Animal-drawn herbicide applicators for use in small-scale farmer weed control systems

by

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Abstract

Early weeds growing close to crop plants can greatly reduce the yield of the crop. Mechanical control other than by hand is frequently impractical, but small-scale farmers often have difficulty in locating or motivating people to hoe. Herbicides are a possible alternative, but it is important to apply herbicides, particularly residual herbicides, at the correct rate. Animal-drawn herbicide applicators for small-scale farmers should therefore not only be robust, simple and cheap, but also ground-wheel monitored. The suitability of various pesticide applicators developed in different parts of the world is discussed in relation to these criteria, and the development of a peristaltic pump-based sprayer is proposed.

Introduction

Weed competition can reduce crop yields by about 5% in commercial agriculture, 10% in semi-commercial agriculture, and 20% in subsistence agriculture (Parker and Freyer, 1975). In the semi-arid tropics, weed-induced yield losses may be up to 80% (Rao et al, 1987). Lack of effective weed control during the first 20–30 days after sowing causes maximum yield losses in crops with a 100-day cycle (Rao et al, 1987). For most crops the critical competitive period is 4–6 weeks after germination (Gill, 1982). In South Africa, during the period 30–60 days after sowing, approximately 2% of the potential maize yield is lost every day that weeds remain in the field (Marais, 1985). Brook (1975) reported that weed control increased maize yields in Swaziland by 1.6 tonnes/ha compared with inter-row cultivation alone.

It is usually impractical to cultivate the area immediately adjacent to crop plants other than by hand (Gill, 1982; Lea, 1991). Rapid urbanisation, improved living standards, increased educational opportunities, and changes in employment opportunities and social values and attitudes in advancing countries, have all resulted in changes in labour availability, such that it is frequently impossible to find the labour to carry out timely hand weeding (Akobundu, 1979).

Effective hand hoeing of weeds in a maize crop in South Africa requires 460 h/ha (Auerbach, 1993). Weeding with animal-drawn implements is faster, but only about 5% of African farmers who use animal traction for plowing use animal-drawn cultivators (Starkey, 1988). Herbicides have been shown to increase agricultural production and improve rural welfare (Young et al, 1978). The incorporation of herbicides into small-scale farmer production systems can minimise labour requirements and increase profitability (Ogborn, 1969; Bell, 1981; Fowler, 1981; Benson, 1982; Ndahi, 1982; Rao et al, 1987; Lea, 1991, 1993; Gill et al, 1992; Hanson and Smith, 1992; Shumba, Waddington and Rukuni, 1992; Auerbach, 1993).

Herbicide use in Europe and North America is currently under review, particularly because of side-effects such as ground- and surface-water contamination. More effective and specific herbicides applied at lower rates and with lower mammalian toxicity are being developed, and their use would result in far less environmental contamination (Schweizer, 1988). Even with existing long residual chemicals, banding herbicides over the crop row would be an acceptable sustainable agricultural system (Benbrook, 1990). The promotion of conservation tillage in advancing communities is an urgent priority (Akobundu, 1982; Rukuni, 1992), and herbicides can be a most effective tool in soil and water conservation (Triplett and Worsham, 1986).
Herbicide application

Application of herbicides early in the life of the crop is often best performed before the emergence of the crop and weeds. The time during which soil-applied herbicides normally remain phytotoxic depends mainly on the quantity applied. Excessive applications may harm both the treated and following crops, while reduced applications may have little or no effect on target weeds.

According to Garnett (1981), herbicide sprayers suitable for small-scale farmers should:
- be cheap but durable
- require as little water as possible
- be small but light and robust
- be ground metered
- require no batteries
- have an adjustable swath width
- produce minimal drift
- be simple, but profitable to use
- be acceptable to both the farmer and the labour available in the community.

Garnett’s dragged CDA sprayer consisted of a Micromax spinning cup fed from two nozzles supplied by two peristaltic pumps set 90º out of phase to reduce pulsing. Commercially available as the Team Pull-Along Sprayer, the target price in 1983 was US$250–300. This price is beyond the reach of most small-scale farmers, and no references to the adoption of this sprayer in the semi-arid tropics have been found.

Sprayers or granular applicators carried by their operators have the disadvantage that the rate of application is affected by the speed of walking. Hand-pumped sprayers often depend on the rhythm and energy of pumping (Fowler, 1981). Safe economical spraying requires reliable uniform spray distribution (Bell, 1981). Gravity-fed weed wiper devices are unsuited to pre-emergence applications, and tend to clog with soil when used on small weeds (Tewari and Mittra, 1985).

