.55	3.46	9.29	9.96
L.s.d.,0.05	1.65	0.79	1.20	0.03	0.94	0.72
	At harvesting					
51	51.41	53.94	54.63	13.22	17.46	15.88
72	60.69	56.13	57.31	15.43	18.92	16.95
75	79.63	59.66	57.71	26.13	20.79	19.22
83	96.13	71.21	61.24	32.72	23.39	20.78
L.s.d., 0.05	3.76	3.62	4.19	6.89	1.19	0.56

Table 18: Effect of levelling forward speeds "LUC" on fresh and dry weight of sorghum forage roots per plant.

LUC values	Fresh weight, g./plant			Dry weight, g./plant		
	Cutting number					
	1st	2nd	3rd	1st	2nd	3rd
	After 30 days from seeding or cutting					
51	3.22	2.71	2.84	1.45	1.24	1.37
72	2.12	2.34	2.12	0.89	0.99	1.16
75	2.80	1.53	2.35	1.10	0.74	1.02
83	1.61	1.81	1.97	0.72	0.57	0.79
L.s.d., 0.05	0.42	0.22	0.15	0.18	0.09	0.05
	At harvesting					
51	21.27	8.16	6.63	14.50	3.45	3.15
72	19.13	6.28	6.20	11.72	3.04	2.86
75	13.84	7.27	5.24	7.96	2.34	2.38
83	12.52	5.78	5.02	7.54	2.51	1.84
L.s.d., 0.05	1.88	0.96	0.12	1.35	0.32	0.23

These results may be, due to the effect of levelling on the increases in the soil bulk density, which resulted in decreasing seedling root growth, Phillips and Kirkam (1962), as well as the uniformity of irrigation water.

It was observed that, the un-levelled land lead to elongate the roots to searching about its needs of ground water requisite for growth and spreading.

3. The number of plants per sq.m.:

Levelling speed treatments (LS_1, LS_2 and LS_3), significantly increased the number of plants/sq.m. when compared with non-levelled treatment (N.L.), table 19.

It is clear that, levelling with 4 km/h. forward speed (LUC value of 83) had the superior effect in the number of plants per sq.m. than the other levelling speed treatments (LS_1 and LS_3), for the three subsequent cuts.

4. The plant height:

The plant height which was recorded after 30 days from seeding and at harvesting response to various levelling forward speed treatments.

Results in table 19 showed that, the plant height of sorghum forage was significantly affected by levelling speed treatments (LS_1, LS_2 and LS_3). Any of the applied levelling forward speeds significantly increased the plants than the non-levelled land (LUC value = 51).

Table 19: Effect of levelling forward speeds "LUC" on the number and plant height of forage sorghum in 1986 season.

LUC* values	No.of plants/m^2 after				Plant height, cm.					
	30 days from seeding or cutting				After 30 days from seeding or cutting			At harvesting		
	cutting number				cutting number					
	1st	2nd	3rd	mean	1st	2nd	3rd	1st	2nd	3rd
51	138	100	85	107.67	58	70	77	183	154	144
72	145	101	86	110.67	64	77	79	199	159	150
75	173	107	93	124.33	73	87	86	202	165	154
83	182	115	101	132.67	77	89	92	208	171	158
L.s.d. 0.05	3.98	4.42	3.33	3.91	0.89	1.03	9.11	4.39	2.76	3.04

* LUC values are resulted from the following treatments :

51 = non levelled land (N.L.)

72 = levelling with 5km./h. forward speed, (LS_1).

75 = Levelling with 3 km./h. forward speed, (LS_3).

83 = Levelling with 4 km./h. forward speed, (LS_2).

These values are shown and definate in chapter IV, part I, table 3.

Meanwhile, the medium levelling speed (4km/h.; LS_2), which have the LUC value of 83, gave the tallest plants, among the other treatments.

The results mentioned above were significantly different for the three cutting, either after 30 days from seeding or at harvesting.

The increases in number of plants per sq.m. and plant height, were due to levelling speed treatments, resulted from a good levelling and improving soil physical properties, and improving water irrigation which attributed to the exact amount of water necessary for plant growth, evently distributed uniformity to all parts of the fields, and this in turn, resulted in increasing high germination, improving plant environment even growth, and ultimately, good and health plant production, Leonard and Dedrick (1979), Kruse (1981) and, Clyma and Reddy (1984).

5. Dry-matter percentage:

The effect of different levelling forward speeds (LS_1, LS_2 and LS_3), which have LUC values of, 72, 83 and 75 resp., on the dry matter percentage of sorghum forage was almost similar for the first and the third cuts.

