FERTILIZER USE IN NORTH AMERICA: TYPES AND AMOUNTS

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Contents

Summary

North America (United States and Canada) produces and sells more fertilizer than any country in the world. The U.S. is the world's largest producer and exporter of phosphorus (P), while Canada leads in production and export of potassium (K). North America is also the world's second largest consumer of fertilizer.

Commercial fertilizers were introduced to North America in the mid 1800s with the import of guano and acidulated phosphates, but the origin of the industry began with the arrival of the early colonists almost 200 years earlier. Within 100 years of their arrival on the Atlantic coast, the agriculture systems of the early colonists exploited native soil fertility resulting in 'worn out' lands. This prompted a nationwide move to improve farming practices, which led to recognition of the importance of soil fertility and the introduction of liming and fertilizer materials.

The finding of phosphate rock in South Carolina in 1837 and then other deposits in Florida, North Carolina and the West were the most important developments in the history of USA fertilizer industry. Later discoveries of potash in USA and Canada and the introduction of synthetic nitrogen (N) production in the early to mid 1900s helped make North America a world leader in the fertilizer industry.

Domestic consumption of fertilizers has closely paralleled trends in crop yields. Consumption has increased from four million tonnes in the 1940s to more than 22 million tonnes today. In the last 40 years N use has steadily increased reaching about 13 million tonnes in 1999. Consumption of P and K peaked in the 1980s and then leveled

off to just less than five million tonnes each, where it is today. Despite the consumption of nutrients, soil test summaries show almost half of North American soils need additional P and K to meet crop demands.

North American agriculture is coping with several environmental issues related to fertilizer use. These include public perception that over-fertilization with N in the Mississippi River Basin is contributing to hypoxia in the Gulf in Mexico and that excess P from manure and commercial fertilizer is causing algal blooms and negatively impacting surface water quality. However, the industry is striving to ensure fertilizers are used properly and in an environmentally sound way. Balancing N fertilizer with P and K improves N efficiency and reduces N leaching and movement into water. Best management practices such as conservation tillage, nutrient management planning, and establishment of buffer strips can effectively control P movement and ensure applied P stays in the farmer’s fields where it is needed.

Increasing world populations are placing greater demands on North American agriculture to produce more food, which will necessitate increasing use of commercial fertilizers. However, society will require that nutrient sources be used even more efficiently and in an environmentally responsible manner. Precision agriculture innovations are providing North American farmers and the industry with new tools to better manage plant nutrients.

1. Introduction

North America is the world’s largest producer and exporter of commercial fertilizers and is second only to China as the largest consumer. In 1998/1999, Canada and U.S. produced 37.2 million tonnes of fertilizer ($N-P_2O_5-K_2O$) or one-fourth of the world’s total production. They accounted for a third of the 59.4 million tonnes sold to other countries and used 22.4 million tonnes, or 16% of the world’s consumption.

North American fertilizer production is inadequate to supply domestic demand for some nutrients; therefore, imports account for a significant share of domestic consumption. USA. Is a major importer of N and K. Phosphate production is sufficient to satisfy domestic demand and to account for the majority of U.S. fertilizer exports, making USA the world’s largest exporter of P fertilizer. Canada leads the world in production and export of K and ranks third in N exports behind Russia and USA However, Canada relies on imports for half of its P requirements.

North American farmers are the most productive in the world, providing food and fiber to meet domestic demand, as well a tremendous quantity of exported foodstuffs for the rest of the world. Fertilizers are extremely important to North American food production and trade.

2. History of Fertilizer Use

2.1. Early American Agriculture

Commercial fertilizers were introduced to North American agriculture in the 1840s with the importation of Peruvian guano (seabird droppings) to USA. Acidulated phosphates and mixed fertilizers followed in the 1850s, but the roots of the fertilizer industry began with the arrival of the early colonists.

Prior to the arrival of the Pilgrims on the Atlantic Coast in 1620, the American Indians had successfully adapted native plants and grew corn (maize), fruits, vegetables, and tobacco for their use. The early colonists were poor agriculturists and were unsuccessful in their attempts to grow the crops they had brought with them from the old world under the soil and climatic conditions of their new land. They were only able to survive by adopting Indian crops and cultural practices. Squanto, an Indian chief, taught the Plymouth colonists how to plant the Indian corn by heaping the earth into low mounds with several seeds and fish in each mound. The decaying fish fertilized the corn and improved yields.

