Originalarbeiten

(From the University of Agriculture in Vienna and the Suez-Canal-University in Ismaelia)

Potentiality for soil erosion control and improving plant production in arid zones*

4th Communication: Field trials and their results

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(With 6 figures)

Summary

For the time being, the field trials in arid zones were done in Egypt as tentative experiments and exact trials in small plots. They were considered preliminary stages of practice-orientated trials. Up to 75 km/h wind erosion was prevented by Bituplant used at a dosage of 750 l/ha or by Sarea Soil Stabilizer used at 100 kg/ha. If wind velocity increased up to 90 km/h, 1500 l/ha of Bituplant or 240 kg/ha of Sarea Soil Stabilizer were needed. Among the crops used the early stages of barley proved extremely resistant to aridity. During the hot season plants emerging from sandy soil may get burned, which will be caused by temperatures too high under the bituminous film. At harvest in June, winter sugarbeet showed a sugar content of 15.6 %, and the total sugar content of winter-chicory was 71.2 % in dry matter.

In exact trials done in small plots, after Bituplant had been applied, cotton showed better field emergence, higher yield and reduced spotoptera infestation, especially at early cultivation.

It was clearly seen that water could be saved by Bituplant or Sarea Evaporation Inhibitor. Very useful results could be obtained concerning product combination and large-scale trials orientated towards practice.

Key-words: Soil erosion, plant production, arid zones.

Möglichkeiten zur Verhinderung der Bodenerosion und Verbesserung der Pflanzenproduktion in ariden Klimagebieten

4. Mitteilung: Durchführung von Freilandversuchen und deren Ergebnisse

Zusammenfassung

Die Freilandversuche in ariden Gebieten wurden vorerst in Form von Tast- und Exaktkleinparzellenversuchen in Ägypten durchgeführt. Sie bildeten die Vorstufe für praxisnahe Großflächenversuche.

* This project has been financed by Shell International and CMB-Cairo (Chemicals for Modern Building). By these companies the Bituplant products will be commercialized.

In Tastversuchen konnte mit 750 l/ha Bituplant oder 100 kg/ha Sarea Bodenfestiger die Winderosion bis 75 km/h verhindert werden. Stieg die Windgeschwindigkeit auf 90 km/h, waren 1500 l Bituplant/ha oder 240 kg/ha Sarea Bodenfestiger erforderlich. Von den verwendeten Kulturpflanzen erwies sich die Gerste im Jugendstadium besonders trockenheitsresistent. Während der heißen Jahreszeit können auflaufende Pflanzen auf Sandböden infolge zu hoher Temperaturen unter dem Bitumenfilm Verbrennungen erleiden.

Die Winterzuckerrübe enthielt zur Erntezeit im Juni 15,6 % Zucker und die Winterzichorie einen Gesamtzuckergehalt von 71,2 % in der Trockensubstanz.

In Exaktkleinparzellenversuchen zeigte die Baumwolle durch die Behandlung mit Bituplant besseren Feldaufgang, höhere Erträge und insbesondere bei Frühanbau geringeren Spotopterabefall. Die Möglichkeit einer Wassereinsparung durch Bituplant oder Sarea Verdunstungshemmer war deutlich erkennbar. Es konnten wertvolle Hinweise für die Kombination der Produkte und für praxisnahe Großversuche gewonnen werden.

Schlüsselworte: Bodenerosion, Pflanzenproduktion, arides Klima.

1. Problem and present stand of knowledge

Beside the investigations in the laboratory, phytotron and green house (Neururer et al. 1991 a, 1991 b, 1991 c) the products were also tested in arid climates. For this purpose tentative trials and exact trials on small plots in different areas of Egypt had to be carried out in the beginning of 1984. The trials should give information on the procedure in the following large-scale trials and practical application of the methods and the results which basically can be expected. Not only questions of plant cultivation but also problems of plant nutrition, activity of soil microbes, consequences of high temperatures and infestation of pests had to be clarified.

The present 4th communication includes the results of tentative and exact-trials on small plots. In further notes the results of the practical large-scale trials with potatoes, cotton, maize, vegetables and wood will be presented.

