HISTORY AND TRENDS IN THE DESIGN OF GROUND BOOM SPRAYERS FOR AUSTRALIAN CONDITIONS

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Summary. The history of boom sprayer design in relation to chemical weed control is considered. Recent developments in boom sprayer design in Australia are reviewed and the need to develop efficient boom sprayers is discussed in relation to performance requirements. Predictions of future design trends are made on the basis of predicted grower attitudes.

HISTORY OF CHEMICAL WEED CONTROL

As the history of chemical weed control and the development of boom spray design are closely allied, both will be briefly reviewed.

Chemical weed control probably began with the use of common salt by the Arabs over the thousand years following the conquest of Rome in 460 A.D. (Smith and Secoy 1976). The same authors also report the use of salt in England for weed control from as early as 1594. Spraying plants probably commenced in the early 1800's when vines were 'washed' with hoses to control insect pests. The use of liquid herbicides probably did not commence until the introduction of iron sulphate and sulphuric acid in Germany in the 1850's. The method of applying such materials was poor, as there were no devices known which could efficiently atomize liquids. However, in 1869 the first efficient atomizer, C.V. Riley's "Cyclone nozzle", was developed (Ordish 1976). By 1887 several types of centrifugal or eddy chamber atomizers had been developed and other types of atomizers, notably "Raveneau's jet" and anvil atomizers, were also available (Viala 1887). The development of efficient atomizers provided the necessary impetus to develop pesticide usage.

Selective herbicides were discovered in the late 1890's when Bonnet (France), Schultz (Germany) and Bolley (U.S.A.), all working independently and at the same time noticed that solutions of copper salts could selectively remove broadleaf weeds from cereals (Klingman 1961). The development of suitable spray machinery for this purpose benefited from experiences gained from the spraying of vines, orchards and potatoes. In particular, a suitable boom spray had been developed for low growing vines in France by 1894 (De Castella 1918), and in the U.S.A. by 1888 (Heijne 1980).

The chemical eradication of weeds was practised in Australia before 1900 with common salt and kerosene (Cuthbertson 1972). By 1915 there was extensive use of herbicides for spot spraying noxious weeds, particulary prickly pear. The benefits of improving the droplet spectra, however, were not noted until 1915 when White-Haney reported improved control of prickly pear with arsenic pentoxide when the spray was "better atomized" (Cuthbertson 1972).

The use of selective herbicides in cereals was widespread in Europe by the early 1900's and this was soon adopted in the U.S.A. following the successful work of Bolley (1908). After this initial period of development interest in selective weed control lapsed, due to the lack of new products and machinery developments. Furthermore, the introduction of the fallow system and the use of cleaner seeds shifted the weed problem toward perennials (Crafts 1975). Although interest in selective weed control lagged in the U.S.A., development continued in Europe (Crafts 1975).

Over the next twenty years the testing of boron compounds, ammonium sulphamate, the dinitrophenols and other active ingredients took place. A similar situation did not arise in Australia, as there appears to have been no interest in broad-acre spraying of weeds until the ingression of the annual weeds, wild turnip and doublegee, in Western Australia. When these two weeds became extensive, they precipitated an active research programme in 1939 aimed at finding suitable selective herbicides (Meadley 1965). It was not until the introduction of the phenoxyacetics in the 1940's that the true potential of selective herbicides was fully realized.

DEVELOPMENT OF THE BOOM SPRAYER

The development of boom sprayers started in the late 1890's with boom like units designed by Vermorel to treat low growing vines in France and by Nixon Nozzle Machinery Co. in the U.S.A. These horse-drawn units comprised copper or wooden tanks of approximately 300 L capacity, ground wheel driven piston pumps and fixed cone atomizers which were modified designs of C.V. Riley's "Cyclone nozzle". Further improvements in the design of these units occurred at the end of the last century. In particular, the original cone atomizers were modified to prevent clogging and in-line cut off valves (interrupters) were developed. Units similar to the above were soon developed in Australia, particularly for the spraying of orchards and potatoes (Pescott 1911; De Castella 1918; Harris 1921). The next major development was to motorize the pump. This was first achieved by orchardists in the late 1890's in both the U.S.A. and Europe and was soon adopted by potato growers for their boom spray units. One of the first motorized boom spray units in Australia appears to be the one manufactured by Langwell Brothers and Davies for potato growers (De Castella 1918), whilst the first motorized orchard unit was described in 1911 by Pescott. The development of broad acre boom sprayers over the next twenty years was based on the early designs of the potato boom sprayer, the only modification being that the units were towed with tractors rather than horses.