The (LS_1, LS_2 and LS_3) treatments caused significantly increase in the dry matter percentage of sorghum as compared with the control (non levelled which have LUC value of 51), table 20.

However, in the second cut, there was no significant differences in the dry matter percentage of sorghum, wheather with un levelled land or any of the applied treatments, Thomas and Cassel (1979).

6. Fresh and dry yields/fed.:

The fresh and dry weights of sorghum forage yield behaved similarly for the obtained three cuts with the applied levelling forward speed treatments (difference LUC values), table 21.

The non levelled land treatment (LUC = 51) produced the lowest fresh and dry sorghum yields compared to the other levelling treatments. These results were clear in the three subsequent cuts.

It should be also pointed out that, the highest value of LUC (83) which resulted from the medium forward speed of levelling, namely LS_2 (4km/h.), produced highest values of fresh and dry sorghum yields when compared with the other forward speed treatments (3 and 5 km/h.).

However, levelling forward speed of 3 km/h. (LUC= 75) produced higher fresh and dry sorghum forage yields than levelling treatment at 5 km/h. forward speed, namely LS_3 (LUC = 72). The same trend was obtained in all three cuts.

In conclusion, levelling at 4 km/h. forward speed (which have LUC value of 83) resulted in increasing the total forage sorghum yields by about 44.82% and 78.66% for both fresh and dry weights, respectively , when compared with the control (LUC = 51).

This increase in forage yield is due to the levelling forward speed which resulted in a good surface of the land, and this in turn gave a good germination of seeds, Borden (1953), Kruse (1981) and Musande et al.(1987).

A good surface of the land levelling also, gave distribution water, and soil moisture is more uniform with more suitable stored moisture, Lyles (1967).

The relation between LUC value with the total fresh and dry yields per fed. has a linear regressions as follows :

Y_t (fresh) = 8.583 + 0.307 (LUC); (r^2 = 0.879)

Y_t (dry) = -1.007 + 0.149(LUC) ; (r^2 = 0.859)

These relations means that, by increasing LUC, the total fresh and dry yields pér fed. were increased consequently.

b- Wheat crop :

The results of levelling number of passes, in a form of LUC, on the yield components of wheat plants at harvesting in season 1988, are presented in table 22.

Table 20: Effect of levelling forward speeds "LUC" on the dry matter percentage of sorghum forage yield, in season 1986.

Cutting number	Dry matter, %				L.s.d., 0.05
	LUC, %				
	51	72	75	83	
1st.	25.74	25.42	32.80	33.96	6.91
2nd.	32.39	33.73	33.80	33.93	n.s.
3rd.	26.88	28.03	32.77	33.94	2.60
Mean	28.34	29.06	33.12	33.94	2.51

Table 21: Effect of levelling forward speeds, in a form of LUC, on the fresh and dry weight of forage sorghum yield per feddan.

LUC values, %	Yield, Ton/fed							
	Fresh weight				Dry weight			
	Cutting number				Cutting number			
	1st	2nd	3rd	Total	1st	2nd	3rd	Total
51	11.176	7.300	5.330	23.805	2.877	2.365	I.437	6.696
72	13.230	8.511	7.540	29.281	3.363	2.871	2.116	8.364
75	15.593	9.642	8.450	33.685	5.115	3.259	2.773	11.142
83	15.970	9.883	8.620	34.473	5.423	3.693	2.925	11.963
L.s.d. 0.05	1.195	0.644	0.574	1.270	1.091	0.251	0.335	1.195

$Y_T(\text{fresh}) = 8.583 + 0.307(\text{LUC})$; Ton/fed. ; ($r^2 = 0.8780$)

$Y_T(\text{dry}) = -1.007 + 0.149(\text{LUC})$, Ton/fed., ($r^2 = 0.8519$)

1. Plant height and stem length :

The height of plants and stem length were increased as the LUC value increased.

The yield components under study were not significantly affected when compared one pass (LUC= 57) with non levelling, one pass and two passes of levelling (LUC= 75), and two passes with three passes (LUC= 83) of levelling.

However, either of the two passes or the three passes of levelling produced taller plants with longer stems than the non levelled land.

The good land levelling (resulted from three passes of levelling) was responsible for produced health and taller plants, similar results were obtained by Johnson et al. (1977).

2. Number of tillers, sq.m.:

The number of tillers per sq.m. was not significantly affected due to levelling number of passes treatments.

3. Number of spikes/sq.m.:

The number of spikes per sq.m., did not significantly increase due to passes number of levelling.