2. Materials and methods

2.1 Tentative trials

Knapsack-sprayers, fertilizers, bacteria-suspensions and seeds were transported by airfreight from Austria to Cairo and brought to the trial locations by car. The dimensions of the test-plots were 1 to 100 m^2 (Fig. 1 and 2). The surface of the firm desert-ground was first loosened by a metal-rake and cultivated with following plants: winter-barley, maize, millet, sunflower, safflower, phacelia, soybeans, sudan-grass, horse-beans, garden-cress and rape.

On areas which already had been recultivated sugar-beet, chicory and cotton were cultivated. Sugar-beet and chicory were cultivated towards the end of October and cotton from January till March. Bituplant 22 and the Sarea Soil Stabilizer were sprayed to the soil surface, the Sarea Evaporation Inhibitor was washed in with 10 000 l water/ha. Irrigation was done by watering, can or rain-simulator (Fig. 3 and 4).

2.2 Exact trials on small plots

2.2.1 Trials on cotton

At the experimental station of Ciba-Geigy near Cairo, cotton was cultivated at three terms, namely in January, February and March. It was treated with

Fig. 1: Tentative trial in the desert; labour is complicated by heat, wind and long transportation distances

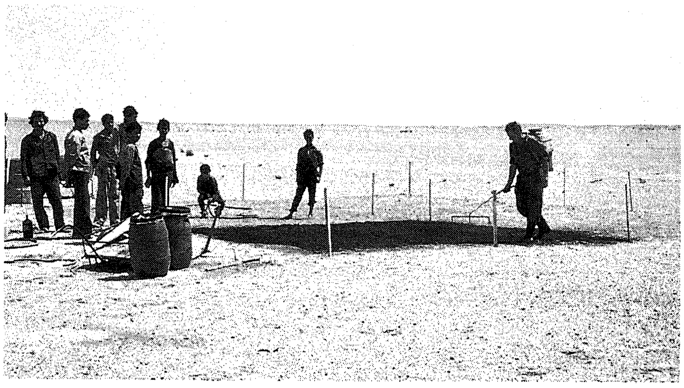

Fig. 2: Very often small plots have to be sunk into the soil and covered with brushwoob in order to get protected against insects and birds

Fig. 3: Exact trials on cotton in small plots; exact dosage of irrigation water is difficult

200 l/ha of a 50 % bituminous emulsion. The normal cultivation time for this region is March. The trials were laid out in four replications à 25 m² and the irrigation water was given in normal dosage and in reduced dosage of a third of the

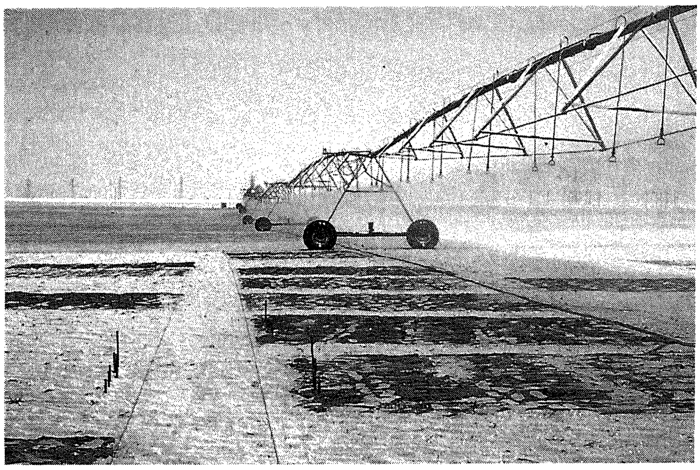

Fig. 4: In exact trials carried out in small plots water amount for sprinkling can be dosed exactly

total amount. The trials were evaluated by control of emergence, flowering, weight of the capsules and infestation. The behaviour of the most important cotton-pest (cotton-worm = *spotoptera littoralis*) was studied in the field as well as by feeding in cages in the laboratory.

2.2.2 Examination of stabilization and retention measurements in the field

The aim of the trials was to examine the retention values obtained in the laboratory as well as the surface stabilization of desert grounds. Further the influence on the plant growth was observed.

