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TREES AND SOIL NUTRIENTS IN SOUTH-WESTERN QUEENSLAND

By J. P. EBERSOHN, M.Sc., Ph.D., and P. LUCAS, Dip. Ind. Chem.*

SUMMARY

Stable native grass communities and ready establishment of introduced grasses under mature poplar box trees prompted shallow soil sampling under and away from trees.

Soil analyses established a higher available phosphorus and exchangeable potassium status under mature poplar box and other trees. A positive association between pH and trees existed in some but not all areas.

Possible sources of phosphorus and potassium, related to soil organic matter, deep-rootedness and longevity of trees, and soil movement by wind, are discussed.

I. INTRODUCTION

Poplar box (*Eucalyptus populnea*) occurs abundantly throughout semi-arid western Queensland. The tree has a spreading habit of growth, reaches a height of 35–45 ft and is long lived. It has been repeatedly observed that shot grass (*Paspalidium globoideum*), a native, forms stable communities under mature poplar box trees. In addition, buffel grass (*Cenchrus ciliaris*) cultivars establish readily on such sites without seedbed preparation. Outside these microhabitats, shot grass is rare and establishment of the introduced grass dubious. The soils are lateritic clay loams and loamy sands, usually self-sealing and infertile away from the zone of influence of the tree.

II. METHOD

In an attempt to find an explanation for the presence of vigorous grass communities in these microhabitats, spade block soil samples (a composite of six subsamples) were taken from such areas and also 30 ft or farther away from the tree-trunk. pH and available P_2O_5 were then determined, and some samples were also analysed for exchangeable potassium.

* Division of Plant Industry, Queensland Department of Primary Industries.

III. RESULTS

The results of an initial sampling from under a tree where the phenomenon was marked are shown in Table 1. Steep declines in phosphorus and potassium existed from the tree-trunk outwards. pH fell sharply beyond 24 ft. The trend was similar for both the northern and the southern radii.

TABLE 1

Soil Nutrient Status under a Poplar Box Tree at "Tooloon", Charleville
0–3 in. depth

Radii	Northern Radius					Tree Trunk	Southern Radius				
Distance from trunk (ft) ..	44	34	24	14	4	—	4	14	24	34	44
Available P_2O_5 (p.p.m.) ..	26	28	48	145	400	—	332	60	38	16	23
K^+ (m-equiv. %)	0·27	0·28	0·39	0·54	0·74	—	0·57	0·65	0·50	0·38	0·28
pH	6·8	7·4	7·9	7·9	7·8	—	7·2	7·4	7·3	5·8	5·6

In order to determine whether the gradient in soil fertility from the tree to the open was fortuitous, two further groups of soil samples to a depth of 1 in. were randomly taken under and away from poplar box trees in the Charleville district (Table 2). The differences in available phosphorus between the microhabitat under trees and away from trees were large and highly significant in both areas sampled. The difference in pH between habitats was small and unproven in the south, east and north, and larger and highly significant in the western areas. The difference in exchangeable potassium level was small but highly significant.

TABLE 2

Soil Nutrient Status Under and Away from Poplar Box Trees
0–1 in. depth

—	East, North and South of Charleville (21 trees)			West of Charleville (24 trees)	
	Avail. P_2O_5 (p.p.m.)	K^+ (m-equiv. %)	pH	Avail. P_2O_5 (p.p.m.)	pH
Tree microhabitats ..	156	0·96	6·9	150	7·2
Inter-tree areas	51	0·65	6·7	86	6·6
Mean differences	105**	0·31**	0·2 (NS)	64**	0·6**
Value of "t"	4·60	21·04	1·57	4·52	4·73
"t" requirement for $P < 0{\cdot}01$		2·85		2·81	

** Differences highly significant
NS Difference not proven

To determine whether a higher soil fertility status occurred elsewhere, 14 trees of species other than poplar box were selected throughout the district and paired soil samples were taken and analysed. The results are shown in Table 3.

