The Tilling in a Village in Southern India

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This study was carried out in a village in the southeastern part of the Karnataka state (former Mysore) near Bangalore, India. The primary purpose was to find the average energy developed by the draught-animals during the tilling process as well as the variations in this energy from time to time.

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Indian farming is mainly based upon cattle which serve as draught animals and supply both manure and milk. The impact of the oil-crisis, being much worse in the developing countries than in the western world, has stressed this great importance of the cattle. Now it has become almost impossible to get fuel for tractors, and the production of chemical fertilizers which was based on the cheap oil has decreased to a minimum. For a long time to come, cattle will remain the most important supplier of manure and traction power in India. For this reason it is very important to find methods to improve the utilization of the cattle. This article is mainly concerned with the tilling process and is based upon observations and measurements made in a village, here called Namma-uru, situated in the SE-part of the Karnataka state.

The size of a given farmstead and the economic situation of the farmer set an upper limit to the standard of his draught animals. The character of the soil differs, and if the fields lie widely scattered this will also greatly influence the tilling work. Furthermore, the variations in precipitation from one year to another are of importance, because without being softened by the rain, the soil cannot be tilled at all.

From one day to another the farmer can adapt his tilling to these varying factors, by his choice of tilling implement, by his timing of the tilling work, and by the way he uses the draught-animal's energy. Some days the bullocks are working very hard because the work is urgent, some days the work is done more leisurely. The urgency of the work is determined by the timings and by the amounts of rain received.

This article tries to shed some light upon these proplems, partly with the aid of the farmers' own information and impressions and partly on the basis of physical measurements. The two most important factors measured are: 1) the yielded effect calculated from average pull of the draught animals, and 2) the variations in the pull (shake) which will necessarily occur, partly due to the uneven movement of the plough through the soil and partly due to the animals' way of walking. The two mentioned factors influence each other. So, for example, a violent shake will cause a fall in the effect yielded. Undoubtedly a kind of chock-absorber or some improvements in the construction of the ploughs might give a better use of the draught animals.

The agricultural set-up in the investigated village

Namma-uru is situated 950 m above sea-level on the Mysore-plateau (Maidan). Most of the rain falls from May to December; the average precipitation is 650 mm per year.

The most important crop is ragi (finger millet, Eleusine coracana) which covers most of the dry land (not irrigated). In the ragi-fields there are mixed rows with an average distance of 1.5 m of other crops such as jolar (Sorghum vulgare), leguminoseae (Dolichos lablab, Cajanus cajan), oil plants (castor, Ricinus communis). Beyond the ragi-fields there are scattered plots with ground-nuts (Arachis hypogaea), horsegram (Dolichos biflorus) or maize (Zea mays). Almost all irrigated land is covered with rice (Oryza sativa).

The local soil is classified as ferruginous, red, tropical soil (Rhodustalf) with black soil in between (Vertisol). The depth of the soil layer varies, in some places the weathering basement (peninsular gneiss) is only one metre below the surface, here end there the bare rock lies open.

The soils of Namma-uru can be classified into several types according to their tilling properties. 1) The common red-coloured soil, which is more or less sandy. 2) More clayey types, which are found at some places in depressions, e.g. old tank bottom. 3) Black soil which is also mainly found in depressions; this type of soil is usually very clayey. 4) Very dark-coloured red soils (drift soils) with a high content of iron-oxides. They are mainly found in high-level positions.

All these soil types have a relatively sandy top-layer which corresponds to the maximum depth of tilling (17–

22 cm). This tilled layer has a comparatively sharp limit to the soil beneath, which is always more clayey and has a more pronounced red (or black) colour. Apparently there is not developed a proper ploughsole by the pressing effect of the implements, possibly because only a few of the tillings reach the maximum depth of tilling. The mentioned sharp limit between the sandy, tilled layer and the soil beneath is most probably created by illuviation of clay from the continuously stirred and turned tilling-layer.

Type 1), the common red soil, has got a relatively low permeability, as a more clayey layer is found at 30–40 cm depth. Due to the high content of sand in this soil, there will not be formed so many clods, and the upper soil-layer is not so much exposed to free air-circulation. For this reason the upper layers retain the moisture even long time after rain.