We had the possibility to carry out the trials at the experimental station of the Irrigation Institute in Wadi Natron (between Cairo and Alexandria). We chose this location in order to test our products under extreme conditions.

2.2.2.1 Examination of soil and compost stabilization

After soil preparation and compost spreading the products were sprayed. Assessment of stabilization followed after wind speed of about 90 km/h had occured and by striking of the irrigation droplets the treated surface. By reduction of irrigation pressure also the stability against bigger droplets and higher striking energy was examined, in order to have sufficient stabilization for the droplet energies at the beginning and at the end of irrigation.

2.2.2.2 Retention measurement

The amount of water retention was found by moisture determinations from soil samples of a depth between 10 and 80 cm each.

To determine the soil specific characteristic values (density, max. field capacity) soil samples were taken with a cylinder out of two profile-pits (before and after excessive irrigation) every 10 to 80 cm depth.

Originally square plots and manual irrigation up to field capacity were planned. But due to the enormous need of time for irrigation, the trials were arranged star-shaped around the circular sprinkler, and the measurements were started one day after excessive irrigation. The soil was loosened with a disc-harrow in a depth of app. 10 cm and subsequently graded again with a wooden board. In total 14 variants (Bituplant, Sarea Soil Stabilizer, compost and product-combinations) were arranged under circular-sprinklers in cake-form, the size of each plot was 18.2 m^2. The trial was carried out in four repetitions (one sprinkler per repetition).

Application of the products was done by using a spraying bar (2 m width) and a knapsack-sprayer. The amount of irrigation and distribution was controlled on the one hand by a flow-meter situated before the sprinklers and on the other hand by a rain-meter situated between the plots. The determinations were started one day after irrigation.

For soil sampling a percussion-drill and a wing-borer were available. The percussion-drill was not suitable for sample taking, because it got stuck in the sand. We had also problems by using the wing-borer after drying of the upper sand layer, because sand was drizzling out of the borer. Therefore an additional tube was used for sample taking.

All samples were taken out of 30 cm depth and used for moisture determination, which was done in a desiccator at 105° C. The sand in Wadi Natron contains approx. 30 % coarse sand of more than 2 mm diameter, so that sieving was necessary to consider this fraction in the calculation of retention and irrigation.

2.2.2.3 Trial for plant production

The most important six variants (main products and their combinations) were chosen to examine the influence of the products on plant-growth. This trial was laid out in three repetitions on plots with a size of 25 m^2 respective 13.8 m^2 with grass-seed, maize and sunflowers. The temperature measuring equipment was fit with sensors to determine the influence of shading as well as the higher moisture content on the soil temperature in depths of 5 and 20 cm.

3. Trial results and discussion

3.1 Results of tentative trials

Tentative trials showed that wind erosion was considerably prevented by a 50 % bituminous emulsion used at a dosage of 750 l/ha and by the Sarea Soil Stabilizer applied at a dosage of 100 kg/ha (Table 1). The Sarea Evaporation Inhibitor did not cause any visible reduction of blowing-off sand.

Table 1

Prevention of wind erosion in open sandy-desert

Products	Application/ha	Erosion behaviour* at km/h wind-speed		
		25	50	75
Bituminous emulsion	750 l	1	1	2
	1500 l	1	1	1
	3000 l	1	1	1
Sarea Soil Stabilizer	100 kg	1	1	2
Sarea Evaporation Inhibitor	75 l	2	3	3
Untreated		2	3	3

* 1 = no sand-drift, 2 = slight sand-drift, 3 = strong sand-drift

In sandy soil and when bituminous emulsion was used, seed emergence was disturbed only in the hot season. Emerging plants showed symptoms of burning. During the rest of the year, however, no substantial damages of emerging plants were observed in medium sandy soils. But plant emergence was reduced when higher amounts of a 50 % bituminous emulsion were used at a dosage of 3000 l/ha (Table 2).