These results (number of tillers and spikes per sq.m.) were obtained probably from the wheat plants irrigated by enough water in the first irrigation.

4. Number of spikletes/spike and spike length:

The number of spikletes/spike and spike length were significantly affected by the applied levelling treatments having similar trend.

Meanwhile, levelling by three passes produced higher number of spikletes per spike and spike length than those obtained from the two passes of levelling. Also, these characteristics under study were significantly higher in magnitudes than the non levelled land or single pass of levelling.

It is also clear that, the spike length increased due to the increase in the number of spikletes per spike.

Also it is noticed from the table 22 that, the hight average of spike length was obtained from LUC = 83, when compared with the other treatments, the number of spikletes per spike gave the same trend of the spike length.

In conclusion, three passes of levelling resulting in a good land levelling which is more effective in producing the higher number of spikletes per spike or spike length of wheat plants.

The good land levelling resulted in attributing the exact amount of water necessary for plant growth evently distributed uniformity to all parts of the field, Leonard and Dedrick (1979), Kruse (1981), and Clyma and Reddy (1984).

5. Spike weight:

The spike weight increased significantly by increasing the LUC value (increased the number of levelling passes) when compared with the control (N.L.).

There was also, a continuous increasing in spike weight of wheat as the levelling uniformity coefficient LUC increased with a significant difference between the single and two passes of levelling only.

This result was obtained due to the effect of good land levelling on the uniformity of the soil moisture and storage water similar findings were reported by Mcclung et al.(1985), and to changing the fertilizers into suitable and efficient form, with improving water management, Johnson et al.(1977).

6. Number of seeds and seeddweight/spike:

The number of seeds and weight of seeds per spike of wheat responded similar to the applied land levelling treatments.

Single, two or three passes of land levelling significantly produced the higher number and weight of seeds/spike when compared with the control (LUC = 35).

There were also, a continuous significant increase in number and weight of seeds/spike as the levelling uniformity coefficient increased (the number of levelling passes increased).

In other words, the more passes of levelled land, the more number and weight of seeds/spike were obtained.

This result is due to the effect of land levelling on the soil properties, El-Said et al.(1988), and consequently improving water irrigation and soil moisture distribution as discussed previously.

The effect of levelling passes number on the yields of wheat is presented in table 23.

7. Grain yield :

The grain yield of wheat was significantly affected by the passes number of levelling treatments. Levelling of two or three passes significantly resulted in increasing the grain yield of wheat when compared with the control (LUC=35).

Whereas, single levelling of pass produced higher grain yield than the control, which did not reach the level of significant.

The increase in grain yield of wheat was obtained from the high value of LUC (83) resulted from the three number of levelling passes treatment, due to the increases in the yield components as: number of spikeletes/spike, spike length and spike weight, number and weight of seeds/spike, which were discussed before.

8. Straw yield :

The straw yield of wheat responded similarly to the applied land levelling treatments (number of levelling passes).

It is clear that, the three passes of levelling were responsible for high value of LUC (83) and a good levelling, and gave the highest yields of wheat, due to the increases in the plants hight, and stem length.

These results (grain and straw) could be due to the firm, good aggregates and smooth seed bed preparation, better irrigation and efficient distribution of water with improve soil properties, and thus in turn resulted in a high germination of the best levelled land, similar results were reported by Borden (1953), Johnson et al.(1977), Leonard and Dedrick (1979), and McClung et al.(1985).

Meanwhile, proper irrigation management of the best levelled land play an important role in producing healthy plants and higher yields, Lyles et al.(1967), Khattak et al. (1981), Oliveira et al.(1981) and Musande et al.(1987).

These results emphasized that, the effect of good levelling gave a favourable land media and micro-environmental condition for better growth and development of wheat.

The relation between LUC and: grain and straw yields of wheat has a linear regression as follows :

$Y(\text{Grain}) = 7.470 + 0.098(\text{LUC})$, Ardab/fed., $(r^2=0.9507)$

$Y(\text{Straw}) = 2.042 + 0.035(\text{LUC})$, ton/fed. , $(r^2=0.9801)$

The increase in grain yield was 42.90% for a good levelling (LUC = 83) and in the straw yield was 53.33%, as comparison with non levelled land, N.L. (LUC= 35).

Table 22: Effect of passes number of levelling in a form of LUC on the yield components of wheat plants at harvesting, season (1988).

