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Weeds and Shifting Cultivation*

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Summary. Traditional labour-intensive methods of weed control which are normally associated with shifting cultivation are evaluated and compared with the use of herbicides and improved cultural practices. Problems occurring in shifting cultivation, such as weed seed dormancy, erosion and changing weed population; and methods of reducing the weed problem are discussed. **PANS 21: 188–194, 1975.**

Introduction

Shifting agriculture and related bush-fallow cropping systems constitute the predominant practices on large areas of the potential arable and grazing land of the tropics extending more than 36 million square kilometres and are a means of subsistence of more than 200 million people. Most land under shifting cultivation is in tropical Africa but even south-east Asia which is the most densely populated tropical area has about one-third of its farm land under shifting cultivation.

The method involves farming a piece of land for a short period following clearing until declining yields force the farmer to abandon the land to fallow. Generally the land is fallowed for a longer period than it is cropped. The length of fallow depends on amount of land available, pressure of population, level of fertility, rapidity of regeneration of the fallow and various other factors.

Luxuriant weed growth is a major problem of tropical agriculture. The depressive effect of weeds can be so great as to completely destroy the crop. Most tropical farmers use simple tools to control weeds. They are forced to abandon the land when they can no longer control weeds or when clearing a new piece of land will give greater returns than extra weedings on the old piece. The fallow suppresses the weeds that were a problem during cultivation and is a cheap and efficient means of weed control. Weed growth is a major obstacle to continuous cultivation in the tropics. Because weeds cannot be controlled successfully with practices used at present the possibility of the introduction of alternative methods of weed control is being examined. It is necessary to highlight the role of weeds in shifting cultivation and to examine ways in which the weed problem may be reduced.

Clearing

Ideally, the bush fallow is a stable almost completely woody community. Grasses and herbs are confined to the edges of roads, paths and open places (Obi and Tuley, 1973, unpublished report No 161, Land Resources Division, ODM).

The end of the forest fallow occurs with land clearing in the dry season, followed usually by burning before the onset of the rains. Deforestation is arduous and the farmer never completely clears his land before

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planting. He leaves the large trees and those of economic value standing and the stumps and roots from which the forest regenerates in the ground (Clayton, 1958; Tempany and Grist, 1958; Miracle, 1967; Greenland, 1970).

Burning

In general, burning removes debris rather than controlling weeds (Crafts and Robbins, 1962). Fire seldom reduces the viability of weed seeds that have fallen to the soil surface (Crafts and Robbins, 1962) although there are reports that burning will destroy all (Clark and Haswell, 1970) or at least some seeds (Klingman, 1961; Webster and Wilson, 1966; Oyenuga, 1967). The degree of destruction depends on the heat intensity generated by the burn (Klingman, 1961).

Fire may promote weed seed germination by ending seed dormancy (Went *et al.*, 1952; Klingman, 1961; Crafts and Robbins, 1962), although it has been reported that burning seemed to delay (Brown, 1969; Ahn, 1970) or had no effect (Went *et al.*, 1952) upon germination. Burning, with clearing, will also promote weed seed germination and growth by removing competition of other plants and litter, allowing more light to reach the soil surface and causing greater temperatures alternations in the upper soil layers between day and night (Went *et al.*, 1952; Watters, 1958; Klingman, 1961).

In some areas, cleared land is protected from fire until after the first rains have fallen and the first weed seeds have germinated (Parsons, 1970) or new shoots have sprouted (Davies, 1972). Burning should destroy these young plants (Parsons, 1970; Davies, 1972) and the need for subsequent weed control may be reduced (Parsons, 1970).

In the forest zone, when the land is cultivated repeatedly, grasses often increase in amount. Frequent burning will then destroy seedling forest trees preventing natural reforestation and the vegetation eventually converts to savanna (Pelzer, 1945; Keay and Onochie, 1947; Bartlett, 1956; Clayton, 1958; Jurion and Henry, 1967; Tiley, 1970; Ruthenberg, 1971). Land burned too often frequently becomes overgrown with perennial grasses which may render it useless for agricultural production when simple tools are used (Bartlett, 1956). Burning also stimulates the growth of some perennial weeds such as *Imperata cylindrica* (L.) P. Beauv.

Seed dormancy and cultivation

Following clearing and burning, the land is often weed free (Ruthenberg, 1971). Fallowing usually prevents excessive annual weed growth and thus further seeding of arable weeds and a gradual diminution of the weed seed content of the soil occurs. It does not eliminate arable weeds completely. The seeds of many weeds retain their viability for 20 years or more when buried in the soil (Crafts and Robbins, 1962). They will not germinate because of unfavourable conditions and can outlive virtually any fallow period irrespective of its length. Thus, only weeds having short-lived seeds can be controlled by this means.

