The Soil Profile's Contribution to Plant Growth

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LITTLE enough has been explained about the requirements of various plants, to say nothing about the contribution of the various soil horizons in the production of plants. To illustrate this premise, such crops as broccoli, cabbage, cauliflower, celery, lettuce, and spinach have a relatively shallow root system but require about as much nitrogen as potash for production, namely, between 50 and 150 pounds of the respective nutrients per acre. On the other hand, such crops as tomatoes, potatoes, and carrots utilize considerably more potash than nitrogen.

It is well recognized that approximately 450 to 500 pounds of water are required to produce one pound of dry plant material. This figure is almost constant irrespective of the type of plant grown. The difference in the various crops for the humid and arid areas is associated with the extent of the root system and the evaporation from the plant. Because of this fact, too little attention has been focused upon the properties of the different layers of the soil in supplying the essential elements for crop growth.

A well-developed profile that exists in the eastern and southern parts of the United States is composed of an A_p (plowed) horizon, A_2 (leached) horizon, B_1 (accumulative) horizon, followed by a greater density down to the 3- to 5-foot level. Below this the parent material is found extending to various depths. While the above figures describe a well-drained yellowish brown sandy loam, other soil series exist with varying degrees of depth.

Figure 1 shows a yellowish brown sandy loam that has a characteristic soil profile to the 42-inch depth versus a grayish brown loam with a characteristic profile to approximately the 24-inch depth.

Each of these soil horizons contributes to the ultimate production of the plant. Every plant must have adequate water for optimum growth. Therefore, one of the first discussions of the two soils is their power to supply water to the plant. The yellow brown soil, in the plowed horizon, has the power to supply 880,000 pounds of water per acre. The yellowish brown leached horizon (9-23″) has the power to hold 1,100,000 pounds of water. The subsurface layer likewise has the power of holding 2,700,000 pounds of water.

At this point it may be of interest to call attention to the fact that 100 bushels of corn per acre will utilize between 4 and 5 million pounds of water or between 12 and 19 inches of rainfall. A 15-ton crop of tomatoes requires 2½ to 4 million pounds of water. It must also be remembered that the amount of water that falls upon the ground does not mean that all of that water will be available to growing plants. Such factors as surface runoff, sub-drainage, and evaporation from the soil without actually going into the plant are the predominating conditions that consume part of the rainfall. Because of the difference in soils, these factors greatly influence crop production.

