the path of least resistance; they made or used upward of a hundred different grades.

Six to Twelve Will Do

In Tennessee there is no legal limit on the number of grades. During 1938–39, some 85 different mixed goods were offered for registration and sale! (Most of the tonnage, however, moved in a relatively few grades.) The College of Agriculture now recommends only 12, but, as in the past, the bulk of the complete (NPK) tonnage movement is with six grades.

Georgia also permits unlimited registration and sale of fertilizer grades. But the College of Agriculture and the Georgia Plant Food Educational Society only make recommendations from a list of 12. Even with unlimited registration, a mere handful of grades supplies practically all of the tonnage.

Alabama's State Department of Agriculture very definitely restricts registration of mixed fertilizers to a specific number—12 for 1955. The College of Agriculture recommends ratios or grades to the State Board of Agriculture which, after a hearing with industry representatives, issues the approved list.

From his experience in analyzing soil samples, the Director of the Alabama Soil Testing Laboratory recently stated that in his judgment Alabama needs only four complete (NPK) ratios or grades for practical coverage of all the state's soils and crops. In the early days there were as many as 50 grades sold annually in Alabama, but in 1954–55 only 12 grades are on the approved list. For the future, it looks like four NPK and three OPK grades will meet all requirements.

North Carolina and Mississippi, along with several other states, have strict legal requirements governing the number of permissible grades. In these states the College of Agriculture and the State Department of Agriculture are working and cooperating with industry in arriving at the suitable number.

But Why Not Four?

Louisiana takes a different road. Each year certain "experimental" grades are added to the "approved" list on a trial basis, and "specialty" grades are permitted. This may look sound, but in practice it has led to abuses—which multiply the problems of research, industry, and education in maintaining a reasonable list.

In the seven year period 1944–51, Louisiana had an average of 19 NPK grades, but six grades represented 94% of the tonnage. This would indicate that Louisiana's situation is getting worse, while in most other states the trend is toward approved lists of fewer grades.

Fewer grades lead to less storage space in factories, less price spread between low and high grades, and less cost per pound of plant food in higher analysis goods. Manufacturers can reduce their assembling and handling problems at the plant's loading platform; they save money on registration, tag and bag printing costs, keeping of records, and chemical control procedures. Fewer grades encourage farmers to follow recommendations and create more confidence on the part of the customer.

Since the soil tester does not attempt to pinpoint his figures, why should farmers try to add accuracy that doesn't exist? The soil test simply indicates whether the essential plant food elements are in low, medium, or high supply—low, medium, and high have different meanings for different soils.

The problem is to match a low phosphorus soil with a high phosphorus fertilizer to give the plant or crop a balanced phosphorus ration. And the same is true for potash, calcium, sulfur, magnesium, and the trace elements. With the guaranteed mineral elements (PK) in a complete (NPK) grade, the ratio is either high-low, low-high, or equal. Agronomists have spent days trying to figure out other combinations for Louisiana, but the suggested arrangement seems to be the answer—it especially satisfies the requirements for cotton, corn, grain, pastures, and other crops.