Characteristics	LUC , %				L.s.d. 0.05
	35	57	75	83	
Plants height, cm.	107.00	110.75	113.75	116.00	4.28
Stem length , cm.	96.50	100.40	103.10	104.00	7.34
No. of tillers/sq.m.	378.25	344.00	376.75	354.25	(n.s.)
No. of spikes/sq.m.	363.25	333.25	372.00	343.25	(n.s.)
No. of spikeltes/spike	19.70	19.65	20.18	21.65	1.11
Spike length, cm.	10.58	10.38	10.70	11.25	0.54
Spike weight, g.	2.323	2.605	2.893	2.930	0.168
No. of seeds/spike	47.98	53.35	59.05	64.60	4.91
Seed weight/spike, g.	2.28	2.40	2.52	2.73	0.11

* LUC values are resulted from :

35 = non levelled land,

57 = single pass of levelling,

75 = two passes of levelling,

83 = three passes of levelling.

These values are shown and definate in chapter IV, part I, table 4.

Table 23: Effect of passes number of levelling in a form of LUC on the yields of wheat.

Yields	LUC, %				L.s.d., 0.05
	35	57	75	83	
Grain:					
Ardab/fed.	11.217	12.328	15.131	16.029	(3.711)
Ton/fed.	1.683	1.850	2.270	2.404	
Straw:					
Ton/fed.	3.300	3.922	4.763	5.060	(0.749)
Total:Ton/fed.	4.983	5.772	7.033	7.464	

Y(Straw) = 2.042 + 0.035(LUC) , Ton/fed., (r^2 = 0.9801)

Y(Grain) = 7.470 + 0.098(LUC) , Ardab/fed., (r^2 = 0.9507)

Y(Total) = 3.174 + 0.050(LUC) , Ton/fed. , (r^2 = 0.9722)

PART "3"

ECONOMICAL EVALUATION

Economical evaluation are necessary to find the best treatment throughout the studied paramiters.

The section dealt with the following two paramiters as :

a- Energy consumption per unit output.

b- Cost analysis to estimate the economical benefit of land levelling.

a- Energy consumption per unit output :

The consumed energy to produce a unit of crop output comprises of the sum of the consumed energy in executing the different operations from seed-bed preparation to harvesting, in kw.h./fed., divided by crop yield in ton/fed.

In order to compare the different levelling systems according to this criterion, the total input energy to execute the required agricultural operations was determined for each system, Appendix 1.

The consumed energies of different operations (mechanical and manual) under different systems of land levelling (LUC) are shown in tables 1 and 2, Appendix 1, for both sorghum and wheat crops.

Table 24 shows the total output in ton/fed., energy consumption in kw.h/fed., and the energy consumed per unit output in kw.h./ton, for sorghum and wheat crops under different levels of land levelling (LUC).

There were highly significant differences on energy consumption per unit output for all crops studied.

Although the energy consumed per fed. increases with LUC, the energy consumed per ton of output was low, this result is due to high production of levelled land.

The reductions in energy consumed per ton of output were : 20.48% and 15.94% for, sorghum and wheat production, resulted from good land levelling only (compared with non-levelled N.L.).

This means that, levelling the land lead to improved irrigation, higher performances of farm machines; higher germination and consequently higher crop yields; with the least energy consumed per ton of total yield, fig.24.

b- Cost analysis per unit area :

A detailed cost analysis of different elements included in the production of crops was carried out in order to evaluate the economical feasibility of land levelling; (cost = operations cost + wages + losses + materials).

Two parameters were calculated as: the absolute total cost (including both fixed and operating costs per hour

Table 24: Energy consumption per unit output of some crop yields under different LUC.

Crops	LUC, %											
	Total output, Ton/fed.				Energy consumption, kW.h./fed.				Energy cons./unit output, kW.h/ton.			
	51	72	75	83	51	72	75	83	51	72	75	83
Sorghum	23.805	29.281	33.685	34.473	620.24	738.86	814.60	745.49	26.06	25.23	24.18	21.63
	35	57	75	83	35	57	75	83	35	57	75	83
Wheat	4.983	5.772	7.033	7.464	698.00	766.76	856.76	946.59	140.08	132.85	126.82	120.82