Usually little or no weeding is required in tropical crops during the first year after clearing (Pelzer, 1945; Miracle, 1967; Brown, 1969; Clark and Haswell, 1970; Ruthenberg, 1971; Cancian, 1972) but instances where weed growth has caused complete loss of the crop have been reported (Tempany and Grist, 1958; Anon, 1972). As cultivation continues the weed problem increases to such an extent that the farmer is eventually forced to abandon his land (Pelzer, 1945; Laudelot, 1958; Watters, 1958; Nye and Greenland, 1960; Clark and Haswell, 1970). In the first few years weeds increase in inverse proportion to the length of time the land has lain fallow (Cancian, 1972).

Problems associated with weeds

Weed competition greatly reduces crop yields. Ashby and Pfeiffer (1956) estimated that crop losses in the tropics are two to three times greater than in the temperate zones. Yield decreases of 50% or more due to weeds within two or three seasons after clearing have been reported (Jurion and Henry, 1967; Brown, 1969). In Nigeria, crop losses due to weeds range from 20% for maize to 100% for upland rice (Anon, 1972; Anon, 1973; Anon, 1974).

Maximum yields are obtainable when the crop grows without weed competition. If this is impossible, weed control in the early growth stages of the crop is essential (Ochse *et al.*, 1961). In the tropics, the greatest proportion of cropped land is weeded with simple tools. This is slow and usually commenced after weeds have

begun to exert a depressive effect on yield. An assessment of the major tropical crops would probably indicate many instances in which weed problems have either limited the yield of the crop or are a major item in the cost of production (Ashby and Pfeiffer, 1956). More energy is expended for the weeding of man's crops than on any other single human task (Holm, 1971). In western Nigeria, at least 50% of a farmer's working time is spent weeding (Anon, 1972).

Weeds are often a greater problem in a single crop or in simple crop associations than in the multicrop multistoried crop associations that occur over most of the shifting cultivation area (Watters, 1971). The complete cover provided by a mixture of crops not only helps in protecting the soil but may reduce the need for weeding by competing with the weeds. Cropping patterns may have evolved specifically to minimize the labour cost of weed control (Cleave, 1974). In introducing modern weed control methods, it would be more advantageous if monocropping was practiced. However, in western Nigeria many farmers prefer to intercrop rather than monocrop to reduce costs (Williams and Alao, 1972).

The principal limiting factor to the size of tropical farms is the number of necessary weedings during the period following planting (Baldwin, 1957). The size rarely exceeds two to three hectares per family (Terra, 1959). In Lumbata village in Liberia the average area of land cultivated annually per person is 0.31 ha or 2.2 ha for each family (Koch, 1971).

Soil erosion and possible methods of control

While it is important to keep crops weed free in the early stages of their growth, it is also then that the soil is least protected and thus has the greatest susceptibility to erosion. In East Africa, weeds are only hoed when harvesting and planting have been completed (Attems, 1968). Late weeding reduces yield but the weeds cover the soil and protect it against erosion (Attems, 1968). Is the reason for late weeding an unconscious effort on the part of the farmer to control soil erosion? (H. Ruthenberg, University of Stuttgart, Hohenheim, Germany. Personal communication).

Runoff and soil erosion losses can be reduced greatly by mulching (Anon, 1973). In Samoa, a mulch of dead vegetation was spread over the ground between plants to reduce weed growth and on steep slopes living weeds were retained to prevent erosion even though they reduced yield (Watters, 1958).

Using crop residues from a previous maize crop, (B. T. Kang, International Institute of Tropical Agriculture, Ibadan, Nigeria. Personal communication), has successfully reduced weed growth in sweet potatoes. However, in most instances, mulching is not practical because large amounts of material are needed. This may have to be grown on land that could have been used for economic crops. It then has to be cut and transported – which is time-consuming and adds to the cost of growing cash crops (Crafts and Robbins, 1962).

An alternative is to practice minimum tillage. By this method, runoff and soil losses were decreased and the available water-holding capacity of the surface soil was increased compared with conventional tillage for maize (Anon, 1973). Weed growth, primarily annual grasses, was less but bush regrowth was greater on the no-tillage plots (R. Lal, International Institute of Tropical Agriculture, Ibadan, Nigeria. Personal communication). Use of this method is dependant on suitable herbicides being available for weed control.