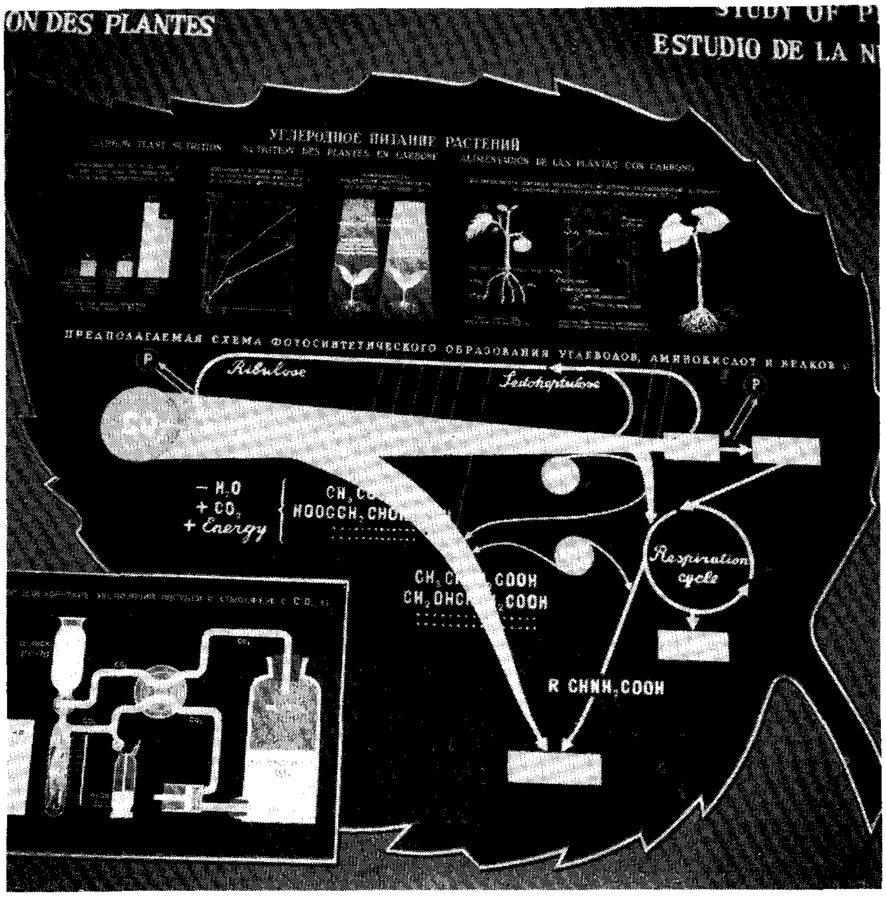
Manufacturers of fertilizer could reduce their assembling and handling problems, save money on tag and bag printing costs, reduce record keeping, simplify chemical control procedures, according to many observers, if the number of fertilizer grades available to farmers were to be reduced

Isotopes in Russia

Radioactive isotopes being employed extensively in U.S.S.R. to solve laws of plant life

USE OF RADIOACTIVE ISOTOPES as a tool leading to advancement in biology and agriculture has been described widely in many countries. Less known are investigations that have been made in U.S.S.R. At the recent United Nations' "Atoms for Peace" Conference in Geneva, Russian scientists told of research in their country which has led to clearer understanding of effective applications of granulated fertilizers, nonroot nutrition, and more effective utilization of fertilizers for feeding plants. Some of the developments were described as "new." Others were said to parallel coincidentally research and findings in other countries. All pointed in an emphatic manner to the fact that development and improvement of practical farming methods in U.S.S.R. have resulted from research of biologists, chemists, and agronomists employing marked atoms and the energy of radioactive disintegration for a better understanding of many facets of plant life.

Root nutrition is that aspect of the physiological development of plants which is most easily controlled. As a result, many scientists employing radioactive phosphorus, calcium, sulfur, and other elements, have concentrated their work on problems of distribution and transformation of nutritive substances in the soil and their assimilation by plants. Earlier, it was believed that only 10 to 12% of phosphorus fertilizers was assimilated by plants. This opinion, based on comparison of amount of phosphorus present in plants grown on fertilized and nonfertilized soils, made no distinction between phosphorus present in the soil and that introduced with fertilizer. A. L. Kursanov, member of the Soviet Academy of Sciences, who reviewed Russian applications of isotopes in agriculture, gave a new understanding of this factor as one of the significant contributions to better understanding of plant life. Rather than 10 to 12%, plants pick up 48 to 68% of phosphorus in fertilizer. Radioactive phosphorus-32 in double superphosphate was used to establish these results showing that plants assimilate several times as much phosphorus fertilizer as previously believed. The work should lead to means of increasing percentage of phosphate assimilated by plants directly from soil, Kursanov believes.



