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The Integration of New Technology in Pesticide Application Systems for Small Scale Farmers in the Tropics (**)

Many have argued that small scale farmers should not use pesticides. Reasons may include a need to conserve foreign currency, concern that all pesticides are too toxic and that it is commercially difficult to reach large numbers of these farmers. Reality is that these farmers do use pesticides and with changes in the supply of labour, wages and farming practices such as direct seeded rather than transplanted rice, pesticide use will increase. However the requirements for protecting small areas of crops are significantly different from the large scale mechanised farm. Unfortunately in promoting pesticide products most effort has been given to promoting a scaled-down version of mechanised technology with no detailed examination of the problems confronting individual farmers. In this paper the requirements and constraints for small scale farmers in the tropics are considered and possible future developments are proposed.

By definition, the small scale farmer has only a small area of individual crops. His main objective is to grow sufficient food crops for his family, but the price paid for his surplus production or cash crops is usually kept low so that urban populations can get cheap food. This simplified description identifies the constraint of insufficient finance for equipment or chemicals and little incentive to seek higher yields. Even when local research has demonstrated improved yields, little recognition has been given to how the farmer could follow research recommendations. As an example, studies in Nigeria showed that yields of June sown cotton could be increased very significantly with relatively few insecticide sprays. Few farmers sow their cotton as early as June, because all

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their effort is on sowing and weeding their food crops such as maize, sorghum and millet (Lyon, 1970). It could be argued that help with weed control was needed, and that herbicides could be used, but spraying recommendations made some 25 years ago required large volumes of water. However, farmers were not prepared to spend a large proportion of time trying to collect sufficient water and transport it to their fields. In consequence cotton production in Nigeria has remained at a very low level.

The Constraints

Apart from financial constraints that can be overcome to a considerable extent by appropriate credit or subsidies, and the lack of adequate water supplies, the small scale farmer has other constraints to his adoption of chemical pest control. Equipment is not readily available at village level. Where it is, the cheapest and least durable is usually offered, even when purchased through Government tenders, so FAO has agreed that application standards are needed for equipment. The enthusiastic farmer may persevere and improvise repairs, but as appropriate spare parts are seldom available, most will be discouraged and abandon further attempts to improve their pest control. Even if protection is continued, in the absence of advice the farmer may use the wrong chemical, the wrong dosage or apply at the wrong time so he may achieve little benefit from his endeavours. To overcome these technical problems, we need to improve existing technology or introduce new concepts on the application of pesticides.

Existing Technology

Most pesticides are formulated for mixing in water and are applied under pressure through hydraulic nozzles. Much of the pesticide aimed at foliar targets is wasted, particularly large droplets which reach the ground, but small droplets also drift outside the treated area. While 200-400 litres of water per hectare may present few problems to the farmer taking water in a tractor drawn tank to his fields, we must remember that for the knapsack sprayer user, this may require at least 10 headloads of 20 litres over distances of up to 1 km which will involve over 6 man hours effort before starting to spray! Reduced spray volumes do have a significant effect on the time needed to treat crops and some manufacturers are promoting better nozzles, but there are other factors which need equal if not more attention.

Most hydraulic sprayers are supplied with a hand-held lance which is invariably carried in front of the operator. This results in excessive contamination of the lower legs while walking into the spray and treated foliage (Matthews, 1985). Only recently has attention been directed at the safety aspects of knapsack spraying, yet Fernando (1956), Cadou (1959) and Tunstall *et al.* (1961) have all developed equipment with rear-mounted nozzles, so that the operator walks away from the spray. The main argument against nozzles behind the operator has been that it is not possible to see if a nozzle is blocked. However with appropriate ancillary equipment to prepare the spray and filter it, and with filters in the nozzle bodies, there is little risk of blockages. Furthermore if a serious blockage occurs, the operator would soon feel it due to increased pressure affecting the ease of pumping.

Clearly if a spray programme is to be recommended, the total operation needs to be planned so that farmers can obtain *all* the components and chemicals needed. A supply of spare parts with the sprayer is clearly crucial, as farmers may not be able to travel easily during the crop season.

As most farmers may not know their exact crop area or be able to calibrate equipment accurately, systems need to be devised which ensure that the dosage applied is appropriate. In Central Africa this was achieved by supplying the insecticides in sachets containing sufficient for each knapsack load, thus the spray concentration remained constant. The volume applied and thus the dosage was determined by the number of nozzles on a boom and walking speed, the latter usually averaging close to 1 m/s. On cotton as the number of nozzles increased in relation to plant height the dosage also increased in the same proportion, thus maintaining a similar dosage per unit of leaf area throughout the season. This system has proved remarkably successful and durable for farmers who could obtain water (Gower and Matthews, 1971), but for many areas of the tropics, especially in the drier savannah areas, water remains the most crucial constraint to crop protection. Even if water is readily available for part of a season, it is seldom plentiful at the start of the season, when herbicides are needed, or at the end of the season, if mature crops require protection.

