ites form a break in this rule: they form a coherent group, independent by their geological occurrence and by their petrological, chemical, and geochemical properties.

The geochemical comparison between Cb and Ta manifests that Cb is the more common and more abundant of the two. With the use of the abundance number of Cb in igneous rocks, one can approach the question of whether or not this element follows the rule of Oddo and Harkins, according to which the elements with odd atomic number are more rare than their neighboring elements which flank them in the Periodic Table. Thus, we should expect that Cb is less abundant than Zr and Mo. The abundances of these three elements, expressed in grams per metric ton, are: Zr, 220; Cb, 24; Mo, 15. Cb most certainly does not follow the rule, but the cause of this deviation may probably be found in the too small value of Mo.

It may be stated, as a general rule, that Cb and Ta commonly occur together, and that minerals and rocks relatively high in one are also usually high in the other. Thus, these elements form a quite coherent pair, as can be expected from the similarity of their ionic radii (Cb^{5+}, 0.69A.; Ta^{5+}, 0.68A.), this being due to the lanthanide contraction, further, from the similarity of their ionic charges and of their ionic types. There is also a marked chemical similarity between these two elements. It could thus be expected that no pronounced separation between them would take place in Nature.

However, this pair is not too coherent, and it is inferior to the rare earths or to the pair Zr-Hf, as is shown by the fact that its component elements are quite often actually separated in Nature. It is even possible to find a geological unit, or area, where, in some minerals at least, the normally less abundant of these two elements predominates. Compared with the pair Zr-Hf, it is noted that geochemical camouflage is in no other case more pronounced than that of Hf by Zr. In conclusion, while easily capable of separating Cb and Ta, Nature is unable to separate Hf from Zr with her methods of analysis. This fact is reflected also in certain chemical features of these elements: no method of everyday chemical analysis is known which is suited for the determination of Hf in the presence of Zr, the separation of Hf from Zr being unexampled in difficulty. Cb and Ta, on the other hand, can be comparatively easily separated from each other by Marignac's method, and routine determinations of these elements by the ordinary methods of chemical analysis are carried out in many laboratories.

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Sensitivity of Grasses and Some Crop Plants to Isopropyl-N-Phenyl Carbamate

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It has been reported that some urethanes injure or kill grass plants when applied to soil in which the plants are growing (*1*, *2*). Greenhouse experiments were undertaken in October 1946 to study the sensitivity of various grasses to isopropyl-n-phenyl carbamate (IPC) and to compare their sensitivity to this compound with that of some dicotyledonous plants.

Seeds of grasses and dicotyledonous plants were sown in fertile potting soil to which known amounts of IPC were added.[1] In some experiments the carbamate was first mixed with a small amount of quartz sand, and this mixture was then added to soil and the seeds planted. In other experiments the carbamate-sand mixture was spread evenly on the surface of the soil after it had been potted and the seeds planted. The amount of sand used was 10 grams/pound of soil.

The IPC affected the growth of grass seedlings in varying degrees, depending on the method of application. When applied

TABLE 1

Emergence of Bluegrass and Crab Grass Seedlings*

Mg. IPC/ pound of soil	Bluegrass†		Crab grass	
	A	B	A	B
0.0	80	57	29	18
3.4	5	3	30	27
10.2	11	0	31	21
20.4	8	0	39	22
40.8	3	0	40	25

*Values represent average percentages of emergence in successive experiments, A and B. Four replications of each treatment (4 × 50 seeds) were used for each experiment.

†Although some bluegrass plants emerged in treated soil, they failed to grow more than ½ inch above the surface.

to the surface of soil at a rate equivalent to 2 pounds/acre (calculated on an area basis), IPC prevented the emergence of quack grass seedlings,[2] while 91 per cent of the seeds planted in comparable untreated soil emerged and grew vigorously. When the same amount of carbamate was worked into the upper 1 inch of soil, the treatment was less effective since 18 per cent of the quack grass seedlings emerged and grew vigorously. IPC applied at a rate equivalent to 2 pounds/acre and cultivated into soil to a depth of approximately 4 inches was even less effective in inhibiting the emergence of the seedlings.

Differences in the sensitivity of grasses to IPC became apparent when crabgrass and bluegrass seeds were planted in soil containing known amounts of the chemical. Emergence of bluegrass seedlings was greatly reduced in soil that contained as little as 3.4 mg. of IPC/pound, while the emergence percentage for crab grass (*Digitaria sanguinalis*) increased with the addition of IPC to the soil (Table 1). Toole (*3*) has reported that the germination percentage for crab grass (*D. ischaemum*) was in-

[1] Compound furnished by J. T. Baker Chemical Company, Phillipsburg, New Jersey.

[2] Quack grass seeds furnished by O. M. Scott & Sons Company, Marysville, Ohio.

creased through the addition of nitrates. Although the emergence percentage of partially dormant crab grass was apparently stimulated by IPC in this experiment, the subsequent growth of the plants was greatly inhibited.