Russian exhibit at Geneva Atoms for Peace Conference reported on benefits to agriculture of research using radioactive isotope techniques

Placement Technique Advance

Through use of phosphorus-32, the rational distribution of fertilizer in the soil, guaranteeing complete and rapid assimilation by roots, can be established. This has been another problem of vital importance in U.S.S.R., where granulated phosphoric fertilizers were said to be widely used. Radioactive phosphorus appears in leaves only 15 to 20 minutes after contact with granule containing it is made by root. Conversely, by observing appearance of radioactivity in leaf, it is possible to determine the rate at which a given fertilizer is assimilated and best application of granules—distance away from seeds or plants—can be set up for various crops and for various methods of mechanized fertilization. A number of Soviet experiment stations are using the phosphorus isotope in field experiments to determine how different plants assimilate phosphoric fertilizers in presence of other elements and varying conditions of humidity, liming, and other factors.

Distribution of root systems, formerly studied by laborious and inefficient digging and sorting methods, can be observed through introduction of radioactive isotopes of several elements into the various soil strata. The scientist can observe distribution of roots in the strata without disturbing plant structure by observing appearance of radioactivity in leaves. Influence of soil cultivation, time and method of irrigation, temperature and other factors affecting root system, all of which are necessary for proper nutrition, can thus be studied. Through use of phosphorus-32 it has been established that the root system is not a uniformly acting mechanism which sends water and nutritive substances to above-ground parts of plants, but a highly adaptable organ whose activity in different sections is rapidly changing under influence of nutritive substances and plant requirements. It is this new understanding of the root system that partly explains how local deposits of granulated fertilizers can be utilized.

Nonroot Nutrition

In Russia, too, attention has been devoted to the problem resulting from those periods of development when a plant is often not able to absorb phosphorus and other needed food elements via the root system. Radioactive isotopes helped to solve this problem. Labelled superphosphate was applied as a nonroot nutrient, its penetration through leaves and inside the plant observed, and, by means of radioautographs, its distribution in the tissues established. As a result, efficiency of nutrition and time and amount of application were established. Nonroot nutrients are now applied by various means, including sprinkling, pollination, and fumigation. Higher yields of sugar beets and cotton have resulted from nonroot application of phosphorus, and foliar application of ammonium salts has boosted yield of cabbage and other vegetables.

Use of carbon-14 has explained other functions of the root system, which are of both theoretical and practical interest. Roots absorb carbon dioxide from the soil. This is conveyed to the leaves and other green parts. Provided there is sufficient light, carbon dioxide from the soil can be as important as that from the air in synthesis of sugars and other products of assimilation. The important role that humus and microbiological processes in soil play in supplying carbonic acid to plants is thus established.

With carbon-14, it was shown that the sugars formed in leaves move downward and into the thinnest and most active root branchings. In the roots, the sugars undergo glycolitic disintegration with formation of pyruvic acid. This acid, with help of enzyme present, picks up the carbonic acid from the soil. The carbonic acid, in form of carboxyl, combines with pyruvic acid and transforms it into oxaloacetic acid, which is reduced to malic acid. The latter is the first comparatively stable compound containing carbonic acid from the soil. It is subsequently partly transformed into citric, keto-glutaric, and other acids. It takes little time for the carbonic acid of the soil in form of organic acids to reach assimilating tissues in green fruit and other parts where it can be reduced in process of photosynthesis to form carbohydrates, proteins, and other energy-rich products.

In other work, employing isotopes and chromatographic analysis, it has been found that the roots synthesize about 14 amino acids. These are partially utilized in the roots and partially in other parts of the plant where they are involved in metabolism and synthesis of new proteins. Thus, in addition to absorbing function, the root system plays an important role in protein metabolism of entire plant. It is by this mechanism that roots assimilate ammonium nitrate from the soil, according to the Russian viewpoint.

