COMPARATIVE PHOTOSYNTHETIC EFFICIENCY OF SOME NATIVE AND INTRODUCED GRASSES

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THE ABILITY OF PLANTS to capture light energy is the key to the continual survival of all life. Light absorbed by the green parts of plants is used to fix carbon dioxide from the air and convert it into energy-rich compounds which are then translocated to other parts of the plants. There they may be stored or used to provide energy for growth processes with consequent release of carbon dioxide. This energy from sunlight which is stored in biochemical compounds is the only source of energy for growth and is only a small portion of the total incident sunlight. The rate at which plants can take up carbon dioxide is thus a good measure of the rate at which plants absorb useful energy. However, in practice, only the net exchange of carbon dioxide which results from the uptake by photosynthesis and release by respiration can be measured.

Species differ greatly in their photosynthetic ability. The magnitude of these differences will depend not only on the species or variety but also on the climate and soil conditions in which the plant is growing. Thus two species which show similar performance in a mild climate may show large differences in the harsher, drier climates of the mountain lands and intermontane basins. These differences among species should be kept in mind in the search for high-producing species for these areas.

Nor, in the search for high-producing plants, should the characteristics of New Zealand native species be overlooked. After all, they have been living in the area for some million years and should have evolved features which allow them to thrive in this climate. Therefore the physiological features of native vegetation should be studied to establish whether these are relevant in the selection and management of species which are grown for increased production, To demonstrate the differences that can occur among species, and to make a start at looking at the physiological characteristics of the natives, measurements have been made of the rates of photosynthesis and respiration at various temperatures of three groups of grasses relevant to the high country. It is a preliminary report on these that will be presented here.

The species examined were fescue tussock, silver tussock, blue tussock, narrow leaf snow tussock, sweet vernal, browntop, cocksfoot, and ryecorn. The first four are examples of native grasses which have evolved in this climate. Sweet vernal and browntop are what have been called "volunteer introduced" species, i.e., species that have spread by natural means into much of the tussock grassland. Sweet vernal is clearly in this category, but browntop is questionable in that it spreads naturally only in the wetter areas, or in areas of slightly increased fertility, e.g., along sheep tracks. The last two are high-producing grasses which generally show little spread outside areas of increased fertility.

The plants were obtained as either field transplants in the case of the native tussocks, or grown from seed. They were grown for several weeks in nutrient culture in a growth cabinet set to simulate the conditions of late spring-early summer in the short tussock grasslands (60°F 15hr light/45°F 9hr dark). By growing plants in nutrient culture, the whole plant could be used, i.e., both root and shoot. Each plant in turn was transferred to a special plant chamber in which the temperature and light can be carefully controlled and in which the rate of carbon dioxide exchange can be measured with an infra-red gas analyzer. The measurements were made in the sequence: dark respiration at 70°, 50°, 35°F, and then net photosynthesis at a light intensity of 2,000 foot-candle (quartz iodine lamp) at 35°, 50°, 70°, 85" and 95°F. Each condition was maintained for half-an-hour before the measurement was taken, except for one hour when the lights were first turned on. Five plants of each species were used.

The results for ryecorn are given in Fig. 1, where the lower line gives the dark respiration, as would occur at night, and the upper line net photosynthesis, as would occur during the day. The first thing to note is the scatter of points which is caused by variation between plants.

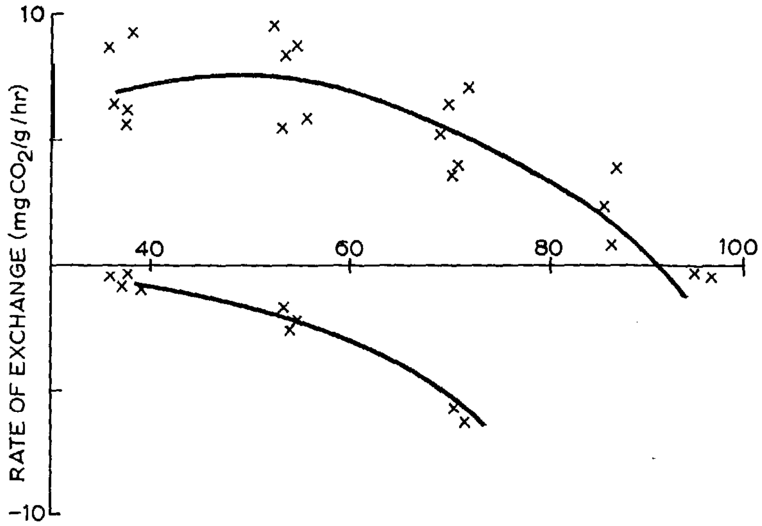

FIG. 1: *Dark respiration and nef photosynthesis at 2,000 foot-candles of five plants of ryecorn at various temperatures.*

This is usual on this sort of work, and differences of about 20 to 30% among individuals of a species are common. The indications are that the variation is very much less when cloned material is used. These types of observe tions suggest that there is considerable genetic variability within species in their photosynthetic ability. This characteristic could be a valuable one to select for in any breeding programme.

