

Farmer Managed Natural Regeneration (FMNR): what it is and how it evolved.

The practice of FMNR has evolved since its introduction in 1983. Farmers have the flexibility to modify the technique to meet their own needs. It is important that they be free to choose the number of shoots per stump and per hectare, the length of the rotation and the method of pruning. Any form of enforcement of FMNR 'norms' was avoided by MIDP. The basics of FMNR are very simple:

Desired tree stumps are selected. For each stump, a decision is made as to how many stems will be chosen for growth. The tallest and straightest stems are selected and side branches removed to roughly half the height of the stem. The remaining stems are then culled. Returning regularly to prune any unwanted new stems and side branches attains best results.



Pruned stems of Calotropis procera attained a height of over two meters in just one year . Contrary to popular belief of both farmers and foresters, indigenous tree and shrub species, especially when growing from a mature stump can grow very rapidly.

FMNR is not a new idea. It is a form of coppicing and pollardingⁱ: techniques which have been practiced for centuries in Europe. Over 1000 years ago, Europeans ran their woods as a renewable resource by coppice farming of naturally occurring woodlands. Without destroying the trees, they produced poles, wood for fences and construction, and firewood. Ash stands that have been repeatedly cut and allowed to re-sprout on a regular rotation for at least 500 years still existⁱⁱ. What may be new about FMNR is that this method of tree management is being carried out on farmland; land which is normally completely cleared of other vegetation.

In 1983, the thought of leaving trees in crop fields was seen as ludicrous by farmers brought up with the belief that cleared fields were essential for realizing good crop yields. Not surprising, adoption of FMNR

was very slow. The few individuals who tried were often ridiculed. Wood being extremely scarce and valuable, theft of rare stems left in fields was a discouragement to the few who gave it a go. Even if the aggrieved knew the perpetrator, it was culturally unacceptable to report him to the chief.

However, in 1984 radio coverage of an international conference on Desertification held in Maradi greatly increased peoples' awareness of the link between deforestation and drought. The message was strongly re-enforced when the disastrous subsequent drought of 1984 caused almost total crop failure resulting in starvation. MIDP operated a *Food for Work* program in 95 villages and FMNR was one of the activities. Farmers in a whole district were asked to leave trees on their farms. Having the whole population leave trees over a wide area helped break some of the stigma experienced by the earlier FMNR pioneers. Now, through first hand experience, farmers in the whole district could see for themselves that their crops actually grew better amongst the trees. Other benefits included having extra wood, mostly for home use.

Unfortunately, during this exercise most farmers had only reluctantly practiced FMNR in order to receive food. At the end of the *Food for Work* program, an estimated two thirds of the 500,000 trees left to grow were cleared. Even so, the seeds of a new idea were sown in over 95 villages for a 12-month period, and for some, fears of ostracism and tree-crop competition were alleviated. Ironically, those who cleared their trees soon experienced a recurrence of their old problems – shortage of firewood and light poles, burial and sand blasting of emerging seedlings, high temperatures, and absence of pest predators in crop land. Even though stealing occurred during the 1984 campaign, most farmers who practiced FMNR were able to harvest something and benefited to some degree from having their own trees. Post 1984, a gradual change occurred, as more and more farmers began practicing FMNR. Today, it is impossible to count the number of trees present on the once barren landscape, but estimates suggest that there are over two million trees standing in the MIDP working area.

Today, Farmer Managed Natural Regeneration in one form or another is a standard farming practice. In fact, an indicator of the extent of the change that has occurred is that a farmer is much more likely to be ridiculed today for not practicing FMNR than for practicing it. The logic behind this is that everybody needs wood, and if you are not growing your own and you are not rich – then you must be stealing or begging from others.

As farmers became confident with FMNR and began to profit from it, it became possible to promote progressively more intensive forms of tree management. There were three main training phases:

a) Modern land preparation

Farmers graduated from completely clearing and burning all tree regrowth on cropland, to selecting and pruning about 40 stems, (one stem per stump) per hectare.

This modest step into FMNR required a lot of courage by early adopters. Their neighbours often ridiculed them. Some had their young trees stolen or deliberately damaged. Many feared a reduction of food crop yields.