TABLE 3

SOIL NUTRIENTS UNDER DIFFERENT TREES IN SEMI-ARID QUEENSLAND

0–1 in. depth

Species	Tree Microhabitat			Inter-tree Areas		
	Avail. P_2O_5 (p.p.m.)	K^+ (m–equiv. %)	pH	Avail. P_2O_5 (p.p.m.)	K^+ (m–equiv. %)	pH
Applegum No. 1 (*Angophora* sp.) ..	95	0·36	6·8	40	0·30	6·6
Applegum No. 2	13	0·63	7·3	15	0·19	8·0
Forest bloodwood (*Eucalyptus dichromophloia*)..	18	0·40	6·0	36	0·31	5·7
Kurrajong No. 1 (*Brachychiton populneum*)	164	0·66	6·5	78	0·45	7·2
Kurrajong No. 2	40	0·85	6·9	24	0·55	5·9
Bowyakka (*Acacia bowyakka*)	149	0·75	6·5	78	0·45	7·2
Eastern dead finish (*Albizzia basaltica*)	138	0·79	5·5	32	0·55	5·8
Bottle tree (*Brachychiton rupestris*) ..	98	0·98	6·9	48	0·60	5·7
Carbeen (*Eucalyptus tessellaris*) ..	400	0·78	6·9	372	0·68	6·8
River red gum No. 1 (*Eucalyptus camaldulensis*)	205	0·47	6·5	70	0·97	7·6
River red gum No. 2	163	0·64	8·1	70	0·30	7·8
Gidyea (*Acacia cambagei*)	83	0·74	7·2	67	0·37	7·4
Western bloodwood No. 1 (*Eucalyptus terminalis*)	60	1·16	6·9	38	0·88	6·6
Western bloodwood No. 2	50	1·16	6·7	44	0·49	5·6
Means	120	0·74	6·8	72	0·51	6·7
Mean differences between sites	48	0·23	0·1 NS.			
Value of " t "	3·916	3·309	0·295			
" t " requirement for $P < 0{\cdot}01$		3·012				

In the microhabitat provided under some trees other than poplar box, soils also had a significantly higher available phosphorus and exchangeable potassium status than soils in the open. The differences in soil pH between the microhabitat and outside were insignificant.

The evidence that the surface soil under mature poplar box canopies has a higher available phosphorus and exchangeable potassium status was not without exceptions; the reverse applied in 4 out of 47 sites in the case of available phosphorus, and in one case the exchangeable potassium status was the same as in the inter-canopy area. The differences in pH were too inconsistent to enable a trend to be discerned: pH was higher away from the microhabitat provided by poplar box trees in 14 out of 47 situations, and in 4 it was identical.

Samples obtained from under other tree species confirm the higher soil nutrient status found under poplar box trees. Exceptions to the general trend occurred with applegum No. 2 and forest bloodwood in the case of phosphorus, and with river red gum No. 1 in the case of potassium. The 6 instances out of 14 where pH was lower in these microhabitats approximate the 14 out of 47 cases where this occurs under poplar box trees. More extensive sampling is clearly indicated before an association between pH and trees can be established.

IV. DISCUSSION

Sampling the surface soil only may be criticised on the grounds that such data would not be reliable criteria for assessing the general nutrient status of the soil profile exploited by herbage plants. In this case, shallow sampling is justifiable, since the seedbed characteristics of non-cultivated country are under investigation. The extent of the soil nutrient-tree association in the deeper soil layers has not been explored.

The study points to the existence of an association between the microhabitat under some mature trees and the nutrient status of soil developed under such micro-environments. A diligent search failed to reveal communities of either *Paspalidium* or ready establishment of *Cenchrus* under either seedling or young poplar box trees.

Fireman and Hayward (1952) in Utah found an increase in soil sodium beneath greasewood (*Sarcobatus vermiculatus*) and suspected the organic acids in the leaves to play a major role in the exchange reactions. Rickard (1965) in Washington found the same shrubs to increase not only sodium but also exchangeable potassium and pH of soil beneath their canopies and assumed that soil changes could have occurred within the past century.

Another possible origin of the minerals could be topsoil blown in under and against the trunks of trees. Inter-tree areas, denuded by overgrazing, fire or drought, or a combination of these agencies, could be adding to the minerals *in situ*.

The relationship is thought to be more probably due to a joint association of these minerals with other factors such as deep-rootedness, accumulation of soil and plant remains, and longevity of poplar box and some other trees. The higher soil nutrient status and the presence of specific plant communities under trees may derive from the build-up of leaves, twigs, bark and possibly bird and animal droppings over a long period. Fertility transference by animals is unlikely to be an important factor in savanna woodland stocked at less than 1 sheep to 10 acres. Johannesson (1958) suggested that the deeper root penetration and longer active growth period of trees, as compared with grasses, result in trees producing more organic material and also translocating more phosphate. He quoted Harradine (1954), who found that organic nitrogen and organic carbon content of soils under trees was much higher than under grass.

Dunne (1951), in an investigation of the profuse growth of subterranean clover (*Trifolium subterraneum*) under marri trees (*Eucalyptus calophylla*) in Western Australia, considered that appreciable quantities of mineral elements, especially potash, are added to the surface soil by annual leaf fall from the trees.

The accretion of plant remains is followed by increased microbial activity, which is especially marked in the surface layers of the soil. A higher soil organic matter content results. This in turn influences the amounts of available phosphorus, nitrogen and sulphur and the cation exchange capacity (Williams 1962), and possibly increases the range of plant available water.

Further studies will attempt to determine the origin, nature, extent and implications for improved pasture growth of the higher soil nutrient status under tree microhabitats. Research of this kind could also lead to a better understanding of the operative mechanisms of and reasons for seral development in these plant communities. Such investigations could also result in an elucidation of the requirements for establishing *Cenchrus ciliaris* and other cultivars in a semi-arid environment on notoriously infertile, self-sealing soils.

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