Mulching with organic materials: knowledge is power

To be in line with traditional tropical knowledge, a mulch can be best defined very broadly as a shallow layer that appears at the soil/air interface with properties that differ from the original soil surface layer (Stigter, 1984a).

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The traditionally most widely used mulches are: thin layers which manipulate surface colour of dry grass, straw from crop residues, leaves, etc., or fresh organic material from weeds, bushes, trees, household refuse, etc. Mulching affects many conditions near the soil/air interface where it is applied. These effects depend on the following:
- form of application: whether the mulch material is incorporated into the soil or left on the soil;
- timing of application(s);
- amounts of mulch applied;
- composition and colour of the mulch;
- deterioration and decomposition rates of the mulches, which depend on the form and timing of application and meteorological conditions in soil and air.

Available knowledge
Effects of mulches may be on: soil temperatures, soil moisture, soil physical properties (mechanical, structural, with respect to water behaviour, including erosion, and aeration), soil chemical properties, soil microbial activities, aerial physical properties (radiation and heat flow), mechanical impacts of rain, hail and wind, weed growth and other pest and diseases. In fact all these effects should be considered when applying mulches for one or more actual reasons. Mulches have been abundantly applied for some, but not all, of the above mentioned effects in horticultural practice in the Western world and Japan. But when the horticulture under glass and plastic became of greater importance, a lot of that practice disappeared. On some larger scale fields, mulching was still also applied for several reasons in the forties and the fifties in more developed agriculture. Then it lost its importance due to more mechanization and less labour being used in agriculture. Only to be rediscovered relatively recently when no-tillage and low tillage and residue management practices and more recently alternative agriculture (Altieri, 1983b) gained impetus. So there are two sources of knowledge from which we may borrow in an attempt to synthesize. There is quantitative scientific knowledge earlier and again more recently obtained, largely in the developed world. And there is traditional often qualitative knowledge of the usefulness of mulching in low external input agriculture farming systems. Below we deal with a terminated and an ongoing, recently started, example of research on traditional aspect of mulch application.

Traditional dry grass mulches
In low-input tea growth, small farmers deliberately use mulches for erosion protection, to conserve water, to suppress weeds and to supply nutrients. In experiments set up by the Tea Research Foundation of Kenya (TRFK), at Kericho in Western Kenya, three dry grass mulches (Napier grass, Guatemala grass, Eragrostis curvula) and a live mulch of growing Kikuyu grass (with the mowings left on the surface) were used in erosion prevention experiments with young tea. It appeared that with some of the dry grass applications the young tea suffered much more from drought stress after a while. Excavation indicated very shallow root growth in such cases. Unwanted soil temperature differences could be considered as the only cause. At the altitude of Kericho, only a few degrees difference in the top soil would be enough to have appreciable differences in young root growth. Experiments were set up to monitor the diurnal soil temperature patterns under mulches and bare soil for several years at three depths. The average temperatures appeared only partially conclusive. Certainly no conclusions could be drawn form these averages on built-up and seasonal differences of thermal efficiency of mulches. Changes of thermal efficiency with decomposition of the mulches could not be detected. For the latter purposes it would be necessary to quantify more precisely differences in thermal climate which the young tea roots actually experience. But that implied the differences in the actual daily fluctuations of temperature within the soil. How to use these in a meaningful comparison?