As confidence grew and farmers became convinced of the benefits, and as negative peer pressure diminished, a more intensive form of FMNR was promoted. Even so, 'modern land preparation' remains the most commonly practiced form of FMNR.

b) Next-step land preparation

Instead of only leaving one stem per stump, five or even more stems were left. The intent was that one stem would be harvested each successive year, and each year, a replacement young stem would be encouraged. The longer a stem is left to grow, the greater its size and value. Stems on fifty to one hundred stumps per hectare were pruned in this way. This was the ideal taught by MIDP, however practice varied from farmer to farmer.



*Next step land preparation.
Five or more stems are left
and pruned on each
selected stump.*

A very significant change in mindset and practice was occurring. Trees were no longer considered as nuisance weeds needing to be chopped down. The majority of the population were now seeing trees as valuable cash crops in their own right. Where force and appeals to save the environment failed, the sheer economic benefits of farming trees began to bring about radical changes in farming practice. It was now time to introduce a third modification.

c) Profit from every stump.

For a significant part of the eight-month dry season, woody vegetation continues to grow and has the potential to provide benefits to the farmer and the environment. Farmers were encouraged to leave and prune five stems on **every** stump growing on their land for at least the duration of the dry season.

Some fields contained in excess of 200 stumps, so with this method, farmers could effectively manage a young forest. Prior to sowing crops, farmers could harvest stems, leaving only the number of trees that they required or that suited their crops. Stems produced over one dry season are still relatively small and of less value than those left for one or two years, but they are of greater value than unpruned stems, which were normally slashed and burnt at the end of the dry season.

Apart from the economic benefits, there are environmental gains. Extra vegetation in the fields results in greater deposition of rich, wind blown silt. Livestock spend more time in fields with increased tree cover, fertilizing them in the process. Greater quantities of organic matter from leaf fall and trimmings are produced, enriching the soil. Habitat, food and shelter are created for predators of crop pests. Practicing "profit from every stump" FMNR, allows idle land to become a productive resource during an otherwise unproductive eight-month dry season.

Species used in FMNR

In Niger, the species regenerated include *Bauhinia reticulata*, *Guiera senegalensis*, *Ziziphus* species and *Combretum* spp. The species mix will vary from farm to farm, district to district and from country to country.

Selection will depend on a number of factors including:

- which species occur naturally
- coppicing ability of these species
- local beliefs and values ascribed to each species,
- uses and characteristics such as thorniness, competitiveness with crops, and growth rate.

A principle of FMNR is to use whatever is available.

Make your starting point one of documenting existing species and their importance in the local culture. There may well be a niche for exotics, particularly fruit trees, but the great potential of what is already present should not be ignored.

Benefits of FMNR

■ Firewood and building timber:

Pre FMNR, rural people had to travel to Maradi to buy firewood and building materials which had mostly been brought up from remnant forests on the Nigerian border. Women had no choice but to travel long distances in search of wood. As it disappeared, they substituted crop residues and dung for firewood. Today, FMNR meets domestic demand, and a significant surplus is sold. For example, in 1984 barren plains surrounded the village of Sarkin Hatsi. Today, lightly wooded fields surround the village which boasts a thriving wood market. Merchants come twice weekly to buy wood for resale in Maradi.



Land Rover taking load of firewood to city market.

■ FMNR contributes to land reclamation:

A significant spin off from FMNR is the restoration of otherwise un-usable, hardpan sites and nutrient-depleted sandy soils, without financial expenditure.

On hardpan sites, harvested branches are simply left in a pile for a period of time, resulting in:

- **Termite activity.** In search of food, termites burrow through the hard soil crust, breaking it up in the process.
- **Better water infiltration.** Rainwater can now penetrate the broken crust instead of washing off.
- **Silt deposition.** Turbulence caused by winds passing over the woodpile causes deposition of silt rich in organic matter. Topsoil deposits 30cm deep have been recorded.

In this manner, farmers restored hundreds of hectares of hardpan sites, which had been idle for decades. They did this free of charge, and independent of any NGO or government program.



Cut branches have attracted termites. Note: clay 'tunnels' built by termites to preserve moisture while they work.

Similarly, practicing FMNR rejuvenates farmland that has been depleted of nutrients. The trees draw nutrients from deep in the soil profile, returning them and organic matter to the soil surface through leaf fall. Trees cause winds to drop their load of nutrient rich silt and provide perches, nesting sites and food for birds which deposit their droppings. The shade and edible leaves and pods also attract livestock, which enrich the soil. Sites treated in this manner are suitable for cropping again within two years.

