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The tillage of rice soils at the Wageningen project — B. van den Broek

The Wageningen Rice Project has been founded for the purpose of developing the mechanized argriculture in Surinam specialy for the cultivation of rice. The Polder is situated in the Western part of the young Surinam coastal plain (Demerara formation). On three sides it is surrounded by swamps which are innudated during part of the year.

The Southern border is formed by the Nickerie river which supplies the desirable amount of irrigation water. At the same time it is used as a kind of transportway for the products to the port of Nieuw-Nickerie.

Along the river grows a swamp forest of about two miles wide. North of this area a large herbaceous swamp of about 10 miles diameter is found. Near the coast this herbaceous swamp is separated from the sea by a territory of a tidal forest (mangrove). The greater part of the polder consists of a former herbaceous swamp area, only in the South a part of the swamp forest was reclaimed.

The Western part of the coastal plain has a tropical monsoon climat (Am — according to Köppen). The yearly rainfall for the polder varies from 68 up to 80 inches. Most rain is falling in the Southern part of the polder and is decreasing gradually going northwards. The following seasons may be indicated (taking the rainfall as the basis) :

a) the long rainy season — from mid April till the end of August
b) the long dry season — from the end of August till December
c) the short rainy season — from December till mid February
d) the short dry season — from mid February till mid April

In practice it sometimes differs from the calculated data. For one year it will be dry from September up to April and the next year there is hardly a short dry season at all. Especially for the soil tillage the latter is very difficult.

The soil consists of a very heavy marine clay sediment (about 70% of silt) which depending on the former vegetation and drainage situation differs in the ripening of the soil. In the Southern part of the polder a yellow mottled clay is found which has been oxydated till a depth of 7 ft. In the middle of the polder the clay has very moderately been oxydated (till about 2 ft) and is nearly unmottled. In the most Northern part the clay has again been oxydated somewhat deeper (till 3 to 4 ft) and is sometimes brown mottled. Rather little has been left of the original pegasse (= organic matter = O horizon). Only a small A_1 horizon of about 4 inches deep is left and the percentage of the organic matter is about 5 —8%. Only in the most Northern part you can come across a thicker A_1 horizon (till about 1 foot) and the percentage of organic matter is from 10 — 13%. This however, concerns a rather recently reclaimed area.

The polder includes at present about 17.000 acres. The two wet seasons allow the growing of two rice crops a year. Each rice crop takes about five months :

a) the first crop — from November up to and including March
b) the second crop — from May up to and including September

Normally, two crops are grown in succession, the third season some type of fallow is practised. Artificial irrigation and drainage meet irregularities in the weather circumstances. The present yields are about 3600 lbs. paddy/acre.

Starting in 1951 with the reclamation of this swamp people could not yet boast of a large experience with relation to the mechanised rice cultivation in the wet tropics. Here in Surinam it was the VAN DIJK family of Nickerie that already before the war experimented in this field. Furthermore the Prins Bernhard Polder was set up shortly before 1951 for the purpose of trying out mechanised land reclamation, and for gathering further practical data. The small farm holders had been organized on different lines to be of much use. Speaking about soiltillage we can split that into a soiltillage in behalf of the reclamation and a soiltillage in behalf of the exploitation. In this account these two kinds of soiltillage are a bit interwoven, because through the years it was tried to find a plough which could function both ways.

