ASPHALT BARRIERS TO IMPROVE PRODUCTIVITY OF SANDY SOILS—A PRELIMINARY ASSESSMENT

By M. E. SUMNER
(Department of Soil Science, University of Natal, Pietermaritzburg)
and
E. C. GILFILLAN
(Tongaat Group Ltd., Maidstone)

Abstract

When a layer of asphalt is placed below the plant root zone, the quantity of water which a sandy soil can hold is approximately doubled with the result that far more water is available to the crop. Losses of water by deep percolation are effectively reduced to a minimum. Field trials with sugar cane, cotton and lucerne show that the productivity of sandy soils can be markedly increased both under dryland and irrigated conditions.

Introduction

Large areas of sandy soils occur in Southern Africa particularly on the east coast from south of Durban through the Makatini Flats to north of Beira in Mozambique, parts of the western Cape, Highveld, western Transvaal and Orange Free State and northern South West Africa. Production on these soils is currently low, being limited by the low water holding capacity and high permeability together with the leaching of soluble fertilizers.

Hansen and Erickson[3] have developed a technique of placing an almost impervious 2 mm layer of asphalt at a depth of approximately 60 cm below the soil surface to improve the water holding capacity of the soil above the barrier. This barrier retards the downward movement of soil moisture and establishes a temporary perched water table. The rate of water seepage through the soil with barrier is reduced by a factor greater than 4.

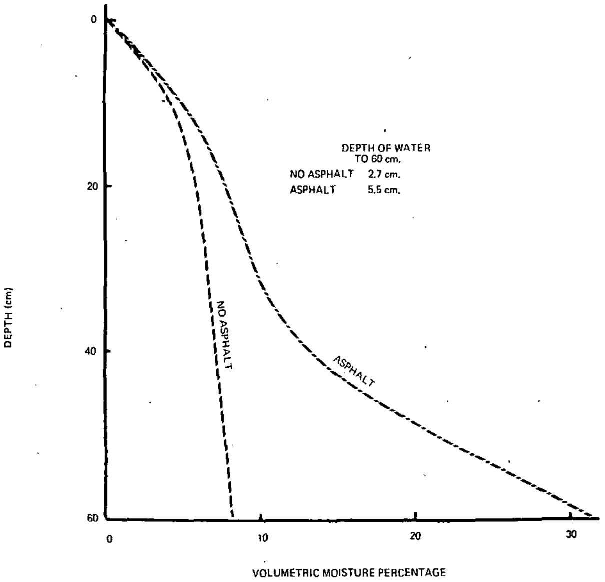

FIGURE 1: Effect of asphalt barrier on the moisture-holding capacity of Maputa sand

The moisture distribution in a profile of the Maputa series with and without asphalt barrier is shown in Figure 1. The soil above the barrier holds twice as much water as untreated soil. The greater

TABLE I

Details of Experiments

Site	*Series*	*Crop*	*Treatments*		*Date Planted*	*Date Harvested*	*Total Water Applied*
			No. Asphalt	*Asphalt*			
Tongaat	Fernwood	Sugarcane	(1) Control	Control	5-3-70	14-5-71	1 358 mm
			(2) Lime*	Lime			
			(3) Temik†.	Temik			
			(4) Lime & Temik	Lime & Temik			
Makatini	Maputa	Lucerne	(1) Control	Control	13-8-70	3-11-70	810 mm
			(2) Gypsum‡	Gypsum		22-12-70	
			(3) Lime§ 0-30 cm	Lime 0-30 cm		28-1-71	
			(4) Lime** 0-60 cm	Lime 0-60 cm		10-3-71	
Makatini	Maputa	Cotton (Albar 637)	(1) Control	Control	13-8-70	12-1-71	750 mm
			(2) Gypsum‡	Gypsum		28-1-71	
			(3) Lime§ 0-30 cm	Lime 0-30 cm			
			(4) Lime** 0-60 cm	Lime 0-60 cm			

* 4t Ulcolime/ha incorporated to 60 cm
† 5.6 kg active ingredient/ha in row at planting
‡ 2t $CaSO_4.2H_2O$/ha on surface before planting
§ 3t $Ca(OH)_2$/ha mixed to 30 cm
** 6t $Ca(OH)_2$/ha mixed to 60 cm

TABLE II

Selected properties of soils from experimental sites on Fernwood and Maputa series