The soil types 2) and 3) viz. the clay-soil and the black soil, have very marked formations of cracks and fissures and are very permeable especially during the tilling period. Later on, when there comes more rain, some of the fissures are closed again due to the swelling of the soil. Soil type 4) drift soil, has also a high and stable permeability; this type of soil becomes easily hard and dry, and remains only soft for a short time after the rain.

Most of the cattle in Namma-uru are of the so-called Hallikar type (halli = village, kar = cattle). This type, together with the other types of the so-called Mysore-cattle, forms a distinct group within the Indian group of cattle. The Indian type of cattle (Zebu cattle, Bos indicus) as a group is characterized by their hump, distinguishable from the European cattle (Bos taurus) which have no hump.

In general, the hallikar cattle has a grey colour, a few of them are black and many are white, but red or brown colours are never seen. The horns sit close together at the base and point obliquely backwards from the scull. Usually the horns are straight or slightly bent. This type of horn is a good support for the yoke when the farmer hitches his animal.

The horns are also a good and effective defence against dogs. The Mysore-type of cattle are good and enduring draught animals, but they are hot-headed and get easily frightened. The yield of milk is only small, and the cows of this type of cattle have got a more masculine appearance. For this reason the cows are often used as draught animals too (only tilling). In most other places in India only the bullocks are used as draught animals. The big and strong cows yield the same work as the average bullocks do (table 2) but generally they have no calf the years when they are working in the field. On small farms, however, weak cows may also be used for tilling even if they have got a calf, simply because the farmer has no other animals.

Cattle are also used for other works than tilling; the bullocks e.g. for different sorts of cart-driving. They are used to cart the manure to the fields in April before the soil is softened by the rain. When the tilling is finished, the quickest of the bullocks may pull the sowing machine, and later, by the intercultivation of the crop, they pull the special implements for this purpose. The bullocks cart the crop home from the field, and they pull the big stone rollers used for the threshing in January. From time to time they may be lent or rented out for work in the towns or for road transport.

From January to August the main fodder for the cattle is dry ragi straw together with some green plant material (grass, foliage, etc.) if available. The working animals will get a supplement of horsegram and concentrates. When the jolar-plants have reached a certain height, they are used as green fodder. During the period September to January, when there is plenty of green fodder, the animals are storing fat in their bodies to be used later on when fodder is less abundant; this period also comprises the tilling period.

Besides as traction power, the cattle are also of great value as a decomposer of dry plant material (especially cellulose, which cannot be used otherwise) and as a producer of milk and manure. The quantity of milk produced by the cattle is very small and part of it is drunk by the calves, although it might be a very useful supplement to the diet of small children, if it was used more for this purpose than it is the case now.

The tilling

The main subject of this article is the function of the cattle in one of the most important processes in agriculture, namely the tilling.

The purpose of the tilling is first to make a seedbed of a convenient depth and with a loose and soft soil to ensure a correct sowing and thus make it easy for the seedlings to develop their root system. The local sowing machine made out of bamboo and wood, is of such a light construction that even smaller clods or hard spots overseen during the previous tilling may easily cause troubles during the sowing. The tilling also serves to remove the weeds and to get the supplied manure mixed down into the soil.

The field is usually tilled 3–4 times the length and the breadth of the field before the sowing in July. Mostly the tilling begins late May or first days of June, when the first rain of the year (premonsun, mangoshowers) has softened the soil. Only the first and the last tilling have got special names in the local language, they are called "tokkle salu" and "bittne salu" respectively. Usually the first tilling reaches a depth of 7–15 cm, dependent upon the moisture of the soil and the tilling implement (gunte 7–10 cm, negilu 8–15 cm). The water from the showers falling before the first tilling does not soak very well into the soil. If the showers are heavy and of long duration most of the water will run from the fields through open drainage canals and gullies, "hallas", out into the bigger water system. First the water runs to the water-reservoirs (tanks) and maybe afterwards into the big rivers. When the first tilling in Namma-uru was completed in 1973, no showers gave water enough to cause superficial run-off of importance. The water remained on the uneven surface made by the first tilling and could then penetrate slowly into the soil. After a heavy shower, the water remained on the surface in a lot of small waterpools for hours.