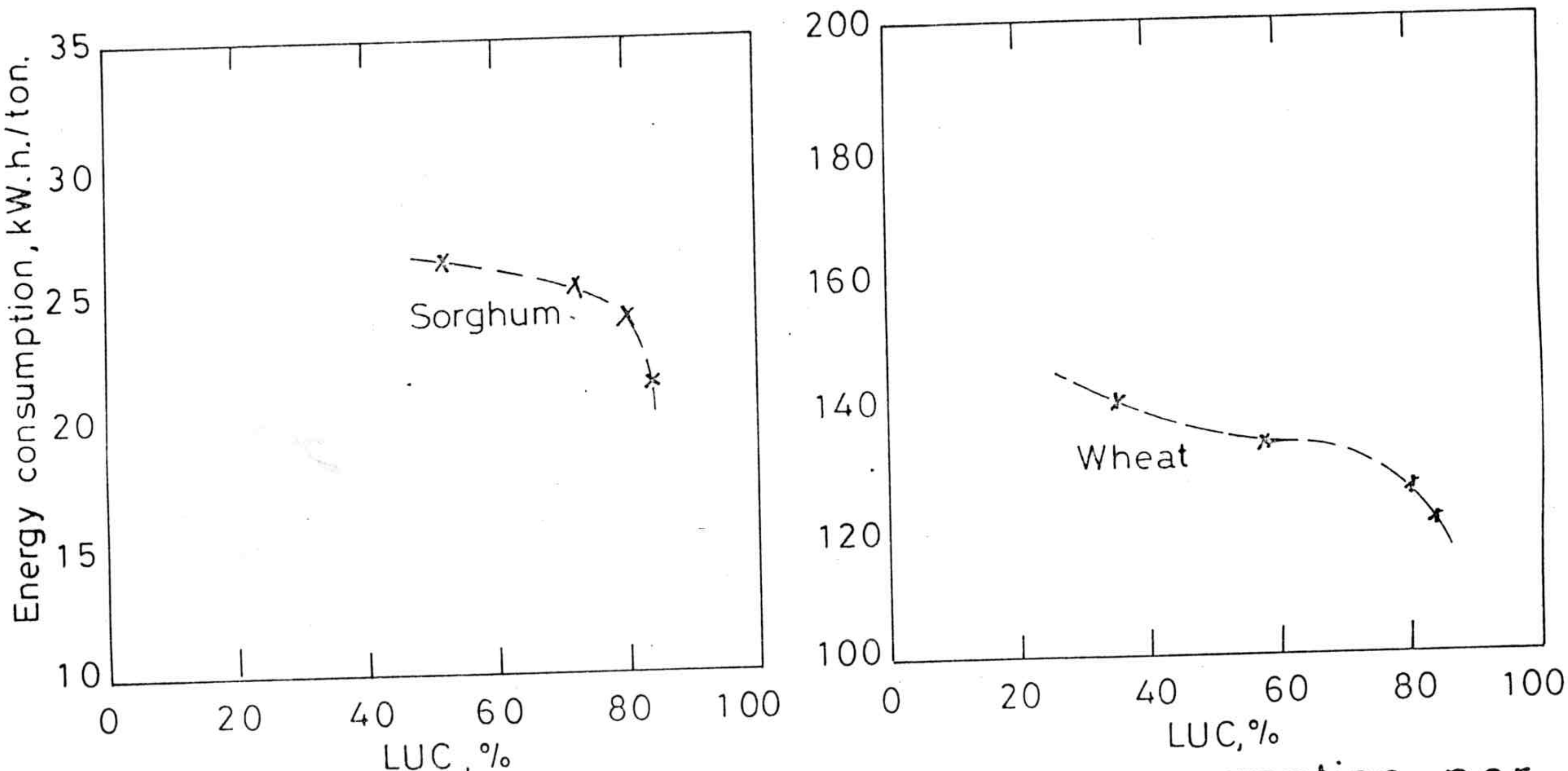

Fig.24:Relation between LUC and energy consumption per unit of some crops production .

according to price level of 1988, and cost per unit area as estimated for various types of levelling.

Appendix 2: illustrates the methods of calculation and the various working specifications of each of the used machines and implements.

Levelling operation cost was based on LUC values for different machine treatments. The max. LUC value attained during experiments was 84%, further costs for higher LUC values more predicted assuming more levelling passes as extrapolated on fig.10.

Tables I and 2 in appendix 2 indicates the cost of different mechanical operations under different land levelling treatments, but table 3 in this appendix, shows the cost of different inputs of productions, and the total cost in L.E./fed.

Table 25 shows the total yield (revenue), cost of production, cost due to losses, and net income (profit) in L.E./fed.

It is clear that from this table, the yields (total revenue) increased with land levelling "LUC" up to 81-83 LUC.

Also, total cost (due to reduction of production + losses) in L.E./f. had the opposite relation with LUC for sorghum productions, but in wheat production, the total cost decreased with LUC until 85% and total cost increased again with further LUC values due to more levelling passes required with diminishing return.