Table 2

Emergence of culture plants in open desert (out of the hot season)

Crops	Emergence of culture plants in %					
	untreated	Bituminous emulsion 50 %			Sarea Soil Stabilizer	Sarea Evaporation Inhibitor
		750 l	1500 l	3000 l	100 kg	75 l
Barley	90	85	85	80	90	85
Maize	70	80	75	60	70	70
Millet	90	90	85	70	80	80
Sunflower	80	80	78	70	85	80
Safflower	70	80	70	60	70	75
Winter-rape	80	80	75	70	85	75
Sugar-beet	70	80	70	70	75	70
Chicory	80	85	75	65	80	80

Crops sown were of different resistance against aridity, among which summer barley proved most resistant (Table 3). Evaporation was reduced to a large extent by bituminous emulsion and by Sarea Evaporation Inhibitor.

Table 3

Water consumption and begin of wilting of culture plants in open desert
Necessary water amount until begin of wilting in comparison with the untreated control-variant (untreated = 100 %)

Crops	Product and application/ha Bituplant 50 % 750 l	Sarea Soil Stabilizer 100 kg	Sarea Evaporation Inhibitor 75 l
Barley	50	100	45
Maize	70	100	60
Millet	60	100	60
Sunflower	70	100	60
Safflower	70	100	70
Winter-rape	80	100	70
Sugar-beet	80	100	70
Chicory	80	100	70

When the contents of sugar-beet were examined, a sugar content of 15.6 % was measured at harvest in the end of June. In chicory protein content was 3.16 %, extract content was 82.7 % and total sugar content in dry matter was 71.2 %. These results can be compared to European values.

3.2 Results of exact trial's carried out in small plots

3.2.1 Cotton trials

Emergence was significantly improved, yield increased and Spotoptera infestation reduced by bituminous emulsion. Compared to standard cultivation, considerable differences were observed especially at early cultivation (Table 4).

This was caused by faster plant development, due to greater heating of the soil in January and February. Reduced pest infestation may be assigned to the fact that, due to the treatment during Spotoptera mass flight, plant development had been advanced and that the leaves had become less attractive. This opinion could be confirmed by a feeding experiment, when larval weight increase was less (up to 90 %), if leaves from treated plots had been fed (Table 5).

Table 4

Influence of 2000 l/ha bituminous emulsion in the cotton-production (untreated= 100 %)

Parameter	Cultivation time January	February	March
Field emergence in %	140*	125*	105
number of capsules in %	130*	110	104
weight of capsules in %	160*	115	100
Spotoptera-infestation in %	15*	40*	100

* = Significance at $p \leqq 5$ %

Table 5

Influence of prematured plant development and feeding of leaf-mass to spotoptera-larvae in cages

Parameter	Weight-increase of larvae in % compared to untreated (untreated = 100 %)
Leaves from bitumen-treated plots, January-cultivation	13*
Leaves from bitumen-treated plots, March-cultivation	9*

* = Significance at $p \leqq 5$%

Although water-meters had been put into the irrigation ditches, the amount of water could not be dosed as exactly as it had been necessary for calculating the final results. But there was a trend towards 30 % water saving by the use of the bituminous film. Lesser amounts of water combined with bituminous film showed higher yields than high amounts without any bituminous film, which may be of great importance for plant protection in arid regions.

3.2.2 Results of trials in Wadi Natron

Description of the profile pit: As you can see from figure 5 and table 6 the profile can be separated into three layers. The cultivation time is too short to make out a treatment-horizon. Only a small part of peanut-straw reminds on a trial carried out two years ago.

Table 6

Soil characteristic values of Wadi Natron

Prof. No.	depth	density	before irrigation weight %	vol. %	after irrigation field capacity weight %	vol. %	amount of irrigation water mm
1	0—10	1.498	1.05	1.57	6.55	10.27	8.7
2	11—20	1.579	1.25	1.97	6.32	10.37	8.4
3	21—30	1.701	1.22	2.08	6.01	10.58	8.5
4	31—40	1.661	1.20	1.99	4.79	8.29	6.3
5	41—50	1.655	0.48	0.79	4.96	8.21	7.4
6	51—60	1.649	0.74	1.22	3.74	6.17	5.0
7	61—70	1.692	0.49	0.79	3.63	5.85	5.1
8	71—80	1.647	0.67	1.10	3.97	6.54	5.4