The yellowish brown soil would be

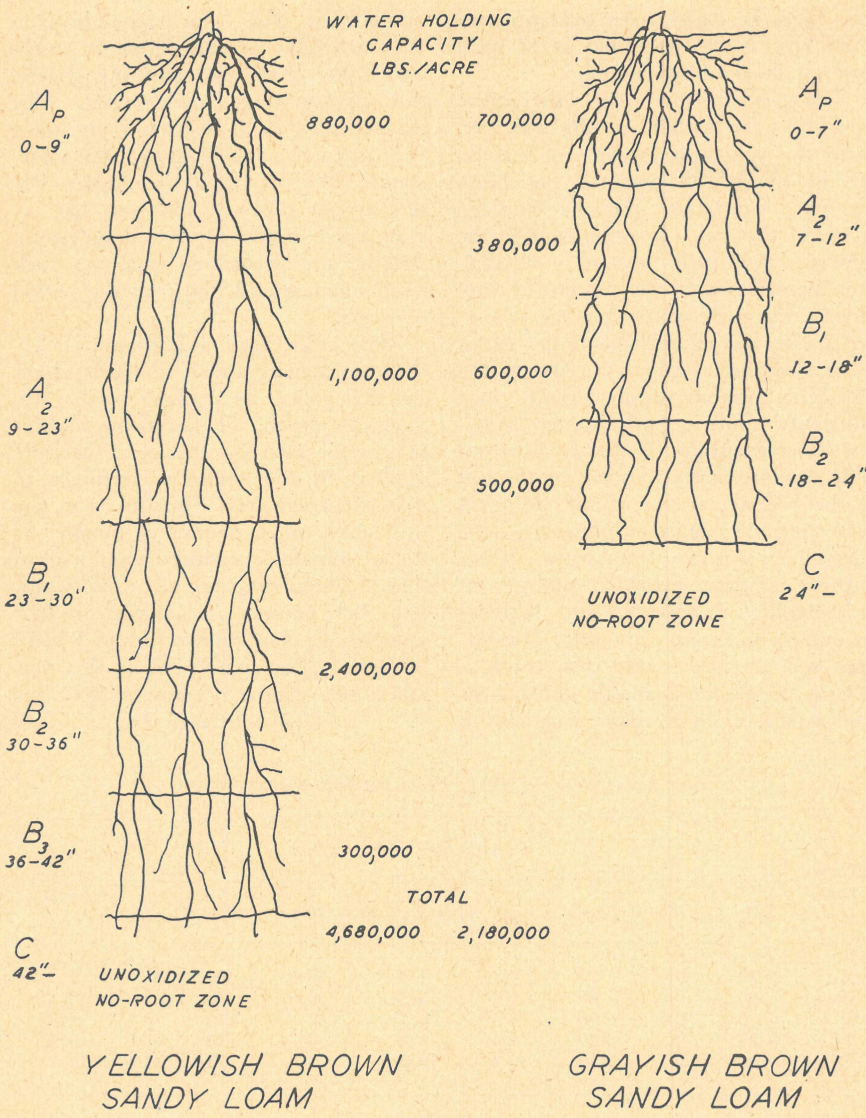

Fig. 1

capable of supplying more than 4,000,000 pounds of water at complete saturation whereas the other soil could supply slightly over 2,000,000 pounds. Complete saturation only occurs for a short time in either of these soils and is more likely in the gray soil with shallow depth, high water table, and heavy clay base.

Water flows through the soil to the streams and underground reservoirs. It is generally reported that each 100-foot depth of Coastal Plain soil contains approximately 17 feet of water which has all moved into the soil from the surface by slow seepage or fissures. Since, however, the plant is confined to the aerated layer of the soil, that is, the layer in which free oxidation occurs, this is the part that is of most interest in plant production.

The grayish brown soil will require irrigation far earlier, in dry weather, than the yellowish brown soil because of the depth and potential possibility of root penetration into the oxidized areas of the soil. In other words, the grayish brown soil, because of its shallow nature, would be capable of supplying much less water than the yellowish brown and related soils under stress.

In addition to supplying water, the different horizons supply various plant nutrients. The organic matter is primarily concentrated in the A_p horizon. The organic matter content of the soil is the primary source of soil nitrogen. The organic matter influences the plowed surface in various ways. It improves aeration, furnishes energy for microbiological activity, and supplies secondary and trace elements. The surface soil to plow depth also contains almost all of the available phosphorus and a part of the available magnesium and potash. The A_2 or leached horizon is practically devoid of plant nutrients other than iron and manganese, but supplies considerable water. The accumulative or B horizon is the most fundamental part of the soil from many standpoints. It has a tremendous water-holding capacity and also has accumulated much of the magnesium, potash, and secondary elements such as manganese and iron over the period of years.

Most crops have a high potash absorbing capacity and it is highly essential that potash be available to the ultimate root depth. Seldom is the amount of potash used by the plant actually applied in the form of fertilizer to that particular crop. For instance, the utilization of 20 pounds of potash per ton of tomatoes produced would mean that a 20-ton crop would actually utilize 400 pounds of potash or that amount of potash in two tons of 5-10-10 fertilizer. Fortunately all of this potash is not removed from the field but

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SOIL ANALYSES OF YELLOWISH BROWN SANDY LOAM

Horizon	Pounds per Acre								% Organic Matter
	pH	CaO	MgO	Al	N as NO_3	P_2O_5	K_2O	Mn	
A_p	5.45	250	25	0.6	4.4	60+	36	0.5	1.1
A_2	5.95	100	45	0.3	5.4	60+	25	0.4	0.4
B_1	6.35	425	90	0.3	0.7	2	140	0.4	0.35
B_2	6.25	425	100	1.2	1.8	3	110	0.4	0.5
C	6.00	200	110	0.8	3.0	3	98	0.4	0.2