Every tilling is done perpendicularly to the previous one. Usually the first tilling is made lengthwise the field, because it is then more easy to remove the stubbles left over from last crop. (The sowing is generally made in rows the length of the field). When tilling the breadth of the field the farmer tills the full breadth without stopping, then he turns the plough, walks alongside the field, turns, takes the full breadth, goes alongside down the field again, turns, and takes again the breadth. Thus the animals will always turn to the left when a furrow is finished. When a plot is half-way finished, the farmer takes in a new plot a little further down the field and ploughs these two together and so on. When the last furrow is finished, it remains as a "dongiri", an open furrow.

By lengthwise tilling, the field is mostly divided into two or three strips, "maru", which will be tilled in turn in the same way as described above. In this case the plough is turned in the middle of the field. The soil at the sides of the field, where plough and animals are turned, might become very hard with many clods and untilled spots. Therefore, some extra furrows are made alongside the field now and then.

The same pair of animals will almost always be together at the same yoke when tilling, also when the farmer has more than one pair of working animals. Each animal has his side, the animal to the left is usually the most indolent of the two if they differ in temperament. The animal to the right has to take the longest swung when the plough is turned. This animal is called by a "bha bha" and the animal to the left by a "tjoo tjoo".

The tiller has also a small stick to stir up the animals. The tilling work is generally started at 7 o'clock in the morning and with many rests, in total they may amount to 2 or 3 hours, the work will continue till 12.30 p.m. Maybe the work is started again at 3 o'clock in the afternoon. The farmers said that the animals would work very well the first hours of the morning, but that after some time it was necessary to shout at them to make them walk.

The weather is usually cool and pleasant in the morning with most of the sky covered with clouds. About 10 o'clock the sun is breaking through and the cover of cumulus clouds will be reduced. About 2 o'clock only a few or no clouds will be left. The maximum temperature of the day in June-July reaches 28–29° C. The steadily and often strong wind is also very troublesome. If the rain comes, it is most often after five in the afternoon. Sometimes it drizzles the whole day. Only at the first tilling is it possible to continue work the same day after a shower. The farmers simply sit down sheltered by a tree or by the bullocks, when the shower comes and continue work afterwards. At the next tillings even a small shower may make the soil too slippery and the farmers will have to go home and wait until next day or so.

Types of ploughs

The farmers in Namma-uru use three types of ploughs: 1. The "negilu", which is a hook-shaped plough, very similar to the old European ard. The point of the plough-head is protected by an iron teeth, which breaks the soil. 2. The "gunte" (sometimes "he-gunde"), where the plough-head is made of a short transverse piece of wood with two iron teeth bending a little forward so they form an angle of approximately 75 degree with the soil surface. 3. The iron plough, "kobbe negilu" is made in principally the same way as the normal European swing plough.

Earlier only the negilu was used in this area, but about 25 years ago the gunte was also put into use. Especially in places like Namma-uru, with its relatively sandy soil, many farmers use the gunte. The iron plough has also become quite common in Namma-uru during the last 5 years.

Both the negilu and the gunte has got a long beam to which the yoke is fixed with a rope. The animals carry the yoke on the part of the shoulder and neck that corresponds to the muscels splenius cervicis and trapezius cervicis, but not on the hump itself (rhomboidens cervicis). The iron plough has a short beam and is fixed to the middle of the yoke by strings from the two handles of the plough, and a third string from the tip of the beam.

In general the gunte needs a stronger traction-force than a negilu, because it makes a broad furrow, approximately 25 cm, against negilu's approximately 18 cm. Sometimes the traction-force needed for a negilu can be just as great, because it might go very deep into the soil. The average use of energy is 47 kgm/sec. with the negilu and 56 kgm/sec. with the gunte, cf. table 2, bullocks. The current price of one working day (man + animals + implement) is about 8 Rs. for a negilu and 10 Rs. for a gunte. Both negilu and gunte are made in several types and sizes and the demand of energy may therefore vary a good deal.

The iron plough is demanding nearly the same traction-power as a gunte, but also for this implement the shape and size of it are of great importance. If for example the point of the plough share is not renewed in due time, the plough will be more difficult to pull and the tilling be less efficient.