In the initial stage the opinion took shape that the pegasse layer had to be kept as much as possible. To alternate the rice with some dry crops during the fallow time was one of the most important reasons for this idea. The first plough specially used for the reclamation was a ROME plough, model BA 16 — 26. This type has a front- and a reargang. The frontgang has a shape of a horizontal V pointing to the back. At both ends of the V four scalloped disks are mounted which turn the soil outwards. The reargang is just the same as the front, but here the V is pointing forwards and the disks turn the soil inwards. Along the centerline of the plough a certain strip of soil was left untilled during ploughing. In order to promote the penetration of the disks into the (sometimes) very thick pegasse layers oildrums filled with water served as a kind of weight. In this initial period the reclamation was still carried out in the woody Southern part of the polder. Breakdowns of the plough often occurred because of woodremnants in the soil. For loosening the pegasse and to mix it with the clay the plough seemed to be working very well. But shortly afterwards another problem came out. Formerly, the rice cultivation was much different from nowadays. Directly after the dry soiltillage the rice was sown dry and had to come up during six weeks. Only after that water was put on the field. However, after a few rice crops the weeds became one of the main problems. Puddling was introduced as a kind of weed control. The paddy was pre-germinated and sown in water. It seemed that the pegasse dried irreversibly. As soon as the water was put on the field parts of the pegasse started floating. The seedlings lost contact with the soil and died.

The result of all kinds of troubles in saving the pegasse was that people radically changed their opinion. Now they wanted to remove all the pegasse by burning the swamp vegetation before the reclamation. At the Prins Bernhard Polder some successful efforts using this type of reclamation were made. At first the swamp vegetation was flattened by means of a BRUSH CUTTER in order to get a thick mat which after drying burned very well. The remnant was ploughed under by means of a RANSOMES SOLOTRAC mouldboard plough. However,

the reclamation of the Wageningen Polder took place during some very wet years (1951 — 1957). For this reason it was hardly possible to flatten and to burn the swamp vegetation. So, all the swamp vegetation and pegasse had to be ploughed under. The RANSOMES SOLOTRAC plough was used for the first reclamation tillage after which the RANSOMES BARON and BARONET disk harrows made the field further ready for sowing. Ploughing under all the fresh organic matter seemed also to give a lot of problems with relation to the state of reduction of the subsoil. Lateron some efforts were made in order to plough the organic matter upwards by means of the same plough in order to oxydise. Nowadays the remnants of this type of reclamation are still visual in the subsoil.

One of the first ploughs introduced as an implement for the exploitation tillage was the INTERNATIONAL 9 FEET DISK PLOUGH. The implement was constructed as a bar on which a number of disks were mounted. This plough however was too heavy for these soft clays and was hardly used at all. At the Prins Bernhard Polder the amount of disks was reduced to six. In this way the plough could be used very well and was used till the introduction of the ROME OFFSET DISK PLOWING HARROW.

In 1953 the McCORMICK 98 DISK PLOUGH replaced the INTERNATIONAL 9 FEET DISK PLOUGH. This McCORMICK 98 DISK PLOUGH is also constructed as a bar on which 3 to 5 scalloped disks are mounted. This type of plough was used for the exploitation tillage, whereas the RANSOMES BARON and BARONET disk harrow were used for further seedbed preparation. Up to the introduction of the ROME OFFSET DISK PLOWING HARROW the McCORMICK 98 DISK PLOUGH was used.

Besides the aforementioned types, quite a number of other ploughs were tried out. Also the choice between a mouldboard or a disk plough was discussed. In principle, a mouldboard plough turns the soil better and deeper than a disk plough. But the accessibility of the ploughed field (specially under wet conditions) decreased more and more the deeper the topsoil was ploughed. Formerly, an "URGENT" spraying machine mounted on a crawler tractor was used in order to control the pests and diseases. During a rice season this machine had to drive through the wet fields for several times. A deeply ploughed topsoil always resulted in a lot of problems about the machine getting stuck in the mud. Also during harvesting this deeply ploughed topsoil could give a lot of problems for the combines .Some experimental ploughs were also tried, for example the MULDERS SPIT PLOUGH. Although this equipment had been constructed very ingeniously it finally seemed not to be the ideal implement for the Wageningen Project.