Use of radioactive isotopes to determine speed as well as direction of flow of materials in the plant has considerably altered former opinions that various processes occur very slowly. Russian scientists have found, for example, that products of photosynthesis travel from leaves to roots of sugar beets and pumpkin at rate of 70 to 100 centimeters per hour, or faster. The movement toward fruits and growing shoots is slower, but usually not less than 40 to 60 centimeters per hour. In majority of agricultural crops, it takes only 20 to 40 minutes for products of photosynthesis to reach growing points and organs of accumulation. Other tests show that water moves along the xylene of some trees at a rate of 6 to 8 meters per hour.

Radioactive carbon is also being used to investigate the composition of substances that move in plants. Sacchrose and hexose phosphoric ethers move faster than other compounds in the mixture of substances moving along the connecting tissues of beets, pumpkin, and cotton, and are thus credited as being the most mobile substance in plants. Also present are glucose, fructose, organic acids and amino acids. The mixture differs in various plants at various stages of development and under influence of light and mineral nutrition.

Using radioactive carbon as an observation method, it is possible to change the direction and composition of mate-

Reported Applications of Isotopes in U.S.S.R.

Problem	Isotope used	Results
What percentage of phosphorus fertilizer is assimilated by plants?	P^{32} in double superphosphate for wheat	48 to 68% of phosphorus assimilated from fertilizer; previously believed that only 10 to 12% assimilated. Work suggests methods to increase assimilation directly from soil
What is rational distribution of fertilizers in soil to ensure rapid and complete assimilation by plant roots?	P^{32} in granulated fertilizers for oats	P^{32} appears in leaves 15 to 20 min. after contact by roots. If placed 3 to 4 cm. below seeds, contact between roots and fertilizers occurs 2 to 3 days after germination; contact delayed 3 to 4 weeks if granules placed 5 to 6 cm. horizontally from and below seeds. Technique permits determination of rate of assimilation. Method being tested for mechanized fertilization of cotton.
What is result of single rootlet of root system coming in contact with a fertilizer granule?	P^{32}–labelled fertilizer for spring wheat	Absorbing function of single root comprising only 4 to 5% of root system increased 20 to 30 times when it contacts granule; it is then able to satisfy major requirement of plant for phosphorus. Thus, root system is not uniformly acting mechanism.
What is role of soil microorganisms in soil in plant nutrition?	C^{14}–labelled vitamin B_1 and isotopic sulfur for buckwheat	Vitamin B group easily absorbed by roots and development of plant enhanced; methionine and cystine also readily utilized.
At what speed does sugar formed in leaves travel to roots?	C^{14}–labelled CO_2 for sugar beets	Sugars move downward at rate of 70 cm./hr. along phloem and penetrate even smallest root branchings.
What is ascending speed of organic acids formed by roots?	C^{14}–labelled carbonic acid for herbaceous plants	Organic acids formed in roots from carbonic acid of soil move upward at speed of 3 cm./min. and penetrate green fruit, growing apices, and leaf laminae.
At what rate are proteins and chlorophyll renewed in plants?	N^{15} in ammonium sulfate for rye	Protein material constantly being renewed, some only lasting few hours. More than half of nitrogen in chlorophyll replaced in 2 to 3 days.
In what part of plant are nutritive substances localized?	I^{131}–labelled 4-iodophenoxyacetic acid solution for tomatoes	Greatest part of preparation concentrated in flowers and young fruit.

rials moving in plants, providing agriculture with new and yet undeveloped possibilities. Application is being made in North Russia where poor quality of potatoes has been a problem. Here the products of CO_2 assimilation move from leaves to stems and growing apices, causing slow and retarded flow of nutritive substances to tubers and excessive stems and leaves. Isotopic indicators are being used to determine efficiency of measures being studied to overcome the low-starch potatoes resulting.

Labelled atoms have also been used to study the effect of special chemical preparations, such as 2-4-dichlorophenoxyacetic acid, methyl ether of α-naphthylacetic acid, and 4-iodophenoxyacetic acid on plant growth and formation processes. Other work has led to better understanding of detoxication of alien substances in body of plant. Russian scientists have also shown that radioactive rubber appears in the latex of the plant, kok-saghyz, shortly after introduction of solution of carbon-14–labelled sacchrose, indicating that rubber originates from carbohydrates.