■ **FMNR positively impacts crop yields and animal production:**

Browse from trees and shrubs are critical to livestock production in the Sahel. For much of the dry season grasses are in very short supply. Continuous high stock carrying rates and manual harvesting of grass leave vast areas completely bereft of vegetation. One of the few foods available is dry millet stalks which have a very low nutritional value. Before the introduction of FMNR, it was common for oxen to be too weak to plough fields at the end of the dry season and for suckling lambs and calves to be severely malnourished because their mothers had insufficient milk. Tree species being regenerated in Maradi produce nutritious pods which are eagerly eaten by livestock. Additionally, some farmers now earn extra income by collecting and selling pods of *Faidherbia albida*.



Above Left: Drought: grasses have disappeared and with no fodder bearing trees available, animals go hungry.

*Above Right: Pods of *Bauhinia reticulata* are highly sought after by livestock.*

As animals spent more time in the shade of trees and in search of falling tree pods, soil fertility on treed fields increased through their dung and urine. Trees protect crops from extreme weather conditions: high temperatures; strong winds which may exceed 70 kilometers per hour; and high evaporation rates. Trees enrich the soil, as described in the previous section while dust depositions on the leaves and droppings of birds attracted to the trees can also be significantⁱⁱⁱ. In the absence of shade, plants experience increased heat and water stress as soil temperatures may exceed 60 degrees C.

Pre FMNR, all crop residues were removed from fields for use as cooking fuel and for animal fodder. The production of firewood from trees, and the benefits animals receive by accessing tree pods, has for the first time in decades, enabled farmers to leave crop residues on the field, leading to increased crop yields. In the past, limited availability of crop residues was a major constraint to their application as surface mulch^{iv}.



Farmers believed that leaving trees in fields would depress crop yields. Fields like this one with a bumper millet harvest in a tree studded field helped to change these beliefs.

■ **FMNR increases biodiversity and reduces dependence on pesticides:**

As habitat disappeared with the widespread loss of trees, so did wildlife. By the early 1980's apart from certain bird species, wildlife was rarely sighted. Foxes, wild cats, ground squirrels, hedgehogs, lizards, rats, mice and frogs were the main species remaining, though for the most part, not in large numbers. As the trees returned, this began to change, as particularly heavily treed sites saw the return or at least visit of

monkeys, wild guinea fowl and rabbits. Predators including birds, lizards and certain insects (preying mantis, wasps etc) began to find shelter and places to breed, making a positive impact on crop yields by reducing insect pests. This lifted a great burden from farmers who could not afford pesticides.



Preying Mantis egg sacs. Preying Mantises only seem to set their egg sacs on woody stems. When trees are cleared, many useful predators such as these simply disappear for lack of habitat .

■ **FMNR contributes significantly to the local economy:**

In a twelve-year period, it was conservatively estimated that US\$ 600,000 worth of wood was sold as a result of practising FMNR in Maradi (1994-1997 MIDP Summary Report).



Left: Value added products such as hut rooves and tool handles bring in additional income. This was not possible before FMNR was introduced.

From the first year of practicing FMNR light firewood is collected from pruned branches. From the second year on, cut branches can be sold. As wood availability increases, value added products such as hut rooves and tool handles can be made and sold for additional income. In a twelve-year period, it was very conservatively estimated that US\$ 600,000 worth of wood was sold as a result of practising FMNR in 100 villages in Maradi Department.

Conservative values for income generating potential can be easily calculated:

<u>Area:</u>	1 hectare
<u>No. Trees protected:</u>	40/hectare
<u>No. stems protected per tree:</u>	5five stems/stump

If the farmer prunes 5 stems on each of 40 stumps per hectare and harvests only one stem per stump per year, always encouraging a replacement, by the 6th year, she/he could have an assured annual income into the future in the order of 70,000 cfa (US\$ 120/year).