In 1960 the ROME OFFSET DISK PLOWING HARROW was introduced at the Wageningen Project. Before full experiments with all kinds of this type (according to the number and size of the disks) had already been carried out at the Prins Bernhard Polder. A choice was made for the TCH 24/24 (for the reclamation and the first exploitation tillage) and the TEH 28/22 (for harrowing). (The first figure indicates the number of disks and the second one the diameter of the disks in inches). The ROME OFFSET DISK PLOWING HARROW is com-

posed of two gangs one in front of the other. The frontgang ploughs the soil to the right whereas the reargang harrows the soil to the left. The two gangs can with respect to each other form an angle (up to 50°) increasing or decreasing the penetration of the disks into the soil. The special offset construction allows the crawlertractor to drive on the unploughed soil. Another advantage is the fact that it is possible to plough satisfactorily (though not to so deep as formerly at a maximum of 4 inches) in less time. Just as the aforementioned types the ROME OFFSET DISK PLOWING HARROW is also pulled by a crawler tractor. At the Wageningen Project the CATERPILLAR D4 C and D4 D as well as the HANOMAG K7-B are used for this purpose.

At the Wageningen Project two types of soiltillage are known :

a) *the dry tillage*

Ploughing, levelling by means of a landplane, working with a CAMBRIDGE roller, and the eventually dragging of a heavy beam are used for a dry soiltillage. Ploughing is mostly done twice. The first time of ploughing is for the aeration of the topsoil and the loosening of the weeds in order to kill them. The second time of ploughing is for preparing the seedbed and to plough down all the weeds. After ploughing it is possible to level the field or to crumble the larger clods by means of a CAMBRIDGE roller or a heavy beam.

b) *the wet tillage*

Puddling by means of a mudroller, a weedcutter, a stalkcutter or a heavy beam are used for a wet soiltillage. Puddling had been introduced as a kind of weed control and at the same time for seedbed preparation. Normally, a mudroller is used, although at present a heavy beam has been introduced for the same purpose (the same results in less time). Puddling by means of a weedcutter or a stalkcutter is only done in times of emergency when due to some climatic condition (early rainfall) the weeds germinate on a freshly ploughed soil. As a result from a wet soil condition it is impossible to plough down these weeds again. Therefore, these two implements are used because the knives cut the weeds and press them deep into the soil.

Ploughing is only done during the dry seasons. The range of the soil moisture content between which the ROME OFFSET DISK PLOWING HARROW can work well is very small. Ploughing the first time at a high soil moisture content (above 40%) results in large sticky clods which are drying up very hard and give a lot of problems for the second tillage. The soil clods will stick between the disks and the plough will roll over the soil. Ploughing in this way will make the fields look rough and uneven. Only heavy puddling can prevent this away of ploughing.

Ploughing the first time at a low soil moisture content (depending on the percentage organic matter) makes the penetration of the disks into the soil very difficult. Heavy weights can be added to the plough in order to increase the penetration.

Ploughing a fallow land is much more difficult than a harvested rice field according to the soil moisture content. On a fallow land there are low spots (combine tracks for example) filled with water and high

spots which dried up very hard. So different moisture contents in the same fields result sometimes in good and sometimes in bad ploughing. A harvested rice field (which was levelled a bit by puddling) was moistened all over and dried up at the same time. Drying up under the same conditions the soil moisture content will be more equal.

Nearly always puddling is practised after dry soiltillage. If the climatic conditions are bad, ploughing is impossible and therefore sometimes large areas are puddled. Puddling with little water results in a completely impermeable mudlayer on the surface. A water deficit in the subsoil may be one of the results lateron. If, however much water is used, this mudlayer stays somewhat permeably in order to replenish eventual dificiencies of moisture in the subsoil. It also appeared that especially the permeability on the somewhat older ricefields has much decreased with respect to the same profiles under swamp conditions. The only permeability in these soils is due to the root tubes. The mud sinks after puddling into these tubes and clogs them. In this case ploughing and puddling have to be adjusted to each other. It is advisable not to harrow too fine and to puddle carefully so a certain permeability will be kept and the clods will not completely be destroyed.