SOIL ANALYSES OF GRAYISH BROWN SANDY LOAM

Horizon	Pounds per Acre								% Organic Matter
	pH	CaO	MgO	Al	N as NO_3	P_2O_5	K_2O	Mn	
A_p	4.5	210	13	22.4	4.7	0.75	78	0.5	2.75
A_2	4.3	82	8	17.4	0.5	Trace	48	0.4	1.7
B	4.2	58	94	16.4	0.9	Trace	31	0.4	0.4
C	4.5	58	118	15.6	1.8	0.6	69	0.4	0.3

Region of Washington," Agr. Exp. Sta., State College of Wash., Pullman, Wash., Cir. 245, April 1954, C. D. Schwartze and A. S. Myhre.

"What's New in Farm Science," Agr. Exp. Sta., Univ. of Wis., Madison, Wis., Bul. 511, June 1954, R. Powers and R. J. Muckenhirn.

"Agricultural Extension in Wisconsin, Report for 1953," Agr. Ext. Serv., Univ. of Wis., Madison, Wis., Cir. 476, May 1954.

"Sweet Clover in Wisconsin," Agr. Ext. Serv., Univ. of Wis., Madison, Wis., Cir. 477, May 1954, H. L. Ahlgren, F. V. Burcalow, and W. K. Smith.

"Snap Beans for Marketing, Canning, and Freezing," USDA, Wash., D. C., Farmers' Bul. 1915, Sept. 1954, W. J. Zaumeyer.

"Potato Production in the Northeastern and North Central States," USDA, Wash., D. C., Farmers' Bul. 1958, G. V. C. Houghland, R. V. Akeley, T. P. Dykstra, and W. A. Shands.

Economics

"Orange County Avocado Management Study, 1953," Agr. Ext. Serv., Univ. of Calif., Berkeley, Calif., W. Sullivan.

"Orange County Valencia Management Study, 1953," Agr. Ext. Serv., Univ. of Calif., Berkeley, Calif., G. Ferguson, A. Shultis, and R. Rock.

"Lemon Management Study," Agr. Ext. Serv., Univ. of Calif., Berkeley, Calif., J. E. Pehrson.

"Fourth Annual Report of Santa Clara County Walnut Management Study for 1953," Agr. Ext. Serv., Univ. of Calif., Berkeley, Calif., May 1954, A. Shultis and G. D. Worswick.

"1953 Statistics of Hawaiian Agriculture," Agr. Ext. Serv., Univ. of Hawaii, Honolulu, Hawaii, Agr. Econ. Rpt. 22, June 1954, R. Elliott, S. M. Doue, and S. Takei.

"Application of Econometric Procedures to the Demands for Agricultural Products," Agr. Exp. Sta., Iowa State College, Ames, Iowa, Res. Bul. 410, July 1954, J. A. Nordin, G. G. Judge, and O. Wahby.

"Ohio Farm Leases," Agr. Exp. Sta., Wooster, Ohio, Res. Bul. 749, Oct. 1954, J. I. Falconer and H. R. Moore

"Marketing Methods and Facilities for South Carolina Truck Crops," Agr. Exp. Sta., Clemson Agr. College, Clemson, S. C., Bul. 413, March 1954, C. L. Crenshaw and C. D. Evans.

"A Graphic Summary of Agricultural Change in South Carolina," Agr. Exp. Sta., Clemson Agr. College, Clemson, S. C., Cir. 93, Jan. 1954, C. W. Pitchford.

"Cost of Production Data and Related Materials," Agr. Ext. Serv., State College of Wash., Pullman, Wash., Ext. Mimeo. 1625, M. F. Bunnell and A. W. Peterson.

"A Comparison of Farm Investments, Receipts, Expenses and Income Between 1952 and 1953, 74 Identical Washington Farms," Agr. Ext. Serv., State College of Wash., Pullman, Wash., Ext. Mimeo. 1638, A. W. Peterson.