The colonists were able to develop an effective agriculture. They introduced livestock, utilized the Indian crops, especially corn, and were able to adapt small grains, forages, fruits, and vegetables from Europe and tobacco varieties, cotton, rice, sugarcane, and other crops from the West Indies and Central and South America. Two different systems of agriculture emerged. Small farmers devoted to producing food for their families dominated the northern colonies, and large landholders with labor-intensive plantation systems dominated the southern colonies.

Land was abundant and easy to acquire, so it encouraged poor farming practices. Native fertility was often exploited. Farmers routinely cropped the same fields year after year until productivity declined and then abandoned them for new, productive land. Crop rotations were seldom practiced, and tillage was inadequate. Manure was rarely applied to fields even though there was sufficient livestock to sustain productivity of the soil. Seaweed, fish and fish offal were applied to some fields along the northern coast.

Widespread recognition of the problem of ‘worn-out’ soil in the mid 1700s led to a nationwide move to improve farming practices. Many national leaders and farmers began looking for ways to improve agriculture. About 1750, interest had developed in the application of liming materials. Benjamin Franklin reportedly applied gypsum to a hillside pasture to spell out the words “This land has been plastered.” The increased growth where the gypsum had been applied effectively demonstrated its fertility value. George Washington was conducting experiments on his farm at Mount Vernon to improve his production as early as 1760. He experimented with animal manure, lime, gypsum, marl (mixture of clay, calcium and magnesium carbonates, and remnants of shells), green manures, and salt.

In 1785, societies were organized in Philadelphia and South Carolina for promoting and improving agriculture. Similar societies were organized in Maine, New York, Massachusetts, and other locations soon thereafter. Their goals included obtaining and publishing information from other countries to improve agriculture and soil. Membership in these early societies was predominately men of all professions with interest in agriculture, but few were actually farming. These early societies failed to have much influence on farmers as they were often opposed to ‘book farming’, and many disbanded in the 1820s. However, they set the stage for agricultural fairs, farm progress shows, and agricultural journals that did help educate farmers with subsequent improvements in their farming practices.

Edmund Ruffin of Virginia made some of the most important contributions to early American agriculture in the early 1800s when he recognized the importance of liming acid soils. Though the benefits of liming were well known in European agriculture, studies he conducted on his farm with marl in the humid southern soils boosted his corn yields by 40%. After several years of additional liming experiments, he published his observations in a book, *An Essay on Calcareous Manures*, in 1832. This had a profound influence on agricultural practices in the South and led him to publish other influential articles that helped increase farm productivity and profitability.

Land-grant colleges "to teach such branches of learning as are related to agriculture and mechanical arts" were established across the U.S. after President Lincoln signed the Morrill Act in 1862. The Act granted about 7 million hectares of public lands to help support the agricultural colleges. The U.S. Department of Agriculture was also established that year. There was little mention of fertilizers in the early activities of these institutions, but they undoubtedly had a large impact on the use and promotion of commercial fertilizer in USA.

2.2 Introduction of Commercial Fertilizer Industry

Early sales of materials to improve the soil were limited to liming materials, unprocessed fish, and untreated slaughterhouse wastes. Guano was the first fertilizer material sold in USA for the purpose of adding nutrients to the soil to improve crop growth. Mainly used between 1840 and 1870, commercial guano shipments imported from Peru arrived regularly in Baltimore and New York. First use (early 1840s) was on Long Island and the coasts of New Jersey, Maryland and Virginia. Use spread to South Carolina by 1845 and then to North Carolina and Georgia. Imports reached about 900 tonnes in 1848 and peaked at 158 000 tonnes seven years later. Approximately 763 000 tonnes entered USA between 1850 and 1860, but only 280 000 tonnes were imported during the next 10-year period due to the Civil War.

The first Peruvian guanos contained 12 to 14% N and 10 to 12% P_2O_5, but N content decreased in later guanos. Guano discovered in the more humid climates of the Caribbean, the Gulf of Mexico, and the Pacific Ocean was higher in P_2O_5 (20 to 25%) and lower in N (5 to 8%). These phospho-guanos were acidulated with sulfuric acid in the early fertilizer plants to produce a soluble phosphate product.