Year 1	40 stems x 0.10 cents	\$ 4.00
Year 2	40 stems x 0.70 cents	\$ 28.00
Year 3	40 stems x \$1.50	\$ 60.00
Year 4	40 stems x \$ 3.50	\$ 140.00
Year 5	40 stems x \$ 3.50	\$ 140.00
Year 6	40 stems x \$ 3.50	\$ 140.00
Total		\$ 512.00

[\$1.00 = 500 CFA]

Thus, over a six year period, a farmer could earn over \$512, and \$ 140 per year per hectare each year after that. This may not seem much, but in context, most families total income is only about twice that – and most of their ‘income’ is eaten. The figures used in the calculations are also deliberately low and account is not made of other benefits such as increased crop yield under FMNR (At least 2 times yield increase), wood trimmings used for home consumption, fodder value of leaves and pods, food items etc. When wood is converted into hut roofs or tool handles, the monetary value is higher than that of firewood. Additionally, leaving 40 stems per hectare is a minimal amount. Some farmers are leaving up to 200! They may not leave all 200 for the duration of a six year period, but they do benefit from harvest and sale of a larger volume of wood each year.

Some farmers may not have much land at their disposal. My observation in West Africa, is that there are many millions of hectares of 'common land' and grazing land gradually degrading and becoming less and less productive. With a participatory approach which includes all stakeholders (farmers, nomadic herders, men, women, youth etc), what would be possible on such vast areas?

In November and December, 2005, Mr. Chris Reij from CIS, Vrije Universiteit, Amsterdam and wrote : FMNR seems more widespread and therefore more spectacular than I thought in June. “On the way back to Niamey (capital of Niger) we had made the following calculation on the back of an envelope about the scale of natural regeneration in Niger: the distance between Dosso and Zinder is about 800 km, we assume that Natural Regeneration occurs up to 100 km north of the road linking these two cities and that it concerns 25% of this area of 80,000 km² or 2,000,000 hectares (to be verified). Using averages, the value of these trees can be calculated. If there are 2,000,000 hectares treated with FMNR, there are between 40 and 80 million trees where just 20 years ago there was practically nothing. The monetary value of these trees is between US\$ 28 million and over US\$56 million. This does not include the value of crop protection, increased soil fertility, or the value of lives saved and suffering reduced when families have ready cash from sale of trees to meet medical and food needs quickly.

The area now treated with FMNR is even more spectacular when you realize that in 1983 much of the area was completely cleared. In Maradi, only twelve farmers were tentatively practicing FMNR on as many hectares. In 1984, due to famine, some 500,000 trees were managed through FMNR in approximately 100 villages. This increased to about 2,000,000 trees in 1988 through a second food for work program. Beyond 1988, FMNR took on a life of its own and has spread across the country, through other Non Government Organizations, Farmers groups, Peace Corps and through Maradi Integrated Project Staff and farmers visiting new areas across the country and sharing their experience.



Left: Income from the sale of wood has risen to the extent that farmers are now better placed to buy food during stress periods without selling assets.

- **FMNR contributes to the quality of life.**

The quality of life has improved. Wind velocity at ground level and incidence of irritating dust storms has been reduced. Shade is now available, giving protection from 40°C plus temperatures. Trees reduce the reflection of light from white sand, greatly reducing eyestrain. The once barren landscape is now more relaxing and pleasing to the eye.

- **Human food:**

A number of tree species being regenerated are a source of edible leaves and fruits. Some of these foods are only eaten during times of food shortage, but they do fill an essential gap which was missing. Other foods are sought after eagerly, and eaten whether or not regular foods are available. During recent famines, fruits and leaves from regenerated trees FMNR were the only foods standing between the people and starvation.

Possible constraints in adopting FMNR

- **Presence of live tree stumps:**

Ability to practice FMNR is dependant on the presence of live tree stumps of useful species which can be coppiced. Even so, in some situations it is possible to broadcast seeds of indigenous species and use the ensuing trees as the basis for FMNR. More time is required between seed sowing and first harvest, and high mortality rates can be expected during establishment phase. Trees established in this way are eventually managed in the same way as regrowth from tree stumps would be.

- **Distance to markets:**

There is a severe wood shortage in most districts in Niger. Even when farms are not close to markets, the benefits of FMNR make this activity worthwhile, though farmers closer to markets will realize greater financial gains from sale of wood and other tree products. Though prices are lower in remote areas, due to severe wood shortages, wood is always marketable.