Fertilizer Situation

USDA report indicates nitrogen consumption up 7% last year . . . U. S. to become net exporter of potash for first time next year

Supplies of the three principal plant foods in the 1955–56 fertilizer year will probably exceed the 1954–55 supply by about 2.5%, according to USDA's "Fertilizer Situation" issued last month. This is based on existing rates of production and trends in usage and foreign trade rather than on a capacity to produce fertilizer, says the report.

Here's the USDA expectation for each plant food.

Nitrogen. About 2.35 million tons available for fertilizer, based on rates of production and usage trends, a 4.4% increase over 1954–55.

Phosphate. Available phosphoric oxide is forecast at 2.3 million tons, approximately the same as 1954–55.

Potash. Forecast of available supply as potassium oxide is estimated at 1.94 million tons, an increase of about 4.3% over 1954–55.

In the case of each plant nutrient, USDA emphasizes that its estimate is not based on ability to produce and that if demand arises much larger supplies can be produced, providing that the extra demand does not occur during the spring rush.

U. S. PLANT FOOD SUPPLIES

(In thousands of tons of N, P_2O_5, and K_2O)

	Nitrogen		Phosphorus		Potassium	
	Year Ended:					
	June 30, 1955	June 30, 1956	June 30, 1955	June 30, 1956	June 30, 1955	June 30, 1956
U. S. Production	1997	2167	2411	2445	1821	1947
Exports	155	198	169	210	97	146
Imports	408	381	70	65	141	138
Net Supply	2250	2350	2312	2300	1865	1939

Increased tonnages of nitrogen are expected in every category except ammonia for mixing and direct application. Ammonia, both anhydrous and aqua, for direct application is expected to hit 460,000 tons this year, compared with 414,000 tons last year, a better than 11% increase. Urea, reported for the first time this year now that four companies are producing it, is expected to jump some 30% to 50,000 tons, but the biggest increase is expected in nitrogen solutions for direct application—from 35,000 tons to 50,000 tons. Nitrogen exports are also due for an increase, according to USDA, from 155,000 tons in 1954–55 to 198,000 tons this year, with a decline in imports anticipated—from 408,000 tons to 381,000 tons. Biggest part of the export gain is expected in ammonium sulfate and ammonium sulfate-nitrate, compound solutions for mixing, and other solid forms such as ammonium phosphates, sodium nitrate, cyanamid, etc.

According to USDA figures, a round 2 million tons of nitrogen was consumed for agricultural purposes during the year ended last June 30. This was a 7% increase over the previous year's 1,847,416 tons, and not up to the average annual increase in recent times of 10%.

Total apparent consumption of nitrogen for all uses, less imports amounted to 2,337,206 tons, or about 70% of the nation's capacity to produce nitrogen on July 1, 1955.

Phosphate Expansion

Productive capacity of phosphates is expected to add another 250,000 tons in 1955–56, and a considerable part it will be in the form of ammonium phosphates, says USDA. Between Jan. 1, 1952, and July 1, 1955, the nation's ability to produce concentrated superphosphate increased by 187%, while normal

NITROGEN CAPACITY AND CONSUMPTION

(1000 tons of N)

Region	Production Capacity (as of July 1)				Fertilizer Consumption (year ended June 30)	
	1954	1955	1956	1957	1953	1954
Eastern	791	898	1062	1097	492	518
East North Central	380	472	652	653	239	261
West North Central	188	301	359	452	180	266
East South Central	250	372	408	500	256	263
West South Central	789	949	949	950	151	182
Western	210	297	485	680	266	299
Territories	1	1	1	35	53	58
Total U. S.	2609	3290	3916	4367	1637	1847
Eastern Canada	139	162	204	290	29	30
Western Canada	167	177	190	219	15	12
Grand Total	2915	3629	4310	4876	1681	1889