New Technology

Ultra-low volume sprays are hardly new technology, having been available now for over 30 years, and particularly over the last decade with the introduction of hand-held, battery-driven, spinning disc sprayers which produce a more uniform droplet size (Matthews, 1979). All trial work on field crops such as cotton, cowpeas, groundnuts and rice has indicated that control of pests (including weeds) can be as efficient as with knapsack spraying. Several types of spray formulation have been used with spinning discs but the less volatile ULV formulations at less than 5 l/ha are preferred. The technique has been adopted most widely on cotton in francophone Africa, where over 80 per cent of farmers' crops are sprayed (Table 1) (Cauquil, 1985). The success of the implementation of the change from knapsack equipment must be due to organisation of the supply of everything the farmer needed at village level. This requires considerable logistic support, particularly in the supply of batteries, the cost of which has escalated in recent years. Improvements in sprayer design are possible to reduce power requirements, but there are two other research areas that need far more support. Some effort has been given to alternative sources of power,

TABLE 1 - Adoption of ULV spraying in francophone Africa.

Years	1975	1984
Area (ha)	815,500	785,000
Production of Seed Cotton tonnes	548,500	872,000
Yield Seed Cotton kg/ha	673	1,111
Area protected* % of total	47	80
ULV as % area protected	3	97

* At least 3 spray applications.

including manually operated pumping systems to rotate the disc, but the most appropriate technology for the future must surely be the harnessing of solar energy.

At present photovoltaic cells to convert solar power into an electrical voltage are still relatively expensive, yet with the demand for power for radios and other equipment throughout the year, there is surely scope for developing systems for recharging batteries that could be economically viable. Initial research has shown that rechargeable nickel-cadmium batteries are better for sprayers as the voltage output is more constant, and that such batteries can be recharged from solar cells. Technical support is now urgently required to develop less expensive solar panels and investigating appropriate combinations of batteries and motors to achieve the most efficient utilisation of the technology, for example, should there be a small unit for an individual farmer or a combined resource at village level.

Several systems of electrostatically charging pesticide sprays have been developed (Law, 1980; Arnold and Pye, 1980; Marchant and Green, 1982; Pay, 1985) but a major innovation in spray technology has been the electrodynamic nozzle (Coffee, 1979). This ULV spray system requires less energy to operate it than the spinning disc, but the pesticide formulations require a particular resistivity. This is because the electrostatic forces are used to produce spray ligaments which form the charged droplets. The system only requires 0.1 watt per nozzle and has no moving parts. Appyling an electrostatically charged spray has some advantages and disadvantages.

Taking the disadvantages first, the number of different pesticides available is still limited (Table 2), and as the droplets are deposited principally on the nearest earthed surfaces, penetration through a crop canopy is limited. However in some circumstances this factor can also be advantageous as contamination of the soil under the crop is significantly reduced, so that some natural enemies can be less effected. Some spray drift can occur, but in most situations, downwind movement of spray is significantly reduced. This reduction in drift makes the technique particularly suited to the small scale farmer who may grow

TABLE 2

Electrodyn Products		
cypermethrin	—	lepidopterous pests
pirimicarb	—	aphids
pirimiphos methyl	—	mites
carbosulfan	—	aphid, whitefly
Chemicals for which formulations suitable for ED have been tried		
dicofol	—	mites
bromopropylate	—	mites
profenofos	—	whitefly, jassids
malathion		
chlorfluazuron	—	bollworm
fluazifop-butyl	—	selective grass herbicide

several crops in close proximity. Clearly further research is needed to determine how far the use of charged sprays can be integrated with modified intercropping or mixed cropping systems of agriculture. Traditionally many subsistence farmers grow several crops within a field hoping that at least some will survive pest attack. With previous pesticide programmes, the farmer has been encouraged to grow sole crops, but if narrow strips of several rows of a particular crop were encouraged such as the alley system, it might be possible to integrate chemicals with biological and cultural controls. Thus if one crop needed protection, it could be treated with minimal contamination of adjacent crops due to reduced drift. The untreated areas would provide a refuge for natural enemies so increased infestation of certain pests due to the close proximity of alternative hosts is likely to be less than where sole crops are grown.

Much of the initial work with charged sprays has been with pyrethroid insecticides, but in developing a second green revolution, it needs to be considered as a tool for the dryland farmer. At present, much of the topsoil is lost by erosion accentuated by shallow hoeing of weeds. With minimum cultivation, and localised strips of herbicide, together with development of a new generation of more selective pesticides, such as insect growth regulators, higher yields should be possible even in areas of low rainfall. If this is to be achieved, we need a more positive approach to pesticide use in the tropics. Instead of regarding them as totally unwanted, we need to involve sensible systems of judicious use. Such a bold new approach will need considerable financial support and greater incentives to the farmers to grow better crops.

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