The profite (net income) in L.E./fed., highly increased due to levelling (from LUC = 46% to LUC = 83% by about, 198.06% and 290.04% for production of sorghum and wheat crops, resp. figs. 25 and 26.

This result is due to high yield with the lowest total costs resulted from levelling.

Fig. 27 indicates that the increases in profit resulting from the increases in LUC for sorghum and wheat crops.

There were continuous increasing in profit with increase LUC up to LUC $\simeq$ 83%, which the increase value of profit equal to 198.06% in case of sorghum, and 290.04% in case of wheat.

The relations between LUC with total yeidl, total cost and profits for these crop productions had exponential regessions as shown in figs. 25-26.

From the previous discussion, it might be concluded that, land levelling improved the soil physical properties, improved irrigation efficiencies and produced higher production of crop yields with the least consumption of energy and reduced the cost per unit area with correspondingly, higher net incomes (profits).

And, it might be recommended that, land should be levelled up to LUC equal to 84%, which produced highly profits.

The regression relationships were as follows :

- For sorghum :

$$\text{Yield} = 733.8554\ e^{0.0045\ \text{LUC}} \qquad (r^2 = 0.9338)$$

$$\text{Cost} = 934.6524\ e^{-0.0022\ \text{LUC}} \qquad (r^2 = 0.9681)$$

$$\text{Profit} = 17.9484\ e^{-0.0335\ \text{LUC}} \qquad (r^2 = 0.8895)$$

- For wheat:

$$\text{Yield} = 922.393\ e^{0.0078\ \text{LUC}} \qquad (r^2 = 0.9788)$$

$$\text{Cost} = 1046.0115\ e^{-0.0019\ \text{LUC}} \qquad (r^2 = 0.8719)$$

$$\text{Proft} = 91.7190\ e^{0.0283\ \text{LUC}} \qquad (r^2 = 0.9985)$$

Table 25: Total yield, production cost, losses, levelling cost and net income, in L.E./fed.

Crops	LUC %	Total yield, L.E./fed.	Cost of production, L.E./fed.	Losses; cost, L.E./fed.	Total cost (prod.+loss.) L.E./fed.	Profit, L.E./fed.	Levelling cost, L.E./fed.
Sorghum	51	936.06	671.96	157.16	829.12	106.88	0.00
	72	936.00	687.76	106.71	794.47	141.53	21.56
	75	1080.00	697.96	117.29	815.25	264.75	33.44
	83	1080.00	688.53	72.90	761.43	318.57	26.08
Wheat	35	1220.85	735.07	243.19	978.26	242.59	0.00
	57	1400.80	744.22	180.71	924.93	475.87	13.04
	75	1709.15	756.12	186.47	942.59	766.56	26.08
	83	1813.45	756.08	1111.17	867.25	946.20	39.12
Expected (4)	86	1813.45	769.12	109.32	878.44	935.01	52.16
(more pass.)(5)	87	1813.45	782.16	100.19	882.35	931.10	65.20