With the introduction of the phenoxyacetic herbicides in the mid-1940's, boom sprayers again underwent a number of developments. Units were changed so that they could be used with three-point linkage and the tractors' P.T.O. to drive either a gear or piston pump. Following detailed studies on atomizer design (Coulter and Dombrowski 1949; Dombrowski and Fraser 1954; Fraser and Eisenklam 1956), the fan atomizer became widely adopted for use on broad acre boom sprays. The design of the booms also changed in that they were constructed of lighter materials but this induced too much yaw. Developments in the 1960's were mainly centred around larger booms, the introduction of plastics for tank construction and increased adoption of diaphragm pumps. The most significant changes in the 1970's were to the design of the boom in an endeavour to make it more stable. Several boom suspension systems were developed which showed that stability could be improved if the boom were mounted on a sprayer in such a way that it provided flexibility and yet isolated it from the roll of the sprayer's frame (Nation 1978; 1980a and b). Although advanced boom designs, such as the Gimbal (in which the boom is restrained by springs and prevented from oscillating by viscous dampers and the mounting incorporates both horizontal and vertical pivots) are used in Europe (Nation 1978), such designs have not been introduced to Australian sprayers. The main method of stabilizing the boom on Australian sprayers has been the use of a simple pivot or at best twin links in an A formation. The former design is fairly successful with longer booms, whilst the latter is preferred with booms less than 12 m long. Since such mountings reduce the transmission of high accelerations to the boom, it can be constructed of lighter material (Nation 1980a).

In the latter part of the 1970's, the "Computer" sprayer was introduced, which employs a ground wheel to drive a positive displacement pump, thus varying spray volume directly with any variation in ground speed. There is, of course, nothing new in this concept as the first such units were developed in France and the U.S.A. in the late 1890's.

THE BOOM SPRAYER OF THE LATE 1980's

There will be an increase in the use of boom sprayers over the next decade to control not only weeds but also insects and fungi. Future developments in boom spray design will probably evolve around six factors:

1. The need to apply lower volumes (probably down to 20-30 L ha^{-1}) to a range of crop heights.
2. The need to reduce environmental contamination both within and outside the target area.
3. The desire to spray at the optimum time of application with respect to both pest and crop.
4. The need to apply herbicides, insecticides and fungicides with the same unit.
5. A desire to monitor the spraying operation.
6. The need to keep the spray liquid away from the operator.

How will, or can these objectives be achieved?

Firstly, lower volumes of application will probably be achieved by a number of means:

a) travelling faster - which would necessitate greater boom stability;
b) the use of smaller atomizers - which would necessitate better filtration if blockages are to be prevented. These may increase the potential droplet drift hazard, due to the production of an increased volume of small droplets;
c) changing the atomizer type - for example, to rotary or anvil atomizers. As the coverage achieved when such atomizers are used has not been measured, these are not yet practical solutions.

When lower volumes are used it will be essential that boom stability is improved to ensure that droplet drift is not increased and evenness of droplet distribution is maintained. Changes to boom construction will be needed to prevent wettable powder formulations from settling out and this may be achieved by making the boom a continuous line from tank to boom to tank. The use of lower volumes of application down to 20-30 L ha^{-1} is seen as necessary to ensure that the ever increasing area of crops grown can be sprayed at the optimum time of application. The need to build sprayers with an easy to operate boom height adjustment will become necessary as crops will be sprayed over a wider range of crop growth stages if fungicides and insecticides are to be sprayed with the same unit.

Secondly, there is a need to increase the efficiency of boom spraying. In particular, it is essential that more of any foliar herbicide used is collected on the target weeds rather than the crop or the ground. A reduction in droplet losses from the sprayed area will be necessary, not only to prevent damage to herbicidally sensitive plants grown adjacent to the treated area, but also to ensure the minimum of environmental contamination. This will be achieved by using the most appropriate droplet spectra and formulations, so that the spray is collected efficiently by the most susceptible part of the target.

Thirdly, as the cost of agricultural chemicals increases, there will be increased demand to optimize their use. Growers will, therefore, require maximum effectiveness with the minimum practical dose rate. For this to be possible, knowledge of the optimum spraying parameters such as droplet size, droplet concentration and droplet spacing in relation to the most susceptible part of the target is needed. By the end of the 1980's, such information should be available to ensure that the materials are used to best advantage. The introduction of rotary and/or electrostatic atomizers may be necessary to enable this information to be utilized.

Fourthly, since boom sprayers will need to be used for a range of pesticides, they will have to be designed so that this is practical. All fittings and lines will be constructed of non-absorbent materials, the atomizer bodies will be of a quick change design to ensure that the appropriate atomizer can be used for each operation, the atomizers will be hard wearing (e.g. stainless steel or ceramic), and easy height adjustment will be essential to ensure optimum spray coverage for each operation.

Fifthly, to ensure that the pesticides are being applied accurately there will be an increase in the use of electronic monitoring equipment. This will monitor three things:

a) the direction of travel, to ensure the accurage passage of the spray rig;

b) the flow rate to the boom and thus its output;

c) the travelling speed.

From these inputs the data will be relayed to show area sprayed, liquid used, and thus the accuracy of the operation.

Sixthly, there will be an increase in the use of electrically operated solenoid valves, thus obviating the need to bring the liquid close to the operator.

Other possible modifications to the sprayer include self-propelled units which have low profile tyres to enable application under wet conditions and reduce soil compaction; the use of computer controlled mixing of the spray on the delivery side of the pump, thus avoiding the hazards associated with mixing; the use of rotary atomizers for improved drop size control; and the use of electrostatics to improve small droplet (< 80 µm) collection and thus reduce droplet drift.

CONCLUSIONS

In view of the increased use of herbicides in broad acre cropping areas of Australia, the boom sprayer will become a more important piece of equipment to the farmer. This will be reflected in both the design of sprayers and the attitude of the growers as to its importance. It is hoped that Australian manufacturers will take up the challenge to improve boom stability and other aspects of the performance of these units in the 1980's.

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