There are two categories of negilus: 1. The old worn-out negilu which was used last year and therefore smaller. 2. The new and big negilu made the same year (usually in March in connection with some fertility rites). The small negilu is used when dry-land is tilled for the first time, and wet-land is always tilled with the small negilu. The big negilu is used for the second and the third tilling of dry-land. Sometimes a stone is placed on the negilu in order to press it down.

The gunte is found in many forms. The iron teeth can be of different thickness and length. The part of the teeth which is protruding on the wooden bar is 20–30 cm in length. Also the distance between the two teeth may vary. If the teeth are too short, the wooden bar itself may sometimes slide on the soil. The angle between the teeth and the soil surface may be adjusted by wooden wedges in the plough-head and also by bending the iron teeth, when heated, more or less forward by hammering.

Finally it is also possible to adjust especially the negilu, but also the gunte, by changing the position of the yoke on the beam. If the yoke is put more forward, the beam will be lowered somewhat and the point of the plough-head will cut deeper into the soil. In this case more traction power is needed. It is very important to fix the yoke in a correct position, so that the negilu neither cuts too deep and gets sticking in the soil, nor on the contrary slides upwards so that the tilling is not in a sufficient depth. There are nearly the same problems with the gunte, though this implement is not so sensible to the height of the beam. The position of the plough can also be adjusted by placing the yoke either upon the beam or beneath it. Sometimes a string is bound firmly between the neck and the front legs of the young bullocks to make them keep neck and head down in order to make the plough work correctly.

Choice of tilling implement under special circumstances

In the heavy clay soil and in black soil it is in general only the negilu (or the iron plough) that is fit for use. This is so because the coherent and sticky character of these soils prevents the gunte from breaking the clods easily and from pushing them aside. If the soil (both sand and clay) i tilled under wet conditions, a big, pressed lump of soil may form in front of the plough-head of the gunte. This does not happen with the negilu, which easily pushes aside the soil, and it is not necessary to lift the plough and shake off the soil so many times during the work. Strips of hard soil along the margins of the fields, trampled footpaths and threshing floors from last year can only be tilled with a negilu. If, for these reasons part of the filed can only be tilled with a negilu, this will often be used for the whole plot for practical reasons. As mentioned earlier, it is most common to use a negilu for the first tilling. Many farmers also prefer to use a negilu for the last tilling before the sowing, because the gunte does not till as nice and even as the negilu; it also leaves some very broad furrows "dongiris" on the field. Even if the field is harrowed once or twice immediately before the sowing, it is very difficult to remove these "dongiris" completely. Sometimes the farmers try to level them out by sliding the plough lightly over the soil.

The negilu is especially vulnerable if there is a layer of stone in or just beneath the tilled layer and then the gunte is preferred. It may be very difficult to lift the negilu with its long, protruding plough-share over the manure heaps; therefore, a gunte will sometimes be used instead of a negilu. (The manure heaps are not spread and ploughed in until at the second or third tilling). The negilu is more effective against some of the local, common species of weeds with their deeply growing tubers. On the other hand, the gunte is more effective against some grasses, because the long rhizomes are caught by the iron teeth and can be removed by hand. However, it often proves necessary to clean the field for old roots and tubers by hand whatever has been the tilling implement. This work is mostly done by women and children; sometimes the field is harrowed if there are too many weeds.

As mentioned the iron plough is now being used by more and more farmers. This implement is good, particularly in heavy soil, because with its broad furrows (approx. 22 cm) it can work over a given area just as fast as a gunte. Contrary to the gunte, it is not impeded so much in heavy soil because it can easily push aside the soil. Likewise it is also very handy in moist soil being tilled for the first time. One farmer stated that the iron plough was most easy to pull in heavy clay soil, whereas the gunte was easier in sandy soil, all other things being equal. All farmers mentioned that it was more difficult to steer an iron plough properly and make the furrows straight and nice. It is also difficult to lift the the iron-plough and clean it for weeds and soil during the work, because it is heavy and has no firm connection with the yoke, but is only suspended in strings. Due to its very broad and deep "dongiris" the iron plough is nearly never used for the last tilling before the sowing. The iron plough turns the soil more than any of the other plough-types. Many farmers said that the iron plough mixed the manure deeper into the soil than the other ploughs did. Generally this is an advantage, but if the seedlings for some reasons (drought or the opposite, too much water) get a bad start, it will be an disadvantage because the roots cannot reach the manure quickly. The iron plough covers the weeds more thoroughly with soil, and this is an advantage under certain circumstances. It is a general statement in literature that the swing plough, due to the more effective turning of the soil, effects a quicker decomposition (mineralisation) of organic matter. In Namma-uru this is of very little importance, because as mentioned, the iron plough is burying the manure deeper into the soil.