U.S. production of superphosphate and mixed fertilizers began soon after John B. Lawes patented a process by which phosphate rock was acidulated with sulfuric acid in 1842 in England. Three firms were producing and selling superphosphate in USA by 1853, and many others followed in the 1860s and early 1870s. Early U.S. manufacturers acidulated bones or bone products and phospho-guano until the discovery of domestic phosphate rock deposits. U.S. census data reported that 93 260 tonnes of superphosphate were produced in 1870 and 290 304 tonnes in 1880. Canada's commercial fertilizer industry began in 1869 when an Ontario company began treating phosphate rock from a nearby deposit.

2.3 Discovery of Phosphate Rock

The most significant development in the history of the U.S. fertilizer industry was the discovery of phosphate rock and sulfur (S)-bearing deposits. Development of domestic reserves of raw materials freed American farmers from dependence on scarce phosphate sources and opened one of the world's greatest phosphate fields.

Phosphate was first discovered in USA in South Carolina in 1837, but its value as a source of P was not recognized until years later when mining began in 1867. The South Carolina deposits produced almost 12 million tonnes before production ceased. The only other known deposits in North America at that time period were in Ontario and Quebec, which were mined from 1863 until about 1895. However, their ore was shipped to England and had little effect on USA fertilizer industry. Small deposits were found in south-eastern British Columbia in western Canada years later, and a small deposit is currently being mined in Ontario.

The Florida phosphate deposits were discovered in the 1880s as production at South Carolina was declining. They had a much higher P_2O_5 content and were capable of producing 20 to 40 times more phosphate per hectare. Soon after the deposits in Florida were identified, phosphate rock was discovered in Tennessee.

The western phosphate deposits (Idaho, Montana, Utah, and Wyoming) were discovered in the late 1890s and were among the largest in the world. Prior to 1920, phosphate rock was discovered in 14 other states, but none produced significant amounts except North Carolina, which is still in production today.

Sulfur is the second essential raw material needed for the manufacture of superphosphate. The phosphate industry relied on imported elemental S for the manufacture of sulfuric acid prior to the 1880s until the advent of U.S. Gulf Coast S production.

Domestic pyrites and sulfur dioxide recovered from smelter stack gases provided early sources, but the extensive Gulf Coast S deposits and Frasch process for recovery developed in 1894 opened the door to an era where USA became the largest producer and exporter of elemental S. By 1920, 204 plants in 32 states were producing sulfuric acid, with about one-third of their production going to fertilizer manufacture.

U.S. phosphate production changed significantly after 1950. Normal superphosphate had dominated production from the opening of the South Carolina phosphate deposits until early 1950.

Following World War II, concentrated superphosphate (triple superphosphate) became increasingly important, but its production reached a plateau in the 1970s and leveled off. Ammonium phosphate was introduced to USA in 1916, but substantial production did not begin until the 1960s. Since then, ammonium phosphates are the most common P fertilizers used in North America.

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Biographical Sketches

Dr. Terry L. Roberts is an agronomist with the Potash & Phosphate Institute (PPI)/Potash & Phosphate Institute of Canada (PPIC). He is located in Norcross, Georgia where he is Vice President, PPIC Latin America Program, and President of the Foundation for Agronomic Research (FAR). Dr. Roberts responsibilities in Latin America include overseeing PPIs regional programs for Mexico and Northern Central America, Northern Latin America, Latin America Southern Cone countries and Brazil. At FAR, he is directing the Foundations research and education programs and is responsible for fund raising. PPI/PPIC and FAR are not-for-profit scientific organizations dedicated to advancing the appropriate use of phosphorus (P), potassium (K) and other inputs in crop production systems through the worldwide development and promotion of scientific information. Dr. Roberts research interests and educational activities have included soil testing, fertilizer use efficiency, site-specific nutrient management, and the agronomic training of crop advisers and others working in the retail fertilizer industry.

Dr. David W. Dibb is President, PPI, located in Norcross, Georgia. As President of the Institute, he directs the activities of 27 Ph.D. level agronomists, 10 in North America and 17 internationally, in developing world markets for P and K, using sound, science-based agronomic and economic practices. Under his leadership, PPI has played a key role in delivering new production technology in North America, China, and other areas in Asia as well as in Latin America. He has directed the establishment of new PPI programs in Northern Latin America, Mexico and Central America, the Southern Cone Countries of South America, and India. Although not actively involved in research, Dr. Dibb because of his administrative role at the Institutecontributes to soil fertility research around the world. He helps to define for the fertilizer industry the need for and the benefits derived from financial and technical support of research. He has been administratively responsible for the management of millions of research dollars funded by PPI, FAR and other organizations to scientists in North America and internationally.