Representative values for the other species- are given in Table 1. The values for net photosynthesis in the light show the large differences among the various species. As expected, the high-producing species show the maximum rates at all temperatures and the slow-growing natives the minimum rates. Cocksfoot and ryecorn-which are considered to be better producing species in these areas—have rates which are below that of the two volunteer species. Of the natives, silver and blue tussock show similar rates, the fescue tussock rates are lower, and snow tussock the lowest. The low rates for ryecorn are possibly associated with leaf arrangement, as ryecorn-like the native tussocks-has erect leaves whereas the leaves of the other three species are more horizontal. All the introduced grasses have a similar upper temperature limit of about 100°F.

TABLE 1: NET PHOTOSYNTHESIS AND RESPIRATION OF NINE SPECIES OF NATIVE AND INTRODUCED GRASSES AT 45 deg., 70 deg., and 95 deg. F

As mg Carbon Dioxide per Gram Dry Weight of Whole Plant per Hour, Light Intensity of 2,000 foot-candle,

Species	Net Photosynthesis			Respiration	
	45 deg.	70 deg.	95 deg.	45 deg.	70 deg.
Native Tussocks					
Fescue tussock	1.8	1.1	-1.2	-0.5	-1.8
Silver tussock	3.5	2.5	-0.3	-0.8	-2.2
Blue tussock	4.3	2.9	0	-0.8	-2.3
Narrow leaf snow tussock	0.5	-0.1	—	-0.2	-0.9
Volunteer Introduced Species					
Sweet vernal	13.4	10.6	3.1	-1.6	4.6
Browntop	12.7	10.1	4.4	-1.8	-6.2
Improved Introduced Species					
Cocksfoot	11.7	9.3	3.7	-1.2	-2.9
Ryecorn	7.5	5.4	-1.7	-1.4	-5.0

The dark respiration measurements show similar differences among the species, though the actual values are very much less.

With the exception of ryecorn, all grasses appeared to have their maximum photosynthesis at the lowest temperatures. This does not mean plants grow best near freezing point. What has been measured is the net carbon dioxide exchange of a whole plant, i.e., the uptake by the leaves, less the loss by respiration from the leaves, stems, roots, etc. Over short periods such as the half-hours used in this study, the processes of photosynthesis and respiration are largely independent of each other. However, over longer periods the two processes interact. The' rate of respiration will be influenced by the rate of supply of the photosynthetic products to the various parts of the plant, and this will be determined by the previous temperature and light received by the leaf and by the influence of temperature and other environmental factors on the transport of these products out of the leaf to other parts of the plant. Also, if the products of photosynthesis are not removed from the leaf they will inhibit the process of photosynthesis. It is probably the inhibitory effects of low temperature on the translocation and utilization of the photosynthetic products which causes the poor growth at low temperatures rather than the effect of low temperatures on the photosynthetic process itself. Thus the measurements given refer to the rates of carbon dioxide exchange of plants grown at one temperature and then subjected to brief changes of temperature during which there has probably not been time for the effects of accumulation and transport of products to become apparent.

What all these results have shown is the large difference in photosynthesis efficiency among different grasses, and the great potential there is for increased production by changing a less efficient species-in this case, the native tussock-for more efficient ones-either one of those considered here or others. This is assuming there are good growing conditions, and also that the same plants can survive poor periods and continue to express their production potential reliably over a number of years. The less efficient natives have a place by virtue of the fact that they already exist and thrive in these areas. It is because of this that further investigation is required into the physiology of the native species to see what features they have which can be considered as adaptations to the New Zealand environment and which may be worth while to look for in selecting plants for these areas. The field *is* wide open for research in this direction. This paper has looked at photosynthesis after short periods at various temperatures and there does not appear to be anything special about the natives in this respect, apart from the fact that they have very low rates-and this is not what is wanted. Of the many other aspects that should be looked at, the one that would be most valuable is *to* see how these native grasses withstand drought conditions. Another feature which should be investigated is the significance of the "tussock" form of growth which is common in New Zealand, but which is relatively rare in other parts of the world. By the tussock habit is meant a plant with a dense base with many relatively narrow upright and spreading leaves. In New Zealand it can be observed in the short tussocks, in the tall red and snow tussocks, in the Spaniards or spear grasses, in the native flaxes, and in other species. What is there about the tussock form of growth which suits it for the New Zealand climate?

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