FERTILIZER APPLICATORS AND PLANT PROTECTION EQUIPMENT

Palaniappa Krishnan
Bioresources Engineering Department, University of Delaware, USA

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Summary

Chemical pesticides have played and will continue to play a major role in the rapid advancement of agricultural production as we enter the twenty-first century. Crop quality and yields have been improved and the use of chemical herbicides has greatly reduced labor requirements for weed control. But the widespread use of pesticides has resulted in some serious environmental and health problems. These problems are of direct concern to both the user and the equipment designer.

The use of commercial fertilizers and pesticides has increased steadily over the past decades. Both fertilizers and pesticides are available in dry and liquid formulations. Uniform distribution and proper placement of them will continue to become increasingly important as factors in producing maximum crop response at minimum cost. Improvement of application equipment and techniques to permit the effective use of smaller dosages of chemicals and to reduce drift and harmful residues has become increasingly important as one means of minimizing the problems associated with the use of chemical pesticides.

This article considers methods and equipment for applying fertilizers and pesticides. Application rates for granular pesticides are low in comparison with fertilizing rates, and distribution requirements are different, but the general problems and basic principles of the equipment are similar. Dry and liquid fertilizer application equipment includes broadcasters, attachments for row-crop planters or cultivators, and fertilizer drills. Dry and liquid fertilizers are sometimes applied through irrigation water through special injection systems.

Present-day agricultural pest control equipment includes (a) boom-type field sprayers, (b) high-pressure orchard and general-purpose sprayers, (c) airblast sprayers, which utilize an air stream as a carrier for sprays, (d) aircraft sprayers, (e) ground-rig dusters, and (f) aircraft dusters. Aerosol generators, which atomize liquids by thermal or mechanical means, are widely used for the control of mosquitoes and other disease-transmitting vectors, but have only limited application for agricultural pest control.

In the new millennium, the way fertilizers and pesticides will be applied will be revolutionary. Precision farming will be the norm in the developed countries. In the underdeveloped and developing countries, where labor is abundant, appropriate technology needs to be continually developed to apply both fertilizer and pesticides more efficiently and safely. However, this appropriate technology needs to consider the safety of the fertilizer and pesticide applicator. Life is precious everywhere—whether it is in a developed country or in an underdeveloped country.

1. Introduction

Fertilizers and pesticides are broadly classified as chemicals. Fertilizers are applied to the soil to increase the available supply of plant nutrients—namely nitrogen, phosphorous, and potassium—to promote greater yields or better crop quality. The use of commercial fertilizers has increased steadily over the past 50 years, with over 143 million kg being applied to crops worldwide covering nearly 1.2 million ha of cropland.

Both fertilizers and pesticides are available in dry and liquid formulations. Uniform distribution and proper placement of fertilizers in the soil continues to become increasingly important as factors in producing maximum crop response at minimum cost.

Chemical pesticides have played and will continue to play a major role in the rapid advancement of agricultural production as we enter the twenty-first century. Crop quality and yields have been improved and the use of chemical herbicides has greatly reduced labor requirements for weed control. But the widespread use of pesticides has resulted in some serious environmental and health problems. These problems are of direct concern to both the user and the equipment designer. Drift from the treated area may result in poisonous or toxic chemicals being deposited on adjacent crops intended for either human or animal consumption. Pesticide residues can also enter the general environment by transport out of the treated field on harvested crops, in ground water or surface runoff water, and by wind picking up deposited materials.

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2. Dry Fertilizer Application Methods and Equipment

Dry fertilizers are applied in connection with practically every kind of field operation performed in the production of crops worldwide. Application methods for dry fertilizers include:

(a) Broadcasting before plowing, or placing at the plowing depth by a distributor on the plow that drops fertilizer in each furrow.
(b) Placing deep with chisel-type cultivators.
(c) Broadcasting and drilling into the soil after plowing and before planting.
(d) Applying during the planting operation.
(e) Side dressing on growing row crops.
(f) Drilling into established pastures and other sods with special equipment.

Application rates of 225 to 560 kg ha^{-1} of fertilizer per treatment are common, but rates may be as high as 1100 kg ha^{-1}. A portion of the total amount is often broadcast and plowed under or worked into the soil prior to planting where large amounts of fertilizer per hectare are needed for row crops.

Materials such as lime and gypsum are not fertilizers but are used to improve the chemical or physical condition of a soil. Lime is useful for correcting soil acidity and is the most common commercial soil amendment. It is usually applied before planting and then worked into the soil, but it can be applied to a crop at any stage without injury. Either centrifugal broadcasters or drop-type broadcasters are employed.