In the United States, satisfactory results are being obtained with no-tillage in maize and soybeans but problems have been encountered when perennial weeds are present (Peters, 1972). In Nigeria, this method has been used successfully in both maize (Anon, 1973) and cowpeas (Anon, 1974) where there were few perennial weeds.

Overcultivation and the shift in weed population

As cultivation continues, the composition of the weed population may also change. In Peru (Sanchez and Nurena, 1970), weeds in rice have changed from a broadleaved to a grass population after two crops. Similarly in Mexico in recently cleared fields broadleaved weeds are the major problem but in fields that have been cropped for some years grasses provide the principal competition for maize (Cancian, 1972). In western Nigeria, at the end of the first season after clearing the forest, only 14% of the weed population consisted of grasses. However, by the end of the second season grasses comprised at least 77% of the weed population (Anon, 1974). De Schlippe (1956) reports that weed composition changes in the fourth year after clearing and these weeds (*Bidens pilosa* L., *Chloris* spp., *Eleusine indica* (L.) Gaertn., *Commelina benghalensis* L., and *Pennisetum pedicellatum* Trin.) are the indicators of soil degradation.

In many overcultivated areas *Imperata cylindrica* (L.) Beauv. becomes established (de Schlippe, 1956; Clayton, 1958; Tempany and Grist, 1958; Ochse *et al.*, 1961; Jurion and Henry, 1967; Eussen and Wirjahardja, 1973). *Imperata* is a poor competitor and can be destroyed by being shaded out by other more desirable grass species. In the derived savanna in Nigeria (Clayton, 1958), *Imperata* is suppressed by *Andropogon tectorum* Schvmach. which in turn is gradually replaced by other grasses consisting mainly of *Hyparrhenia subplumosa* Stapf., *H. rufa* (Nees) Stapf. and *Schizachyrium* sp. In Indonesia, the first stages of succession from ar. *Imperata* vegetation to a secondary forest are characterized by the occurrence of *Eupatorium odoratum* L. followed by a more mixed vegetation consisting of relatively short-lived shrubs and small trees. Disturbing the natural balance of the succession results in maintenance or increase of the *Imperata* vegetation (Eussen and Wirjahardja, 1973).

In the south east of Nigeria, overcultivation gives rise to a grass and herb flora usually dominated by Guinea grass (*Panicum maximum* Jacq.) or *A. tectorum*. At this stage, if the land is rested, it quickly returns to bush fallow. If further cultivation continues there are indications of a succession of arable weeds and smaller grasses culminating in the appearance of bracken (*Pteridium aquilinum* (L.) Kuhn) (Obi and Tuley, 1973, unpublished).

Abandonment

Most of the plant species comprising the forest fallow grow at the later stages of the cropping cycle provided no clean-weeded crops are used for closing the cycle (Laudelot, 1958). Greenland (1970) states that the land is abandoned because the rate of redevelopment of the forest creates a 'weed' problem that is more difficult to manage than clearing an older area of forest.

Abandonment occurs when the effort of controlling weeds becomes too great and the farmer considers that the benefits obtainable from labour expended in clearing a new site will exceed the benefits obtainable from extra weedings of the current site. In addition, clearing is done during the dry season when the farmer has little else to do whereas for effectiveness weeding must be done over a short period during the growing season. Thus the farmer reduces his work load at the busiest time of the year and distributes his work more evenly throughout the year (Nye and Greenland, 1960; Watters, 1971).

Laudelot (1958) emphasises that the cropping cycle should end with plants such as cassava which require no cultivation and little weeding. These plants complete their growth cycles in a tangle of regrowth which can be already considered as the onset of the forest fallow. With their harvest, the cultivation cycle comes to an end.

Abandonment of the cultivated area to fallow is one of the cheapest and most effective forms of weed control. Bush regrowth is rapid and within 5 to 6 years after abandonment may be up to 7 m high (Koch, 1971). It rapidly suppresses the growth of weeds that may have been difficult to control during cultivation (Vine, 1968; Watters, 1971). Following abandonment various vegetation communities will succeed one another until the final phase, a stable community, is reached (de Schlippe, 1956). Once this occurs, the forest is then cleared again. Clearing may occur prior to this time but if it does, it is delayed until certain plants have become established indicating that weeds which were a problem during cultivation have been suppressed or until undesirable weeds have disappeared (de Schlippe, 1956; Nye and Greenland, 1960; Jurion and Henry, 1967).