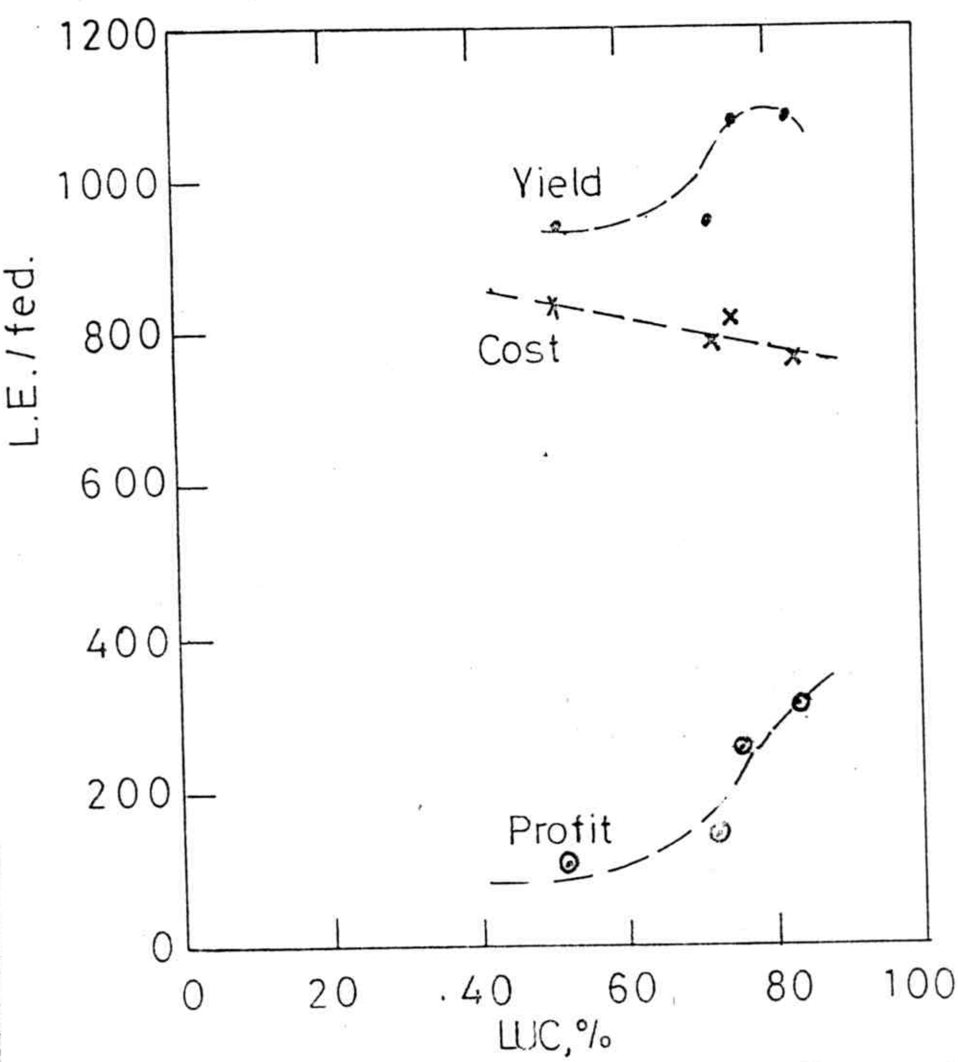

Fig.25:Relation between LUC and cost,yield and profit of sorghum.