TABLE 2

SENSITIVITY OF SOME MONOCOTYLEDONOUS PLANTS TO IPC WHEN APPLIED TO THE SOIL AT A RATE EQUIVALENT TO 5 POUNDS/ACRE*

Plant	Emergence index	Plant	Emergence index
Bermuda grass	130	Fescue	0
Amber sorghum	99	Ryegrass	0
Sudan grass	88	Redtop	0
Millet	86	Timothy	0
Bluegrass	4	Orchard grass	0
Barley	0	Quack grass	0

*Values represent relative emergence from seeds planted in treated soil calculated on the basis that emergence in comparable untreated soil equaled 100 per cent.

On the basis of the emergence percentage of grass species tested, the effect of IPC when added to soil varied from complete inhibition in the case of quack grass, fescue, and others (Table 2) to stimulation of growth during the very early stages of development of Bermuda grass and crab grass (Tables 1 and 2). Applied at higher rates (30–60 pounds/acre), the effect of IPC on the growth of less sensitive species (sorghum, Sudan grass) was prolonged so that the plants grew above the surface of the soil for a distance of 1–3 cm. and then failed to develop further. Microscopic examination revealed that these plants remained alive but stunted after appearing above the surface. These stunted plants failed to produce seeds.

When IPC was applied at relatively high rates (50 and 100 pounds/acre) to potted soil in which crab grass had become established and had developed leaves extending about 1–2 cm. above the surface of the soil, the plants failed to grow further and died within a period of 2 weeks following treatment.

To observe the effect of the carbamate on the emergence and growth of such crop plants as sugar beets, table beets, carrots, radishes, onions, and spinach, seeds of these crops were planted, together with measured amounts of quack grass seeds, in soil to which different amounts of IPC were added. When applied evenly to the surface of the soil at the rate of 2 pounds/acre, IPC completely prevented the emergence of quack grass seedlings and only temporarily checked the growth of sugar beet seedlings which germinated from seeds planted in the same lot of treated soil (Fig. 1, Table 3). The emergence percentage for onions was not reduced by the presence of IPC in soil at rates of 2, 4, or 8 pounds/acre (Table 3). The growth of radishes was slightly less in soil treated at the rate of 2 pounds of IPC/acre than in untreated soil. The growth of spinach and table beets was not visibly affected by the application of the carbamate at the latter rate to soil in which the seeds were germinated and the plants grown for a period of 6 weeks.

IPC is inactivated in the presence of moist, fertile soil (*1*), as is the case with 2,4-D. In testing for the inactivation of IPC, quack grass failed to survive when the seeds were planted in soil to which 40.8 mg./pound of soil had been freshly added.

TABLE 3

AVERAGE PERCENTAGES OF EMERGENCE FOR ONION AND SUGAR BEET PLANTED TOGETHER WITH QUACK GRASS IN SOIL TREATED WITH DIFFERENT AMOUNTS OF IPC*

Pounds IPC/acre	Onion	Sugar beet	Quack grass
0	46	76	98
2	69	69	0
4	59	83	0
8	68	66	0

*Carbamate applied to surface of soil at time seeds were planted.

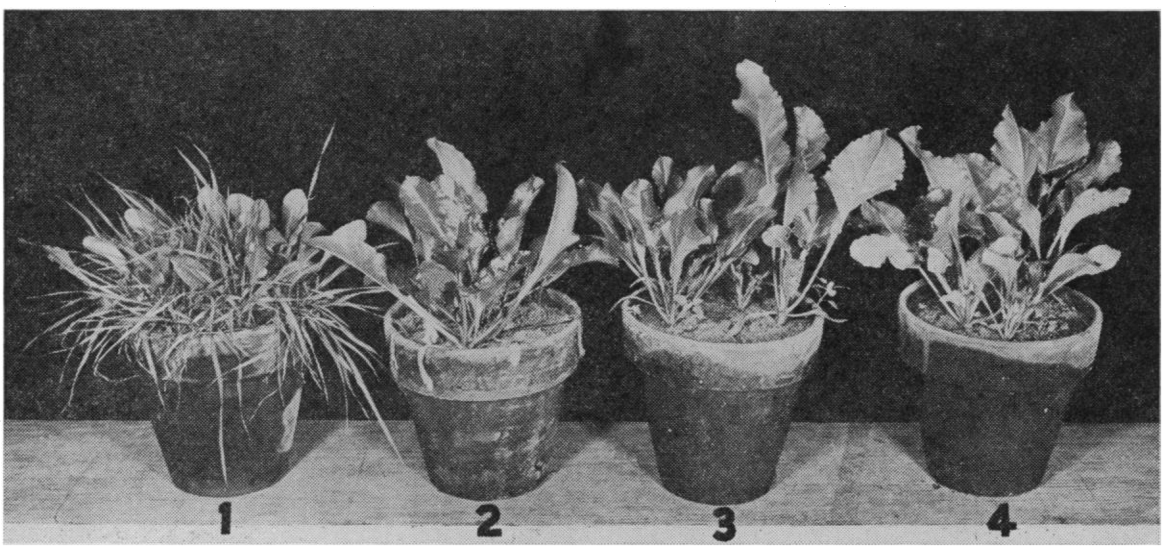

FIG. 1. Measured amounts of sugar beet and quack grass seeds planted together in potted soil. IPC applied to surface of soil immediately after planting at rates equivalent to (1) 0.0; (2) 2.0; (3) 4.0; and (4) 8.0 pounds/acre. Photographed 6 weeks after planting.

