This paper is published in: Starkey P and Simalenga T (eds), 2000. *Animal power for weed control*. A resource book of the Animal Traction Network for Eastern and Southern Africa (ATNESA). Technical Centre for Agricultural and Rural Cooperation (CTA), Wageningen, The Netherlands. ISBN 92-9081-136-6. For details of ATNESA and its resource publications see **http://www.atnesa.org**

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

by

Richard M Fowler

Agricultural Research Council, Grain Crops Institute, Summer Grain Sub-Centre: Cedara P/Bag X 9059, Pietermaritzburg 3200, Republic of South Africa

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 90° 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

This paper is published in: Starkey P and Simalenga T (eds), 2000. *Animal power for weed control*. A resource book of the Animal Traction Network for Eastern and Southern Africa (ATNESA). Technical Centre for Agricultural and Rural Cooperation (CTA), Wageningen, The Netherlands. ISBN 92-9081-136-6. For details of ATNESA and its resource publications see **http://www.atnesa.org**

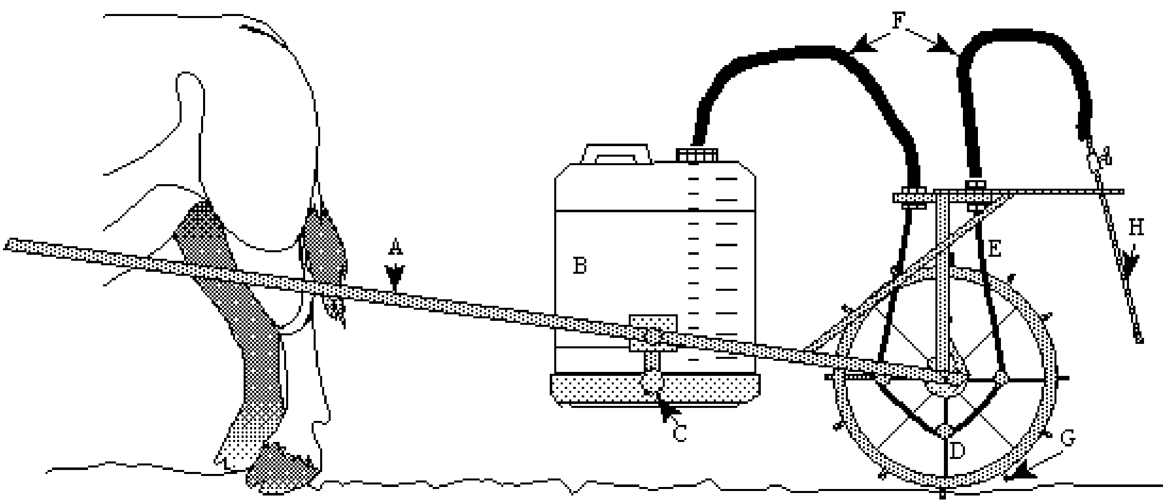

Figure 1. Prototype of the SGSC animal-powered herbicide applicator, showing the shafts (A), tank (B), cradle (C), rollers (D), peristaltic tubing (E), lightweight transmission hose (F), auto-skid wheel lugs (G) and a single nozzle assembly (H)

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.

Acknowledgements

Monsanto South Africa and the Anglo American Corporation's Chairman's Fund financed the preparation of this paper. Valuable advice and help was provided by my assistant, Priscilla Soobramoney; the coordinator of the Animal Traction Network of South Africa, Bruce Joubert; John Bissett of Harare; Dr L P Gakale of Botswana; Tom Bals of Micron Sprayers, UK; Charles Crosby of Pretoria; and librarians at the Cedara Agricultural Development Institute, Agricultural Engineering Research Division, CSIR, and the Universities of Natal, Fort Hare and Botswana. The assistance of all of these people and my colleagues at Cedara is gratefully acknowledged.

References

Akobundu I O, 1979. Weed control in Nigeria. *PANS* 25:287–298.

Akobundu I O, 1982. The role of conservation tillage in weed management in the advancing countries. pp. 23–39 in: *Improving weed management*. FAO Plant Production and Protection Paper 44. 185p.

Auerbach R M B, 1993. *A farming systems research evaluation of maize production practices in southern KwaZulu*. MSc thesis. University of Natal, South Africa. 190p.

Awadhal N K, Takenaga T and Bansal R K, 1987. Development of improved agricultural implements at

ICRISAT. *Agricultural Mechanisation in Asia, Africa and Latin America* 18:21–25.

Bell R D, 1981. The relevance of recent developments in pesticide application technology to crop production in the tropics. In: *Proceedings of the 4th Session of the FAO Panel of Experts on Agricultural Mechanization*, Montpellier, France. FAO (Food and Agriculture Organization of the United Nations), Rome, Italy.

Benbrook C M, 1990. Society's stake in sustainable agriculture. pp. 68–76 in: Edwards C A, Lal R, Madden P, Miller R H and House G (eds) *Sustainable agricultural systems*. Soil and Water Conservation Society, Iowa, USA. 696p.

Benson J M, 1982. *Weeds in tropical crops: review of abstracts*. FAO (Food and Agriculture Organization of the United Nations), Rome, Italy. 63p.

Bockhop C H, 1985. Mechanization for small farms: state of the art. *International Rice Commission Newsletter* 34:205–216.