■ **Respect for private property:**

It is critical that the general population respect private property. It is common in Niger to treat all land as common property once the harvest is in since there is free access to farmland during the dry season. Farmers initially received little sympathy from village chiefs if they complained that someone had cut their trees down. In any case, farmers were unlikely to report theft because it was considered anti-social to inform on others. This prevented many from even trying FMNR. MIDP staff worked hard to introduce the idea that it was just as big an offence to steal someone's trees as it is to enter someone's home and steal his belongings.

■ **Ridicule:**

It was common for those who did things differently to become the butt of jokes. For many, this negative pressure was too great and they were discouraged from trying anything new. MIDP encouraged innovation and tried to create an environment which was safe to experiment and that failure of an experiment should not result in embarrassment.

■ **Deeply ingrained attitudes:**

Language may give clues to negative attitudes about trees. For example, in the Hausa language, the word for tree (itce), is the same as the word for firewood. This may indicate that trees are given no intrinsic value of their own, apart from their utility for firewood. Much can be done to teach community members about the value of trees and change deeply ingrained attitudes, as shown by the effect of the International conference on Desertification. Pride in the history of a people group may be a hidden factor shaping attitudes. As with any society, children are brought up hearing the stories of their forebears. In Maradi Department, it is only within the last century that Hausa families moved from the Maradi River valley to the heavily treed sand plains North of the city. The current generation is proud of the pioneering spirit displayed by their forebears who cleared the land and made it possible to farm. Project staff need to be careful how they portray those who clear land. For example, linking the pioneering spirit of those practicing FMNR with that of those who settled the land may be helpful.

■ **History and tribal interactions:**

An understanding of the history of the various tribes and their interactions is invaluable. Fulani cattle herders, equate chopping and selling wood with the lifestyle of their traditional enemies, the settled farmers. A study of actions and characteristics of the 'model' person in a given culture goes a long way to help in understanding why people do or don't do things, and gives insights into harnessing the power of culture to introduce change.

■ **Critical mass:**

Wherever possible, it is important to convince the majority of a given population the value of FMNR. When only a few individuals practice FMNR for the first time, they may be completely discouraged by their peers through ridicule and theft.

- **Climatic factors:**

Trees that are regenerated are indigenous and generally have mature root systems, thus drought should not significantly affect growth rates. Deep-rooted perennial species used in FMNR in Maradi not only survive but also continue growing even when rainy seasons are poor. Re-growth of trees in lower rainfall areas, (below 200 mm), will be slower and the harvest rotation period will be longer than in higher rainfall areas. The potential for FMNR in the 800mm plus rainfall areas of Southern Chad and Southern Ethiopia is enormous.

- **Insect pests:**

There are no recorded accounts of significant insect damage on indigenous species used in FMNR. Even when locust attack occurs, indigenous species usually recover after the locusts have moved on.

Reasons for the successful spread of FMNR in Niger.

- **Conducive legal environment:**

In the past, farmers did not own the trees on their land. Local forestry authorities granting informal approval for farmers to be able to reap the benefits of their labours. This cleared the way for FMNR to spread unimpeded. When trees belonged to the government, in the minds of the people, they belong to nobody. Hence everybody had the right to cut them down! Once farmers had the assurance that they owned the trees on their land, they did everything in their power to protect them. Without this sense of ownership, FMNR could never take hold and spread.

It is only because of an informal guarantee that they would benefit from their labours, that farmers continued to practice FMNR, even after the food for work program phased out. The practice even spread by simple word of mouth, from farmer to farmer.

- **Severe wood shortages resulted in a desperate situation:**

Rural people had to go to the city to buy wood. Buildings were collapsing for lack of durable building material. Women were walking long distances to collect fuel. The substitution of millet stalks and manure for firewood resulted in competition for these scarce resources. This serious need cultivated a climate in which change became possible.

- **Timing of international attention on the problem:**

The International conference on desertification followed by severe drought and famine and MIDPs Food for Work Program promoting FMNR made a big impact on attitudes. Perhaps for the first time a link between drought and famine with the disappearance of trees was made. People not only began to comprehend that they were partly responsible, but also that they could do something about it.

- **Trust:**

MIDP staff and their SIM predecessors worked for many years in the district building friendships and trust. They were responsible for benefits including wells, famine relief and agricultural development.

Even though the message of FMNR was strange, the messengers were trusted, greatly facilitating its adoption.