Series	Depth cm	pH		Clay %	Exchangeable cations				EAI* me %	CEC me %
		H_2O	$CaCl_2$		Ca me.%	Mg me %	K me %	Na me %		
Maputa	0-15	5,65	4,20	5,0	0,22	0,75	0,27	0,09	0,19	2,8
	15-30	5,40	4,00	6,0	0,19	0,71	0,24	0,08	0,24	3,3
	30-45	5,40	4,05	6,2	0,16	0,67	0,24	0,08	0,29	3,1
	45-60	5,30	4,10	5,3	0,16	0,63	0,23	0,07	0,31	2,5
	60-75	5,30	4,05	3,4	0,18	0,84	0,30	0,13	0,29	1,5
	75-90	5,20	4,00	3,4	0,17	0,83	0,30	0,13	0,30	1,5
Fernwood	0-25	5,27	4,81	7,0	0,80	0,23	0,11	0,10	0,00	±2,0

* Exchangeable aluminium index (Sumner[4])

proportion of the additional water between 30 and 60 cm is held at low tensions and is consequently highly available. Because the greater proportion of plant roots occur in the top 60 cm of soil, this concentration of water and soluble nutrients which would largely be lost under normal conditions, will be readily ultilised by plants.

Erickson, Hansen and Smucker[1] and Erickson, *et al*[2] obtained spectacular yield responses to asphalt barriers for a number of crops including sugarcane, rice and vegetables both under dryland and irrigated conditions.

The aim of this paper is to assess the potential of asphalt barriers in South Africa based on the results of a number of exploratory field trials.

Experimental

A number of observational experiments were laid down on soil of the Fernwood series at Tongaat under dryland conditions and on a soil of the Maputa series at Makatini under irrigation (Table I). Some properties of these soils which belong to the Fernwood form are presented in Table II.

All plots received an adequate basal fertilizer dressing. All asphalt barriers were placed at 60 cm below the surface by excavating, spraying with 60% asphalt emulsion and replacing the soil. All no-asphalt plots were excavated and refilled in the same manner. Irrigation on the Makatini experiments was given at the rate of 10 cm per application when the asphalt barrier lime 0-60 cm plot showed signs of wilt.

Results

Maputa series

Because this soil is known to contain toxic quantities of labile aluminium (Sumner[4]), various lime treatments were studied in addition to asphalt barriers. The response to lime was spectacular; the plots receiving no lime yielded poorly particularly in the case of lucerne where the yield for four cuts increased from 1,00 t/ha for the control to 5,73 t/ha where lime was incorporated to 30 cm to 7,58 t/ha for the 0-60 cm lime treatment. For this reason the response to asphalt barrier treatment will be presented in two ways as the average over all treatments and as an average over lime treatments only (Table III).

There is a consistent response of approximately 25-30% to asphalt barriers for both crops. The cotton yield on this soil is disappointingly low as one would expect at least 3 ton seed cotton/ha in this area. After 3 months' growth, the cotton plants looked unhealthy but no pathogenic organisms could be detected. The possibility that the cotton suffered a nitrogen stress cannot be eliminated as only 150 kg urea/ha was applied in order to prevent rank growth to which cotton is prone in this area. The

TABLE III

Effect of asphalt barriers on yield of cotton and lucerne grown on Maputa soil

Treatment	Yield (t/ha)					
	All Treatments			Lime treatments only		
	Cotton		Lucerne*	Cotton		Lucerne*
	Seed Cotton	Lint		Seed Cotton	Lint	
No Asphalt	1,39	0,43	3,81	1,29	0,39	6,66
Asphalt	1,81	0,57	4,72	1,88	0,59	8,24
Difference	0,42	0,14	0,91	0,58	0,20	1,58

* Total of four cuts

PLATE 1: Effect of asphalt barrier on the growth of sugarcane on Fernwood sand. (Pictures were taken 11 months after planting.)

yield of lucerne is also lower than expected but this can be attributed to a row spacing which is too wide. On the best plots canopy was only achieved about one week before harvest. After the fourth cut, additional rows have been interplanted between the existing rows which will certainly increase yield.

TABLE IV

Effect of asphalt barriers on yield of sugarcane grown on Fernwood soil

Treatment	*Yield* (t/ha)	*No. of stalks per plot*
No asphalt	67,8	236
Asphalt	101,5	221
Difference	33,7	—
No asphalt not excavated	63,8	240

Fernwood series

Because responses to temik and lime treatments on this soil are relatively small, the effect of asphalt barrier treatment on yield will be presented as the average over all treatments (Table IV).

The spectacular response to asphalt barrier treatment on this soil under dryland conditions is well illustrated in Plate 1. From soon after planting this difference appeared and persisted until harvest. Part of the response to asphalt barrier treatment on this soil is likely to be due to nitrogen. In the no asphalt treatments, the nitrate anion will be rapidly leached out of the root zone causing the cane to suffer nitrogen stress. The cane on the no asphalt plots has had a poorer colour than that on the asphalt plots from the beginning of the experiment which supports the above statement.