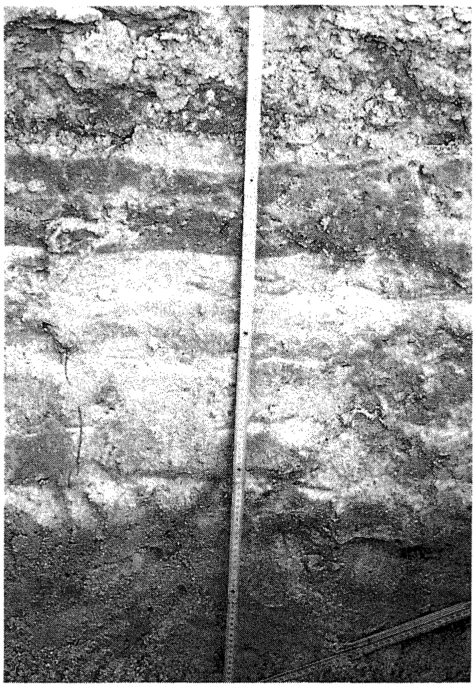

Fig. 5: Soil profile of Wadi Natron

Layer 0—30 cm: Alluvial material, mainly clay, fine sand and approx. 20 % coarse sand over 2 to 30 mm. This layer is very binding because of the clay, so that the very dry soil can only be loosened by high mechanical strain.

Layer 30—45 cm: Transitional layer between covering layer and the quartz-sand layer underneath.

Layer 45—100 cm: Pure quartz-sand which is blown up by wind.

In a depth of 75 cm there is a layer with high quantities of salt in a thickness of max. 5 cm. This layer is not closed and it is possible to take out conglomerates.

It can be seen from the results that a dosage of 750 l/ha of Bituplant (50 % emulsion) and 120 kg/ha of Sarea Soil Stabilizer will be sufficient for sand stabilization, even at a wind velocity of 90 km/h (Table 7).

Table 7

Assessment of sand- and compost-stabilization against wind erosion at maximal wind speed of 90 km/h

Variants	Sand	Compost
1. Bituplant 1500 l 50 % emulsion	sufficient	insufficient
2. Bituplant 750 l 50 % emulsion	sufficient	insufficient
3. Sarea Soil Stabilizer 240 kg/ha	sufficient	sufficient
4. Sarea Soil Stabilizer 120 kg/ha	sufficient	insufficient

sufficient = >90 % stabilization insufficient = <90 % stabilization

Redoubled dosage, however, will be needed for stabilizing very coarse poultry dung not yet composted. Standard dosages of 750 l/ha of Bituplant (50 % emulsion) and 120 kg/ha of Sarea Soil Stabilizer will be enough for sand stabilizing, even at increased droplet energy (Table 8).

If, however, compost is used and droplet energy increases, sand stabilization will prove insufficient, even at redoubled dosages.

Due to particles leached into the soil pores, these will get sealed off so that after the soil will have been irrigated for appr. 30 minutes, irrigation water will

Table 8

Assessment of stability against striking of irrigation-droplets at reduced pressure

Working pressure: 6 bar
Used pressure for assessment: 2.8 bar
Sprinkler: Perrot ZE 30

Variants	Stability at higher droplet-energie	
	Sand	Compost
1. Bituplant 1500 l 50 % emulsion	sufficient	insufficient
2. Bituplant 750 l 50 % emulsion	sufficient	insufficient
3. Sarea Soil Stabilizer 240 kg/ha	sufficient	insufficient
4. Sarea Soil Stabilizer 120 kg/ha	sufficient	insufficient

sufficient = >90 % stabilization
insufficient = <90 % stabilization

Table 9

Assessment of infiltration rate

Irrigation water running of the surface was assessed after irrigation of about 1 hour

Variants	Infiltration rate
1. untreated	insufficient
2. Bituplant, 750 l/ha, 50 % emulsion	sufficient
3. Sarea Soil Stabilizer, 120 kg/ha	sufficient

sufficient = >90 % infiltration
insufficient = <90 % infiltration

Table 10

Determination of the water shed

Depth	Water content (Vol. %) in days after irrigation			
	1	3	13	
0—10	9.62	6.48	4.24	
10—20	8.69	6.41	4.85	
20—30	9.21	6.11	5.52	
30—40	7.91	6.55	4.41	water shed
40—50	6.18	6.64	4.12	
50—60	6.42	6.41	4.55	
60—70	6.64	6.25	5.93	
70—80	7.01	6.42	6.82	

run off the surface. If the soil will be stabilized by Bituplant or Sarea Soil Stabilizer, soil particle leaching will be reduced and water run-off prevented (Table 9).