"How About Soybeans for the Columbia Basin?" Agr. Exp. Sta., State College of Wash., Pullman, Wash., Sta. Cir. 250, April 1954, C. E. Nelson, A. H. Harrington, and J. C. Gifford.

"Father and Son Arrangements on the Farm," Agr. Ext. Serv., W. Va. Univ., Morgantown, W. Va., Cir. 367, Sept. 1953, R. S. Smith and S. W. Warren.

"Use of Credit in Farming," Agr. Ext. Serv., W. Va. Univ., Morgantown, W. Va., Cir. 368, F. H. Branch.

"Getting Started in Farming," USDA, Wash., D. C., Farmers' Bul. 1961, July 1954, M. R. Cooper.

"Report of Agricultural Trade Missions to the Secretray of Agriculture on Foreign Trade of the United States in Agricultural Products," USDA, Wash., D. C., June 1954.

"The Farmer's Share of the Consumer's Food Dollar," USDA, Wash., D. C., Lflt. 123, Oct. 1954, K. E. Ogren.

"Application of Probability Area Sampling to Farm Surveys," USDA, Wash., D. C., Agr. Handbook 67, May 1954, E. E. Houseman and T. J. Reed.

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is returned to the soil in the form of foliage. A rather high rate of fertilization would be 200 pounds of potash per acre. This means that yields in the 20- to 30-ton category actually re-utilizes potash from former crops. The crop also utilizes potash from disintegrated soil materials and from that supplied by the accumulative (B_1 and B_2) horizon. The phosphates applied and utilized are governed almost entirely by the organic matter, soil reaction (pH), and bacterial activity in the plowed layer. The same factors influence the availability of nitrogen. On the other hand, the magnesium and calcium supply to the plant is similar to the potash supply in its location in the soil profile.

It is perfectly obvious from the profile and data that the two soils differ tremendously in practically every respect, namely, difference in depth, water absorbing and supplying capacity, acidity (pH), plant nutrients, drainage, and other characteristics. The yellowish brown sandy loam was influenced by previous soil treatment, whereas the grayish brown sandy loam had been influenced to a lesser extent.

Summary

An effort has been made to point out that each layer of soil makes a contribution to the efficient production of a crop. The plowed layer supplied predominantly the nitrogen and phosphorus, potash and water. The layer immediately below supplies potash, water, magnesium, and calcium. The depth of the soil determines the extent of this supplying capacity of the soil. A true evaluation of the soil must be based upon the whole soil and not just the surface layer.

Guides to the Management of Illinois Soils

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the fertilization and cultural practices used in conjunction with a cropping system are equally as important as the system itself in determining its effects on productivity, organic matter, tilth, and erosion control.

In summary we can say that good soil management is the key to an efficient, productive farm business. Because the soil management problems of an individual field or farm may be unique to that particular field or farm, it is essential that farmers understand their management objectives and the alternative practices that are available for meeting those objectives. The care that the farmer uses in considering the various alternatives and the skill with which he combines them into a soil management program for his particular farm will in large measure determine his production efficiency.

Summary of Ten Years' Work . . .

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nitrogen with 40 pounds of P_2O_5 and 60 pounds of K_2O was 9.3 tons of cane and 1,581 pounds of sugar. The response to potash was very marked. At two locations with stubble cane on Iberia silt loam, 80 pounds of nitrogen with 40 pounds of P_2O_5 and 60 pounds of K_2O gave the highest yields.

The response of stubble cane on Recent alluvial soils to complete fertilizers, while not so marked as to nitrogen alone, is consistent, with approximately 2 tons of increase being derived from phosphate and potash and 7 tons of increase coming from 60 pounds of nitrogen alone. Six locations on Baldwin silt loam, Table V, returned an average increase of 5.1 tons of cane from 60 pounds of nitrogen alone and an increase of 7.7 tons of cane and 1,230 pounds of sugar per acre from 60 pounds of nitrogen with 60 pounds of K_2O. The averages of five experiments with stubble cane on Commerce very fine sandy loam show 8.5 tons of benefit from 60 pounds of nitrogen alone and