2.1. Placement of Fertilizers

Proper placement in relation to the seeds or plant roots is important for maximum response and the most efficient utilization of the nutrients, because movement of most fertilizers in the soil is very limited. Localized placement of fertilizer bands near the seeds at the time of planting, rather than uniform distribution over the entire area, favors early stimulation of the seedlings and results in more effective utilization of the plant nutrients. However, excessive concentrations of soluble nutrients in contact with the seeds or small roots may seriously injure the initial roots or even impair germination. Best results with most row crops are obtained when the bands are 25–75 mm below the level of the seed and spaced 40–100 mm laterally from the row on one or both sides.

Band placement during row-crop planting is accomplished with applicators that are independent from the seed furrow opener and are adjustable both vertically and laterally. Double-disk, single-disk, and runner-type openers, similar to seed-furrow openers, are commonly used. The fertilizer opener usually precedes the seed furrow opener but may be immediately behind it. Limiting the application to a single band per row simplifies the implement and causes less disturbance of the seedbed.

Fertilizer-grain drills often deliver the fertilizer through the seed tube, placing it in direct contact with the seeds in the furrow. Separate disk openers are sometimes provided behind the seed openers to permit placing the fertilizer to one side of the seed row and below it. Fertilizers applied as row-crop side dressings are of most immediate benefit when placed in moist soil within the root zone, but excessive mechanical destruction of the root system must be avoided. Side dressings are usually applied in conjunction with a cultivating operation. The fertilizer is generally dropped in furrows opened by regular cultivator shovels but it can be placed at other locations or depths with separate, narrow-shovel openers or chisels.

2.2. Types of Equipment

Distributors for dry fertilizer may be classified as those that broadcast the material onto the surface of the ground and those designed for placing the fertilizer in rows or bands beneath the surface. Equipment for row or band placement includes (a) attachments for row-crop planters or cultivators, (b) special open-field fertilizer drills, and (c) combination units such as the fertilizer-grain drill.

Drop-type or full-width-feed broadcasters have metering devices spaced at regular intervals of about 150 mm along the full length of a hopper. Implements of this type are suitable for spreading either fertilizer or lime. Some have furrow openers available for band placement below the soil surface and can be used for side-dressing row crops by plugging part of the outlets. Drop-type broadcasters are usually pull-type implements 2.4–3.7 m wide, but are also available as mounted units and as attachments for various types of open-field tillage implements.

Centrifugal fertilizer broadcasters are similar to centrifugal seeders in that the material is metered from a hopper and distributed laterally by one or two horizontally rotating, ribbed disks. Some mounted centrifugal broadcasters can be used for either seeding or fertilizing. The use of bulk trucks and pull-type bulk handling equipment for broadcasting fertilizers and lime is a common practice.

Most of these units employ centrifugal spreaders, primarily because of the compactness and simplicity in comparison with trough-type distributors. Non-uniform lateral distribution is a problem, but the availability of fertilizer formulations with large granules and reasonably close size tolerances has increased the potential for obtaining acceptable distribution patterns.

Fertilizers are broadcasted by aircraft in certain areas, particularly on rice and the small grains and on hilly pasture lands. Over 1 Mha are being fertilized by aircraft in the United States over the past 30 years, the majority of this being rice fields in Texas, Arkansas, Louisiana, and California. During the past 30 years, over 3 Mha in New Zealand, mostly hilly pasture, have been fertilized by aircraft at an average rate of ~280 kg ha^{-1}.

Aircraft fertilization is most likely to be employed where large areas are involved and/or where it is impractical to do the job with ground equipment (as on flooded rice fields or rough terrain).

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Biographical Sketch

Dr. Palaniappa Krishnan is an Associate Professor both in the Bioresources Engineering Department and in the Food and Resource Economics department at University of Delaware. He is also the Director of the Operations Research Program at the University. His primary research has been in the chemical spray application area. His research involves simulating field conditions in the laboratory and modeling nozzle wear.

Dr. Krishnan has been with the University of Delaware since 1985. From 1980 to 1985, he was with USDA–ARS Seed Conditioning Laboratory at Oregon State University, Corvallis, OR.

Dr. Krishnan earned a B. Tech. (Hons) from Indian Institute of Technology, India (1974) , a M.S. from University of Hawaii (1976) and a Ph.D. from University of Illinois (1979). Dr. Krishnan has published over 75 journal articles, conference proceedings, papers, book chapters. He is a patentee in his field. He is listed in Who's Who of Emerging Leaders in America, 4th edition, 1993 and in Who's Who in the World, 18th edition, 2001.

Dr. Krishnan and his wife, Chitra, have a son named Prashanth. He is a member of the Newark Lions Club, serving as President in 1998–1999. He is very active in the community, delivering hospital equipment to the needy on behalf of Newark Lions Club. He enjoys gardening and playing racquet sports.