During measurements it could be observed that the water-shed is located in a depth of about 30 cm, where clay layer turns into quartz layer. Therefore, depth was considered from 0 to 30 cm only (Tables 10 and 11).

Table 11

Evaporation after irrigation (see also fig. 6)
(mean and standard deviation)

Variants	Retention values in % on different days after irrigation							
	1		2		4		9	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Bituplant	60	5.2	22	7.2	6	4.2	3	3.0
Sarea-Evaporation Inhibitor	62	6.5	35	6.9	20	4.8	12	3.6
Compost	70	4.8	25	5.5	15	5.2	5	3.4

Extreme soil differences and soil conditions in Wadi Natron lead to considerable deviations so that there cannot be expected any significance from statistical evaluation. Due to low water retention capacity and high temperatures, the permanent wilting point is reached already after 2 to 4 days. Therefore, only this period will be important evaluating water retention.

Bituplant 22, 1500 kg/ha (50 % emulsion), shows good retention effect in the beginning and, due to its dark colour, heats up very fast. Therefore, after six

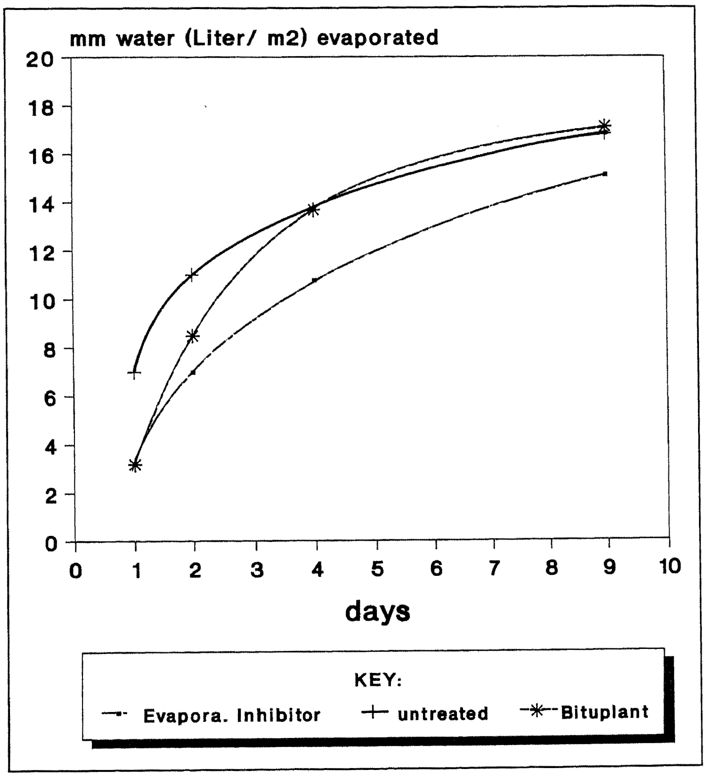

Fig. 6: Evaporation after irrigation

days evaporation will be higher than that of the untreated variant. Sarea Evaporation Inhibitor, 80 kg/ha, shows good retention effect during a longer measuring period. 5 cm thickness of poultry dung film: Because of very poor water retention capacity of the sandy soil, compared to poultry dung, good retention values can be reached, if such compost is partly used (high water retention capacity).

At high temperatures caused by intense isolation the germinating maize plants may be burned under the Bituplant film absorbing high amounts of heat. In a soil depth of 5 cm soil temperatures exceeding 40° C were measured in a trial carried out at an air temperature of 38° C. Concerning Sarea Evaporation Inhibitor, soil temperature in a soil depth of 5 cm will be 34° C, due to better heat conducting capacity at a higher water content, which is more than 3° C, compared to the untreated plot. Due to considerable scattering of individual values, yield assessment by weight could not be done.

Acknowledgement

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