- **Local control:**

Establishment of community based regulations on trees was encouraged by MIDP. The village chief and not a distant forestry agent now dealt with theft. Difficult cases were referred to the district chief. Once farmers gained confidence that their rights would be respected and defended, FMNR began to flourish. MIDP, with support of district chiefs, encouraged farmers to break with tradition and act against offenders, whoever they were.

- **Simplicity and cost effectiveness:**

FMNR is easy to practice, does not require significant extra work over normal land preparation and is cheap, requiring no financial outlay.

- **Accessibility:**

Anybody male or female, rich or poor, who has land containing live tree stumps, can practice FMNR.

- **Profitability:**

FMNR is extremely profitable and utilizes a renewable resource.

- **Compatibility and complementarity with essential activities:**

FMNR has a positive effect on crop yields and livestock. If there were negative impacts, it is unlikely that poverty stricken farmers who regularly face hunger would adopt FMNR.

- **Self-replicating:**

FMNR spread from farmer to farmer by word of mouth. It did not depend on large projects or proclamations of government or NGOs.

- **Perseverance:**

The MIDP staff persevered in the face of many obstacles and setbacks including prejudice and handicapping laws. It took at least five years for FMNR to become acceptable and around eight years before it was established enough to not require ongoing project encouragement.

Conclusion

Desertification and land degradation continues to expand on a massive scale in Africa. Despite enormous expenditure of funds and manpower, traditional forestry approaches have failed to stem the destruction. These expensive, often inappropriate approaches rarely capture the hearts and minds of communities most affected.

Farmer Managed Natural Regeneration (FMNR) relies on local management of existing indigenous species. Where practicable, it should be considered as a rapid and cost effective approach to reforestation. FMNR is easy to adopt and adapt to local needs. FMNR is cheap to implement and has the potential to quickly increase tree cover on a large scale. FMNR benefits soils, crops, livestock, the environment and local communities. Once grasped by the community, FMNR has the potential to become a people movement that spreads by word of mouth, from farmer to farmer, without ongoing project intervention.

FMNR's potential to reverse desertification and land degradation while positively impacting the welfare of communities is enormous, yet it is little known or appreciated. Wherever conditions are appropriate, foresters, agriculturalists, project planners and farmers can benefit from the practice of FMNR.

In describing the benefits of FMNR, this paper is not discounting the value of tree planting schemes. In some regions, there are no live tree stumps in the fields which can be regenerated. A number of tree planting projects have been very successful (eg. CARE International's Windbreak project in the Maaja valley of Niger). For certain tree species such as fruit trees and valuable rare or exotic species, a nursery may be the only way of propagation. However, for rapid, cheap and ongoing reforestation beyond the life of the project, FMNR should be given high consideration.



Left: Circa 1984 before FMNR was introduced in the village of Sarkin Hatsi, this type of land preparation was considered normal.

Right: Sarkin Hatsi today, FMNR has become standard practice.

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Acronyms

FMNR: Farmer Managed Natural Regeneration

MIDP: Maradi Integrated Development Project

NGO: Non Government Organization.

SIM: Serving in Mission. A Christian Missionary Society.

Glossary

Browse. Leaves, small twigs and shoots of shrubs, seedling and sapling trees, and vines available for forage for livestock and wildlife.

Coppice.

1. A method of cutting certain species of trees to encourage them to regrow from the remaining stump. A tree that coppices readily does not require frequent replanting and is, therefore, useful for producing fuel and poles.
2. Shoot developed from a dormant bud on a main trunk.
3. a small wood regularly cut over for regrowth. Also called a ‘copse’.

Maradi. Maradi Department is one of seven Departments or states within Niger Republic. The capital of Maradi Department is Maradi, a city of approximately 100,000 people.

Pollarding. Cutting back in more or less systematic fashion the crown of a tree but leaving a main trunk to 1.5m or so, with the object of harvesting small wood and browse, of producing regrowth beyond the reach of animals or of reducing the shade cast by the crown.

ⁱ See Glossary.

ⁱⁱ Firewood Crops. Shrub and Tree Species for Energy Production. National Academy of Sciences, Washington, D.C. 1980

ⁱⁱⁱ Buerkert A., & Hiernaux P., Nutrients in the West African Sudano-Sahelian zone: losses, transfers and role of external inputs in Z. Pflanzenernahr. Bodenk., WILEY-VCH Verlag GmbH, D-69451 Weinheim.1998. p.161, 365-383

^{iv} ibid