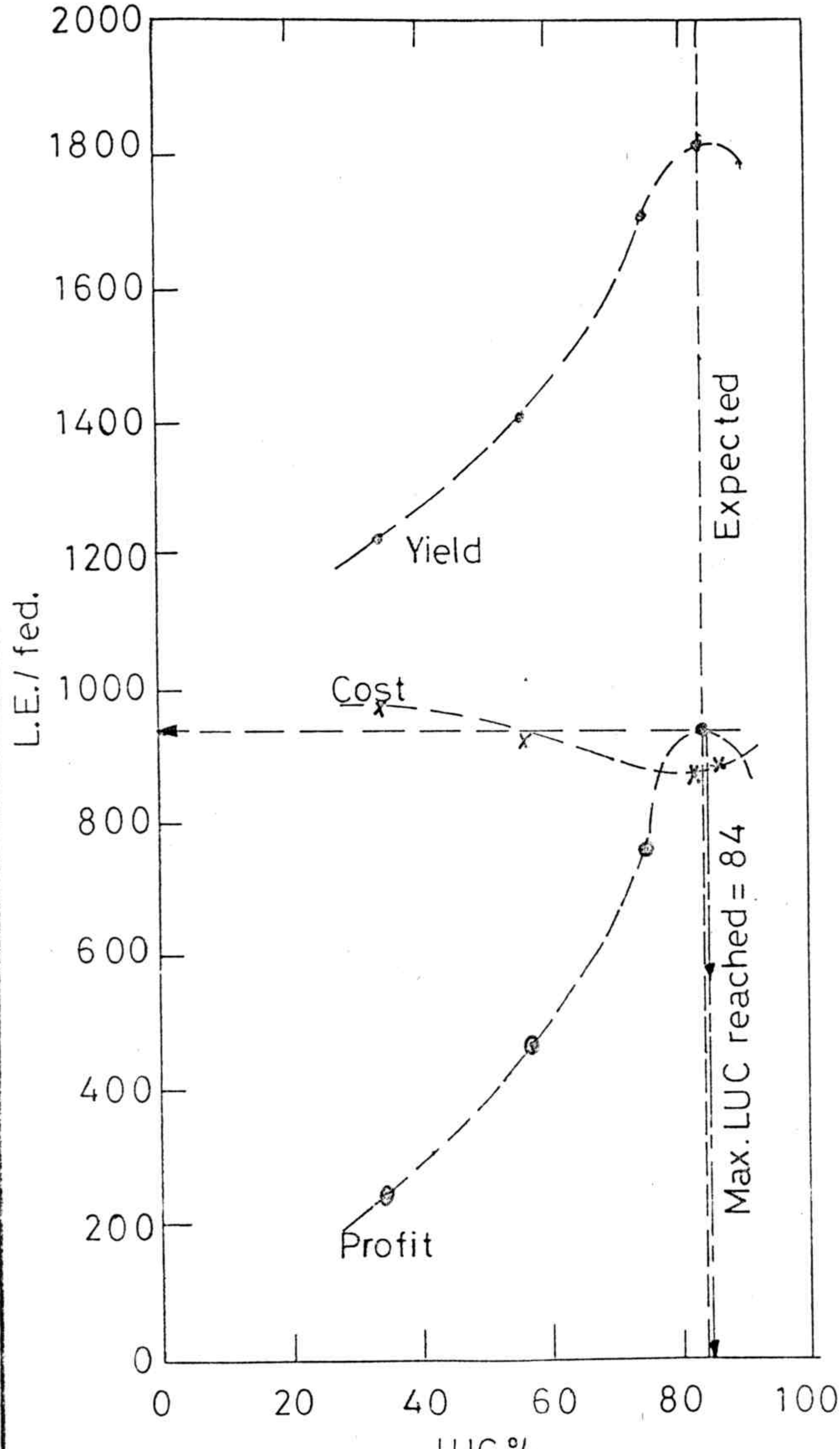

Fig.26:Relation between LUC and cost, yield and profit of wheat.

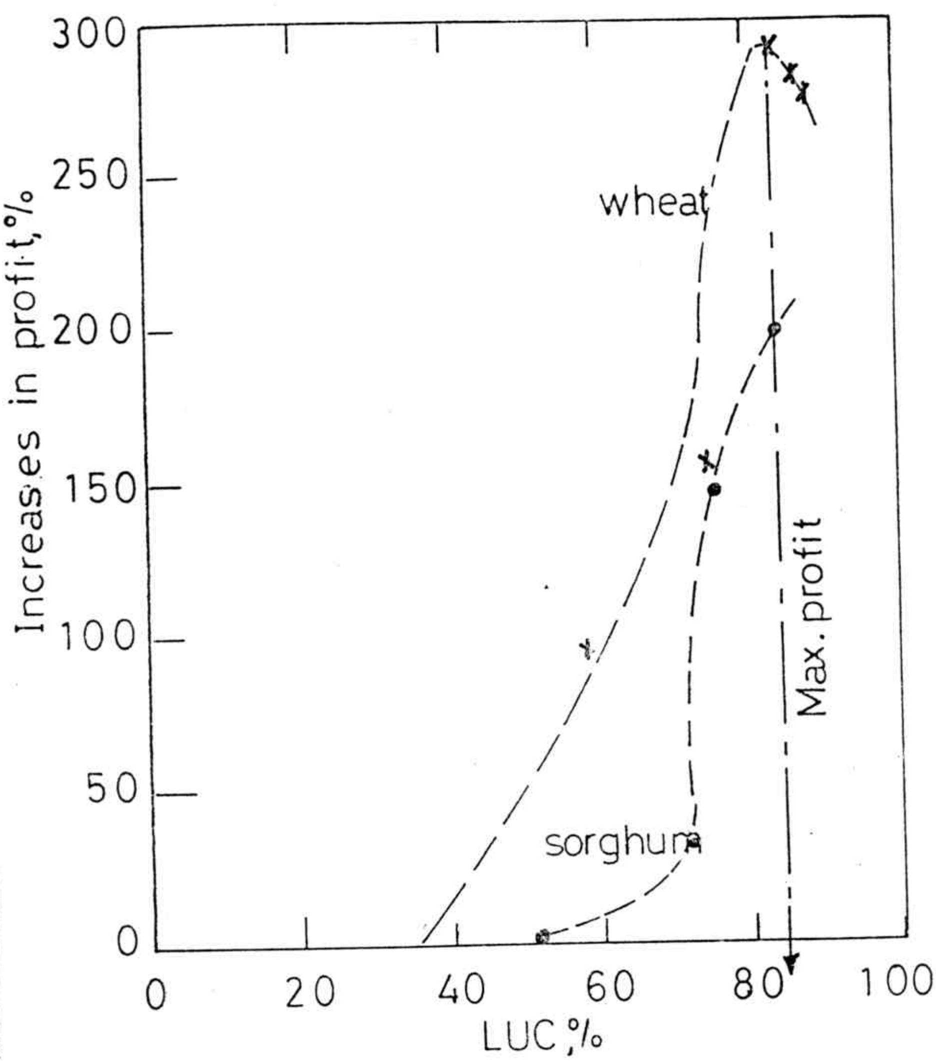

Fig.27: Relation between LUC and percentage of increases profit.