Possible means of reducing the weed problem in traditional agriculture

Weed control is a major problem in many tropical areas yet most weeding is still done using simple tools. At present, in many areas crops are sown in a scattered or staggered pattern on mounds or on the flat. This makes weeding more difficult. Tiley (1970) states that the most effective way of reducing the burden of human toil in weeding would be to sow all crops in rows.

Dadey (1973) notes that only about 10% of the upland rice crop is planted into reasonably clean seedbeds. In order for crops to be able to compete successfully against weeds they must be planted into weed free seed beds.

In Mexico, the period of cultivation in the shifting cultivation cycle has been extended by ploughing (Watters, 1971). One of the most important innovations needed to continuously cultivate the land is the introduction of ploughing. However, ploughing may be difficult in most parts of the humid tropics for some years following clearing because of undecomposed roots and tree stumps. By the time these decompose sufficiently to

make ploughing possible, fertility declines or weed invasion necessitates abandonment to forest fallow (Watters, 1971). The shift to mechanical power brings an increased output per worker enabling him to do the job faster. In addition the physical burden of farm work is lessened because the drudgery of hand labour is eliminated (Miller, 1970).

The disadvantage of inter-row cultivation is that it does not kill all the weeds in the row. These may have to be removed by hand. Also it may not be possible to cultivate at the correct time because of soil conditions. The use of mechanical equipment for land preparation allows for better land preparation and for larger areas to be prepared and planted. It is pointless to plant larger areas unless weed control methods are also improved because in many instances it is labour and not land that is the limiting factor in shifting agriculture. In addition, introduction of mechanisation into the traditional cultivation system may be difficult due to the small size of the farms and the cropping pattern used.

The answer to many of the tropical weed problems may be in the use of herbicides which can be more selective and thorough in their action than cultural methods (Ashby and Pfeiffer, 1956). They can also be applied at an earlier stage in the crop development even before crop emergence and will remain active until the critical period of weed competition has passed.

Cleave (1974) believes that chemical weed control could be the most profitable line of investigation into the intensification of peasant agriculture. Norman (1970) notes that capital goods such as herbicides which could substitute for labour are seldom used because of technical constraints and the unavailability of funds. However, there are reports that herbicides have been used successfully by some farmers in shifting cultivation areas.

Some people (Chang, 1968; Brown, 1969; Renaut, 1972) have expressed the concern that herbicides are too costly to be used by the majority of farmers in the tropics. However, in many parts of the world, increasing labour costs and the unavailability of labour at critical times are rapidly causing the use of herbicides to become more economical than hand labour. Also low-income farmers are more likely to use herbicides than fertilisers. By using herbicides they reduce labour requirements and produce more whereas using fertilisers means more labour but only more produce if conditions are optimum for fertiliser response (Haswell, 1973).

In the Philippines, herbicides which are both effective and economical for weed control are available for upland rice (De Datta and Beachell, 1972). In Kenya, it is cheaper to use herbicides than employ casual labour for weed control in maize (Laycock, 1974). In western Nigeria, if a farmer performs timely weed control, hoeing a field twice is cheaper than the use of herbicides for maize, soybeans and cowpeas but if a farmer has to hoe his field three times, then herbicides are cheaper (K. L. Robinson, Cornell University, Ithaca, New York. Personal communication).

Herbicides are impossible to introduce into the multicrop associations that many shifting cultivators presently use. A change from the system the farmer is presently using to one using a monocrop or simple crop associations will have to accompany the introduction of herbicides as a means of weed control.

In many areas water is scarce and inaccessible therefore the use of low volume applications (Renaut, 1972) or granules instead of applications requiring large volumes of water should be considered. Granules, even though more expensive, may be the most acceptable formulation because they can be applied by hand along with fertilisers. In addition the proportion of chemical in granules is always the same whereas other herbicides have to be mixed and applied carefully to obtain precision.

Conclusions

Weeds constitute a major limiting factor of crop production in the tropics. They are present from the time the farmer clears the land until he abandons it to fallow. They restrict the area a man can farm and their removal occupies most of his time.

During the first crop after clearing weeds may be controlled fairly easily but during subsequent crops the task becomes increasingly difficult. Then the weed population shifts from one that is predominantly broad-leaved to one that is predominantly grasses. Because the farmer is unable to control weeds and because of the reduction in yield caused by them, he is forced to abandon his land. The subsequent fallow provides a cheap means of weed control.

The greatest limitation to continuous cultivation in the tropics is man's inability to cope with weeds. Weed control methods that the farmer presently uses are unsuitable and weed research in the tropics must be greatly expanded so that suitable alternatives can be found in the shortest time possible.

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