Subsequent to this test the soil was kept moist in a greenhouse for a period of 2 months, at which time it was reseeded. Eighty-four per cent of the quack grass seeds germinated, and the plants grew vigorously and showed no symptoms of injury, indicating that the carbamate had been inactivated, possibly through the action of soil microorganisms.

The present results from greenhouse experiments indicate that isopropyl-n-phenyl carbamate may be useful in reducing the population of some weedy grasses, such as quack grass, which infest certain crop areas.

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Geomagnetic Control of F_2 Layer Ionization

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In a recent communication to *Nature* (*2*) the author has given a brief account of the results of a study of the world distribution of F_2 layer ionization. Such a study has only become possible in recent years, when, to serve the operational requirements of the Allied Forces, many new ionospheric stations have been set up in different parts of the world. The chief results which have emerged from this study of F_2 layer morphology can best be illustrated by considering the local noon values of critical frequency at the equinoxes, when the earth is symmetrically illuminated by the sun with respect to the geographic equator. From these values it has been deduced that (a) for a constant longitude, the noon values of ionization at the same numerical latitude, north and south of the equator, are not necessarily equal, and (b) there is a variation of noon ionization with longitude along a line of constant latitude. It will thus be seen that, according to these results, it is not possible simply to relate noon equinox values of critical frequency for the F_2 layer to the sun's zenith distance, as is possible in the case of the E and F_1 layers. An additional controlling factor has therefore been sought.

In Fig. 1 is plotted the relation between equinox noon F_2 layer critical frequency and magnetic latitude, using all the data now available to the author for March 1944. It will be seen that the anomalies mentioned above, which appear when ionization density is related to geographic latitude, have now substantially disappeared.

One of the most remarkable features of Fig. 1 is the trough of low values of ionization density centered on the geomagnetic equator. A study of the detailed ionospheric information available from stations between $\pm 18°$ magnetic latitude shows that these low values are associated with a marked bifurcation of the F layer into its two components, F_1 and F_2. The phenomenon can thus be linked with others already identified previously in studies of the seasonal variation of F_2 layer noon ionization at Slough, England (lat. $51\frac{1}{2}$°N.). In measurements made at that station it has been found that there is a remarkable difference between summer and winter conditions. In winter the F layer appears fairly homogeneous and the ionization density is high, whereas in summer, under conditions of reduced solar zenith distance, there is marked bifurcation of the layer into its two components and the ionization of the upper component (F_2 layer) is much reduced. Under such conditions of bifurcation the F_2 layer exhibits entirely different physical characteristics. The electron production rate at the layer maximum is much reduced, as is also the electron recombination coefficient. Moreover, the variation of ionization is no longer substantially symmetrical about noon, there being often a minor minimum at mid-day, the major maximum of the day occurring in the evening.

It is therefore found that the equinox phenomena experienced at stations situated between magnetic latitude $\pm 18°$ are similar to those experienced at Slough in a northern summer, when the ionization in the F layer as a whole is distributed through a great range of vertical heights. On the other hand, the ionization maxima (Fig. 1), at $\pm 18°$ magnetic latitude, are

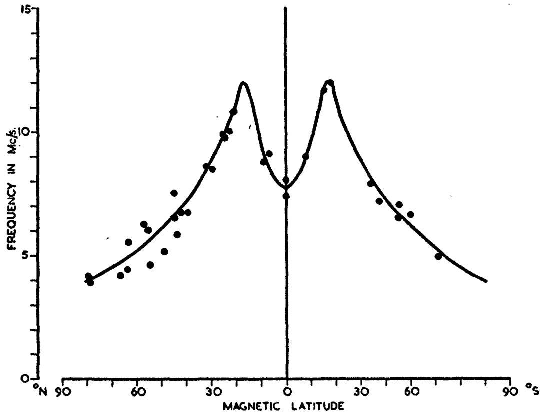

FIG. 1. Relation between equinox noon values of F_2 layer critical frequency and magnetic latitude.

associated with a relatively thin homogeneous F layer without marked bifurcation.

The long-term study of F_2 layer ionization has shown that, as in the case of the E and F_1 layers (*3*), there is marked variation of ionization in sympathy with the trend of the sunspot cycle. Such a correspondence is most strikingly exhibited if ionization density is compared with calcium flocculi figures (*1*). But, in addition, the author has found that the ratio $\frac{N_{max.}}{N_{min.}}$, where $N_{max.}$ and $N_{min.}$ refer to noon ionization densities at sunspot maximum and minimum, respectively, is not constant at any station for each month in the year. For example, this ratio is approximately 4 for the summer months (May, June, and July) at Slough and approximately 2 for the winter months (November, December, and January). Such a variation indicates that either the intensity of the ionizing radiation or the atmospheric medium which is ionized varies throughout the year. A study of similar phenomena at a number of stations in addition to Slough suggests that it is the seasonal variation of the atmospheric medium which is substantially responsible.

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