In Dar as Salaam (DAP-Project, Stigter, 1982), a theory had been developed and experimentally confirmed, initially at the surface, to understand modifications of soil surface and near-surface temperature fluctuations from manipulation of the surface colour. This subject was chosen in 1976 because it is a traditional method of mulching used in Africa. For example, by blackening with charcoal surfaces used for drying (more heat absorption near the drying products) and by whitening with chalk surfaces under which seeds may suffer from too high temperatures (less heat absorbed by the soil). Both these colour manipulations are strict examples of mulching in our broad definition. This theory was then expanded and experimentally confirmed by the data provided from Kenya, and by some additional M.Sc.-experiments in Dar, for mulch covered soils (reviewed in Stigter, 1985a). The result was surprisingly powerful. An operational method was derived which makes it possible, by determining average diurnal temperature fluctuations at only one depth (say between 5 and 10 cm), to quantify and compare the thermal efficiencies of grass mulches on a certain soil. Also their course throughout the year as a function of weather conditions and fresh applications of mulches may be followed. In case of live mulches efficiency may be expressed, in terms of its seasonal growth (reviewed in Othieno et al., 1985). For the dry grasses used, it was now easy to show which one had (in this case the preferred) lowest thermal efficiency: Eragrostis curvula. The Guatemala grass reached the highest efficiency, but lost it fastest in the rainy season, to end below the Napier grass before the next application. The growing grass reached a value close to the highest dry grass values before the dry season started. Such indications can be refined, now that we have this simple operational method, by applying different amounts of the same mulch or by different timings. Combined with quantification of erosion prevention or weed suppression, which have to be obtained from separate local experiments like we did on light extinction in layers of dry grass mulch (Stigter et al., 1984), (weather) advisories on mulching may be given to the farmers.

Alley cropping in semi-arid areas

At IITA in Ibadan, Nigeria, alley cropping was developed (Kang et al.,)984) in an attempt to incorporate the good features of shifting cultivation and other traditional concepts of agroforestry into a continuously productive farming system. Such an agroforestry system may have its value for the semi-arid areas as well, but limits will be set by the tree growth rates obtainable. In alley cropping a cereal or an intercrop with a cereal is grown between trees. Trees may be leguminous and hence nitrogen fixing and prunings are used as mulches for nutrients and other purposes. It is one of the examples which are very suitable to show the interdisciplinary character of agroforestry research. The following quantitative knowledge is needed from trials to fully understand the system and to come to (weather) advisories:

- yields per plant between trees and in controls. If the trees do not yield other economic products than mulch, the yield increase between trees should outweigh the losses due to the area now occupied by trees;
- amounts of mulch that become available from the trees at different prunings as well as from weeds, and their composition (organic matter, nutrients);
- decomposition and deterioration rate(s) of the mulches;
- relevant differences in soil fertility and soil physical characteristics due to the mulches;
- nutrients from the mulch material that show up in the plants and yields mitigated by competition with the trees themselves and with weeds;
- microclimate differences from the presence of the trees and mulches, due to interactions with respect to space (e.g. air movement), radiation (e.g. shade and plant surface temperature) and water (e.g. soil moisture);
- amounts of other useful products which might come from the trees in a cost/benefit ratio calculation.

We may want to have such quantitative knowledge for different row directions (often determined by contour directions), tree spacing and tree species/crop combinations. Times of prunings and mulch applications, mulch treatments (incorporation or at the surface), macroclimates and soils are other factors to distinguish. The results are often cumulative over years as to some important responses such as in changing physical and chemical characteristics of the soil. They are also site and season specific, making long term projects an absolute necessity. The TTMI-Project, on which there is an article elsewhere in this newsletter recently started to participate in the Dryland Agroforestry Research Project in Kenya, already ongoing for several years, in such quantification attempts for alley cropping. Results of the earlier seasons show (Arap Sang and Hoekstra, 1987) that yield response interpretations remain difficult if not all of the above mentioned quantitative knowledge is obtained simultaneously. These are almost heroic attempts, under the research work in developing countries. It will be extremely difficult to get and keep such research going in the tropics with sufficient quantity and quality. However, the acquired knowledge and understanding, validated in farmers' fields, will contribute to increased small farmer's power to satisfy in a sustainable way his own demands and those of internal markets.

This article is compiled by Kees Stigter from results of research done from 1975-1984 at Dar es Salaam, with contributions from 1980 onwards by C.O. Othieno (TRFK), and from present research by C.L. Coulson and the Kenyan TTMI-team.