After puddling the following image of a ricefield may be formed. Through the mudlayer the structure elements have to be seen. The mudlayer should be strong enough to hold the seedlings which are thrown from a certain height over the field (sowing by plane).
When these seedlings fall into the mud they will suffocate and grow mouldy in course of time. Furthermore, it should be possible to put your hand perpendicularly into the furrow and at least for three quarters of a handlength deep a loose soil with all kinds of structure elements should be left. Some rust mottles must be distinguished. Straw and other organic compounds are not allowed to be in the soil or at small quantities (promoting the state of reduction).

For checking the soiltillage a simple reliefmeter is used. The reliefmeter consists of a horizontal board hanging between two vertical pins pressed in the soil. The bottom of the board which at the same time is regarded as a O-line is at a height of 1½ foot over the soil surface. On the board at distances of 4 inches 20 needles can vertically be placed which can easily move up- and downwards.
The needles are lowered to the soil surface and the distance between O-line and soil surface is measured. For one field (30 acres) about twenty measurements are taken. For each measurement (20 figures) the difference between the highest and the lowest measured needle is calculated. So, 20 calculated differences of which the standard deviation (S) is calculated will be obtained. The roughness of a ploughed field is calculated as follows :

$$roughness = 1004 \log S$$

In this way it is possible to compare the ploughed fields. Above the 40% of soil moisture content the roughness of all the fields is very much increasing. Below this level the roughness of the fields may be different from each other though the soil moisture content is the same. The organic matter percentage may be one of the most important reasons for this. The experiments with this instrument are continued.

Technical data

a) *ROME disk plough BA 16 — 26*
Weight about 3100 lbs. Working width 8 ft. Rate about 2.0 — 2.5 acres/hr.

b) *RANSOMES SOLOTRAC TS-1K mouldboard plough*
Weight about 1450 lbs. Working width 1 ft. Rate about 0.5 acre/hr. Fitted with INTERNATIONAL cut-out disk coulter of about 2½ ft. diameter .

c) *McCORMICK No 98 disk plough*
Weight about 3770 lbs. Working width 4 ft. Rate about 1.3 acres/hr.

d) *ROME OFFSET DISK PLOWING HARROW TCH 24 — 24*
Weight about 3300 lbs. Working width 10 ft. Rate about 2.5 acres/hr.

e) *ROME OFFSET DISK PLOWING HARROW TEH 28 — 22*
Weight about 2700 lbs. Working width 10 ft. Rate about 2.5 acres/hr.

f) *RANSOMES BARONET disk harrow*
Weight about 2700 lbs. Working width 10 ft. Rate about 2.5 acres/hr.

g) *RANSOMES BARON disk harrow*
Weight about 3000 lbs. Working width 11 ft. Rate about 2.0 acres/hr.

h) *MARDEN T5 weedcutter*
Weight of one section empty 1000 lbs., filled with water 1450 lbs. Working width of three sections 15 ft. Rate about 3.3 acres/hr.

i) *Mud-roller*
Weight about 1450 lbs. Working width 9 ft. Rate about 2.5 acres/hr.

SUMMARY

In 1960 after years of experiments the ROME OFFSET DISK PLOWING HARROW had been introduced to the rice cultivation system of the Wageningen Project. Ploughing has mostly been done with the TCH 24/24 type, for harrowing the TEH 28/22 has been used. Crawler tractors are used for drawing the implements.

The rice fields are tilled by several steps. The first ploughing gives very coarse clods. The soil can dry up and will be aerated and the weeds die also (loosening of the soil).

By harrowing the soil is crumbled in order to obtain a structure which is not immediately destroyed by puddling. The soil moisture content is very important for the soiltillage. The soil moisture ranges between which the ROME OFFSET DISK PLOWING HARROW can work well is very small.

Formerly wet soiltillage had been introduced as a kind of weed control. The amount of water which is necessary for puddling of the soil is of great importance. Due to the puddling the permeability of the rice soils is decreasing.

A very simple reliefmeter has been introduced in order to check soiltillage. With this instrument it is possible to express the roughness

of a ploughed field in a figure. These figures (with regard to the organic matter percentage) can be compared with each other. The experiments with this instrument are continued.

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