Cane growth in the vicinity of the experiment has been so consistently poor that the area has now been established to gum trees *(Eucalyptus grandus)* in order to attempt to gain an economic return from the land. The average yield from the field for the last three crops harvested has been 44,8 t/ha at 19 months age which is only 2,3 tons/ha/month.

The initial results from asphalt barrier experiments are encouraging but further experimentation is necessary before this practice can be recommended on a large scale. The high cost of laying asphalt barriers commercially (R400-450/ha) will have to be offset by the additional yield in a fairly short period of time for this treatment to be attractive. A response of 30 t/ha/annum will pay for the barrier treatment in five years leaving a clear profit over the remainder of the barrier's estimated 15-20 year life.

Acknowledgements

The authors wish to thank Miss Annette Bellows and Messrs. J. Lonsdale, J. Penfold and J. Thomas for their help in laying down and caring for these experiments.

REFERENCES

1. Erickson, A. E., Hansen, C. M., and Smucker, A. J. M., 1968. The influence of subsurface asphalt barriers on the water properties and the productivity of sand soils. Trans. 9th Int. Cong. Soil Sci. 1: 35.
2. Erickson, A. E., Hansen, C. M., Smucker, A. J. M., Li, K. Y., Hsi, L. C., Wang, T. S. and Cook, R. L., 1968. Subsurface asphalt barriers for the improvement of sugarcane production and the conservation of water on sand soil. Proc. Cong. Int. Soc. Sug. Cane Tech. 13: 787-792.
3. Hansen, C. M. and Erickson, A. E., 1969. Use of asphalt to increase the water holding capacity of droughty sand soils. I. & E.C. Product Research and Development 8: 256.
4. Sumner, M. E., 1970. Aluminium toxicity — A growth limiting factor in some Natal sands. Proc. S.A. Sug. Tech. Assoc. 44: 176-189.

Discussion

Mr. Brown: A cost of R100 per acre is not disproportionate when the price of sugarcane land is considered.

Dr. Thompson: If you had corrected your aluminium problem would you not have been able to do the job more cheaply?

Professor Sumner: On this particular Fernwood soil there was no aluminium problem.

On the Clansthal soil we got a response to lime and an additional response to the asphalt barrier.

Dr. Macvicar: What is the difference between an asphalt barrier and trickle flow irrigation?

Professor Sumner: I think drip irrigation could achieve the same results as an asphalt barrier.

The greatest return will be received from an asphalt barrier under dryland conditions.

Dr. Hill: Are there limitations, such as land slope, to the use of an asphalt barrier?

Professor Sumner: A barrier could be used on slightly sloping land, being placed approximately parallel to the surface, and being slightly deeper under the soil on the upslope side.

Dr. Gosnell: In America is most of the value of an asphalt barrier attributed to moisture conservation? In one graph it was noticeable that irrigated crops did not give as high a yield as unirrigated asphalt barrier crops.

Dr. Sumner: This is entirely due to leaching out of nitrate.

Mr. Harris: How did the Temik plots compare?

Professor Sumner: The highest yielding plot was the Temik plus asphalt plot. The Temik worked even better on unasphalted plots.

On the best plot we obtained 53 tca and the total rainfall recorded was 53 inches, which is in line with Dr. Thompson's findings.

Dr. Matic: In Table IV figures are given for yields under varying conditions. In the slides shown earlier it was indicated that despite increased yield there was a drop in purity and in sucrose. Has an attempt been made to estimate recoverable sugar?

Dr. Gilfillan: In all our tests we always find increased yields go with a drop in sucrose.

Recoverable sucrose was not calculated in this experiment.

Mr. Tucker: On flat land will not excessive rains create a drainage problem when the asphalt barrier is down?

Professor Sumner: The asphalt barrier would be cross-ripped at 100 yard intervals to allow drainage by lateral movement of the water to the ripped areas.

Mr. Dovey: Why should the life cycle be limited to twenty years and is it not possible that the cane roots might rip up the barrier?

Professor Sumner: We are guessing at the life cycle—instead of fifteen or twenty years it might be fifty years. There are possibly micro-organisms that will attack the asphalt.

Roots can penetrate the barrier but conditions above the barrier are so much better than below that there is no point in such penetration.

Mr. Meyer: In the experiment were any differences found in the nutrient content of the cane?

Professor Sumner: There were no differences found in the one analysis carried out but the results so similar that they are suspect and further analyses will be carried out.

Mr. Mann: Did the roots from the cane, cotton and, particularly, lucerne penetrate the barrier?

Professor Sumner: We have not dug up the plots to look but we expect some penetration from the cotton and lucerne.

Mr. Farquhar: Have you had any experience of asphalt for furrow lining?

Professor Sumner: No, but in America they spray catchment areas with asphalt so it should work with furrow lining.