Choice of tilling implement in general

The choice of implement for a given tilling is partly dependent upon the capacity of the available draught animals, partly upon soil type, soil moisture, amount of weeds

Table 1.

Type of draughtanimai (Type trækdyr)	1.tilling (1.pløjning)	2.tilling	3.tilling	4.tilling
Bullocks	52 (29) N		62 (7) G 45 (44) G	
Bullocks	44 (27) N 65 (21) G		50 (12) G 58 (26) G	68 (17) G
Bullocks	61 (26) G	44 (55) G		58 (22) N
Bullocks	73 (29) G			57 (24) N
Bullocks		56 (36) G		56 (29) N
Bullocks		43 (35) G		42 (18) G 27 (21) N
Bullocks	54 (24) G 54 (27) G		52 (34) G 32 (32) N	
Bullocks	50 (36) G		32 (27) N	
Bullocks			48 (25) G 52 (37) G	
Big cows	50 (44) G		55 (31) N 49 (22) N	
Small cows	43 (31) G 44 (23) G	62 (28) G		
Bullocks	67 (33) N 59 (36) G	38 (17) G 46 (23) N		45 (12) G
Bullocks	50 (32) N	69 (30) G 65 (23) G	54 (17) G 59 (16) G	
Bullocks	47 (48) N 51 (18) G		59 (24) G	
Bullocks	52 (49) N	41 (29) G 43 (32) N	33 (27) G	
Big cows	49 (20) G 58 (40) G		54 (19) G 51 (30) G	
Bullocks	46 (67) N 48 (23) G		58 (27) G	
Bullocks	51 (58) N 41 (40) G			

Type of draughtanimal (Type trækdyr)	1.tilling (1.pløjning)	2.tilling	3.tilling	4.tilling
Big cows			75 (35) G	
Big cows	44 (28) G	58 (13) G		
Small cows	42 (41) N			
Bullocks	46 (43) N	55 (18) G	44 (17) N	
Bullocks	73 (28) G			
Bullocks	75 (25) G	58 (18) G	45 (25) G	
Bullocks		65 (46) G	42 (36) N	
Small cows	52 (33) G		31 (34) N	
Small cows			40 (14) G	55 (26) G
Bullocks	50 (55) N 79 (18) G			40 (23) G
Bullocks	80 (17) G			
Bullocks	65 (70) N 70 (36) G		49 (37) N	
Small cows	45 (51) N			
Bullocks	50 (40) N	53 (25) G 51 (28) G		
Bullocks	65 (49) N	43 (14) G		
Big cows	75 (54) N 78 (31) G 67 (25) G	 47 (25) G		
Bullocks	59 (60) N	54 (24) G		
Bullocks	79 (21) G			
Bullocks			46 (39) N 30 (20) N	
Bullocks	49 (41) N	23 (35) G	45 (29) G	
Bullocks		72 (30) G		63 (34) N
Bullocks		63 (28) G 46 (22) N		
Bullocks		37 (20) G 41 (23) N		

Table 1. Effect and average oscillation actually measured for the different pairs of draught animals. First figure indicates effect (kgm/sec.). Second figure in bracket indicates average oscillation (kg). Letter indicates implement used at the test, N: negilu, G: gunte.
Tabel 1. Effekt og middeludsving målt ved de enkelte prøver hos de forskellige par af trækdyr. Første tal angiver effekt (kgm/sek.). Næste tal i parantes angiver middeludsving (kg). Bogstav angiver redskab anvendt ved prøven: N: negilu, G: gunte.

and also upon the kind of implement used at the previous tilling. The choice is often dependent upon the urgency of the work. Sometimes has the farmer to use a gunte, because it can do the work fast, even if it would otherwise have been better to use a negilu.