Animal-drawn herbicide applicators

The literature contains few references to animal-drawn pesticide applicators. In the early 1960s an ox-drawn ground-wheel-driven piston pump sprayer was developed at the Gatooma Research Station in Zimbabwe. Limited numbers were manufactured in that country and by Henry Plenn, Nigel, South Africa, but the sprayer proved cumbersome and unmanageable, especially in wet weather.

In 1981 the FAO Panel on Agricultural Mechanisation recommended giving further attention to animal-drawn sprayers (Weber, 1982). Since 1980 the agricultural engineering staff at IRRI (International Rice Research Institute, in the Philippines) have been developing farm equipment for Asian smallholders, and technical descriptions of sprayers have been distributed (Bockhop, 1985). ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) has developed sprayers suitable for mounting on its wheeled toolcarriers (Starkey, 1987) and has provided drawings and technical advice to interested parties in different countries (Awadhal, Takenaga and Bansal, 1987). Although various designs of animal-drawn pesticide sprayers have been tested in Botswana, no such sprayers are known to be available in the country at present. In Zimbabwe the only reference found to an animal-drawn herbicide applicator in use in the country was the recommended use of a scotch cart carrying a human-powered knapsack sprayer (Whingwiri, Mashingaidze and Rukuni, 1992). However, Taurus Spraying Systems of Harare have available an animal-drawn ground-wheel-powered boom sprayer called the Pedze Nhama (Chikwanda, Machiwana and Vorage, 1992).

Despite the paucity of information on animal-drawn herbicide applicators, such machines undoubtedly do exist. Of importance is cost, both of the equipment and the herbicides applied. Especially when applying residual herbicides, ground-wheel metering makes application safer and more effective. Where water is extremely scarce, opportunities exist for the development of granular herbicide applicators (Shyam, 1983; Dale, 1985), but few herbicides are readily available in granular form. In many small-scale farming areas, therefore, especially where labour is scarce or relatively expensive, the option of a cheap ground-wheel operated and reasonably accurate animal-drawn herbicide applicator may be welcome.

The SGSC animal-powered herbicide applicator

Experience in the development of a hand-pushed peristaltic-pump-based herbicide
applicator for weed control in maize on
small-scale farms in Swaziland (Fowler, 1981)
indicated that an animal-drawn version might
be readily acceptable. Development of the
SGSC (Summer Grain Sub-Centre: Cedara)
animal-powered herbicide applicator (Figure 1)
was therefore begun.

The unit is based on a single steel or galvanised
iron wheel fitted with anti-skid lugs. A tank of
diluted herbicide is carried in a cradle
suspended from the traction shafts between the
animal and the wheel. The tank is a common
25-litre plastic container, preferably
semi-transparent so that it can be graduated and
the level of liquid inside can be seen.

On the spokes of the wheel are bolts carrying
pipe rollers held at 90º to the direction of travel
of the unit. Around these rollers runs a length
of peristaltic tubing, under tension and clamped
to a stay above the wheel. Lightweight hose
connects the herbicide tank to one end of the
peristaltic tubing, and the other end of the
peristaltic tubing to a spraying unit (either a
single nozzle or a boom assembly).

The pumping action is achieved by the opening
and closing of the tensioned peristaltic tubing
(Pisula, 1989). As a roller comes into contact
with the tube it squeezes it closed and pushes
any liquid in front of it through the system. As
the tubing opens after the passing of the roller
it creates a suction which draws more liquid
into the pump, which in turn is forced through
the system by the next roller.

For every revolution of the wheel the same
quantity of herbicide mixture is drawn through
the pump. Provided the nozzle or nozzles are
matched to this output, the area sprayed with a
unit volume of herbicide will be fairly constant
over a reasonable range of operating speeds.

Principles incorporated in the development of
the Swaziland small-scale farmers’ weed
control system can be incorporated according to
the requirements of the farmers concerned to
develop a weed control system suited to
specific crops and regions.

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Development of improved agricultural implements at

Figure 1. Prototype of the SGSC animal-powered herbicide applicator, showing the shafts (A),
tank (B), cradle (C), rollers (D), peristaltic tubing (E), lightweight transmission hose (F),
auto-skid wheel lugs (G) and a single nozzle assembly (H)
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