Brook C E, 1975. *A report on the maize husbandry trials at Malkerns 1973–1975*. Research Report 7, Agricultural Research Division, Swaziland.

Chikwanda B, Machiwana A and Vorage R, 1992. *Catalogue of animal-drawn equipment manufactured in Zimbabwe (1992)*. Agritex Institute of Agricultural Engineering, Harare, Zimbabwe.

Dale J E, 1985. Granular herbicide distributor built from a garden cultivator. *Tropical Pest Management* 31:18–20.

Fowler R M, 1981. Development of a weed control system for small maize farmers in Swaziland. pp. 89–97 in: *Proceedings of the 4th National Weeds Conference of South Africa*.

Garnett R P, 1981. The wheelbarrow sprayer–low volume herbicide applicator for the tropics. *Tropical Pest Management* 27:195–199.

Gill H S, 1982. The role of hand and mechanical weeding in weed management in the advancing countries. pp. 17–22 in: *Improving weed management*. FAO Plant Production and Protection Paper 44. 185p.

Gill K S, Arshad M A, Chivunda B K, Phiri B and Gumba M, 1992. Influence of residue mulch, tillage and cultural practices on weed mass and corn yield from three field experiments. *Soil and Tillage Research* 24:211–223.

Hanson P M and Smith L M, 1992. Economics of chemical and manual weed control in hybrid maize in the Kenya highlands. *Tropical Pest Management* 38:210–213.

Lea J D, 1991. *Maize production in KwaZulu: a handbook for extension officers and farmers.* Institute of Natural Resources, University of Natal, South Africa. 114p.

Lea J D, 1993. *Crop management in KwaZulu: Progress Report 1991/92*. Institute of Natural Resources, University of Natal, South Africa.

Marais J N, 1985. Weed competition in maize with reference to peasant farming. *Fort Hare Papers 8.* University of Fort Hare, South Africa.

Ndahi W B, 1982. Evaluation of glyphosate and paraquat as substitutes for seedbed preparation by tillage in a hoe farming system. *Tropical Pest Management* 28:10–13.

Ogborn J, 1969. The potential use of herbicides in tropical peasant agriculture. *PANS* 15:9–11.

Parker C and Freyer J D, 1975. Weed control problems causing major reductions in world food supplies. *FAO Plant Protection Bulletin* 23:83–95.

Pisula J D Jr, 1989. As the tubing goes, so does the pump. *Research and Development* June: 78–83.

Rao M R, Shetty S V R, Reddy S L N and Sharma M M, 1987. Weed management in improved rainfed cropping systems in semi-arid India. pp. 303–316 in: *Soil, crop, and water management systems for rainfed agriculture in the Sudano–Sahelian Zone. Proceedings of an international workshop*. ICRISAT, Andhra Pradesh, India. 385p.

Rukuni M, 1992. Introduction. pp. 1–6 in: Whingwiri E E, Rukuni M, Mashinguidze K and Matanyaire C M (eds), *Small-scale agriculture in Zimbabwe. Book One: Farming systems, policy and infrastructural development*. Rockwood, Harare, Zimbabwe. 120p.

Schweizer E E, 1988. New technological developments to reduce groundwater contamination by herbicides. *Weed Technology* 2:223–227.

Shumba E M, Waddington S R and Rukuni M, 1992. Use of tine-tillage, with atrazine weed control, to permit earlier planting of maize by smallholder farmers in Zimbabwe. *Experimental Agriculture* 28:443–452.

Shyam M, 1983. Development and evaluation of a granular insecticide applicator. *Agricultural Mechanisation in Asia, Africa and Latin America* 14:34–36.

Starkey P H, 1987. Animal-drawn wheeled tool carriers: a case for caution. *Appropriate Technology* 14:10–12.

Starkey P H, 1988. *Animal traction directory: Africa*. Vieweg for German Appropriate Technology Exchange, GTZ, Eschborn, Germany. 151p. ISBN 3-528-02038-5

Tewari V K and Mittra B N, 1985. Design and development of a low-cost herbicide applicating machine with weeder attachment. *Indian Farming* 43:40–43.

Triplett G B and Worsham A D, 1986. Principles of weed management with surface-tillage systems. pp. 319–346 in: Sprague M A and Triplett G B (eds) *No tillage and surface-tillage agriculture: the tillage revolution*. Wiley, New York. 467p.

Weber R, 1982. The 4th session of the FAO panel on agricultural mechanization: materials and methods for the application of pesticides for soil preparation and crop protection. *Machinisme Agricole Tropicale* 77:54–63.

Whingwiri E E, Mashingaidze K and Rukuni M, 1992. *Small-scale agriculture in Zimbabwe*. Rockwood, Harare, Zimbabwe.

Young D, Miller M, Fisher H and Shenk M, 1978. Selection of appropriate weed control systems for developing countries. *Weed Science* 26:209–212.

This paper is published in: Starkey P and Simalenga T (eds), 2000. *Animal power for weed control.* A resource book of the Animal Traction Network for Eastern and Southern Africa (ATNESA). Technical Centre for Agricultural and Rural Cooperation (CTA), Wageningen, The Netherlands. ISBN 92-9081-136-6. For details of ATNESA and its resource publications see **http://www.atnesa.org**