The farms af Namma-uru can be divided into four distinct groups according to the types of tilling implements they use, and in what sequence they use them. Here the fields with special soil conditions are omitted, because for very sandy and very clayey soils the tilling implements are nearly determined in advance according to the previous mentioned rules.

Group 1. Here the gunte is used for all the tillings. This group includes comparatively big farms, where a large area has to be tilled within a short time. Also smaller farms, where most of the fields are sandy fall in this group.

Group 2. Here the gunte is used for the first two or three tillings, whereas the last tilling is made by a negilu. The farms in this group are also comparatively big, and the work has therefore to be done fast. The farmer wants to make a fine and nice sow bed at the last tilling, maybe he wants it a little deeper than a gunte can make it; if so, a negilu is used. In certain cases this method implies that clods are broken loose from the untilled layer beneath, and these clods may give some trouble at the sowing.

Group 3. Here the negilu is used the first times and the gunte the last time before sowing. This group includes mostly farms of average size. The negilu is used the first times, either because it is necessary due to hard soil, or because there is time enough to do the work with the

Table 2.

	Implement used at test (Redskab brugt ved prøven)	Bullocks Stude	Big cows Store køer	Small cows Små køer
1.tilling (1.pløjning)	Gunte Negilu	63.3 (16) 52.8 (15)	57.7 (6) 75.0 (1)	46.3 (3) 43.5 (2)
2.tilling	Gunte Negilu	51.7 (18) 44.0 (4)	52.5 (2) -	62.0 (1) -
3.tilling	Gunte Negilu	51.4 (14) 39.3 (7)	60.0 (3) 52.0 (2)	40.0 (1) 31.0 (1)
4.tilling	Gunte Negilu	48.7 (4) 52.2 (5)	- -	55.0 (1) -
1-4.tilling (Table 1)	Gunte Negilu	54.9 (52) 48.6 (31)	57.3 (11) 59.6 (3)	49.3 (6) 39.3 (3)
1-5.tilling (all tests)	Gunte Negilu	56.2 (67) 47.4 (45)	56.1 (16) 59.6 (3)	48.1 (17) 40.4 (8)

Table 2. Average effect for different tillings, types of implement used at the test and types of draught animals. First figure indicates effect (kgm/sec.). Figure in bracket indicates number of tests.
Tabel 2. Gennemsnitlig effekt for de forskellige pløjninger med forskellige typer af redskab og trækdyr. Første tal angiver effekten (kgm/sek.). Tal i parantes angiver antal af prøver.

Table 3.

1. Test No.	7A	7B	7C	7D	7E	8A	8B	5A	5B	5C	5D	5E	9A	9B	9C	6A	6B	6C
2. Tilling No.	1	1	3	3	4	1	3	1	2	2	3	3	1	2	3	1	2	3
3. Length of furrow (m)	64	52	64	49	27	64	64	64	52	46	64	38	47	75	50	42	52	34
4. Speed of walk (m/sec)	78	104	94	87	88	91	88	100	101	93	86	97	85	92	101	81	91	73
5. Distance from impinge to impinge (cm)	27	42	38	32	34	29	38	36	36	36	30	35	34	36	37	31	36	26
6. Average oscillation (kg)	29	23	14	29	19	31	8	34	34	26	19	18	46	20	19	27	20	27
7. Effect (kgm/sec)	44	65	50	58	68	52	62	50	69	65	54	59	46	55	44	75	58	45

Tabel 3. 1: prøve nr., 2: pløjning nr., 3: furens længde (m), 4: ganghastighed (m/sek.), 5: afstand fra stød til stød (cm), 6: middeludsving (kg), 7: effekt (kgm/sek.).

comparatively slow negilu. The work was urgent at the last tilling because the sowing had to be done shortly afterwards. As the soil was already well worked and deeply tilled with the negilu, it was sufficient to use a gunte the last time, even if it did not go so deep.

Group 4. In this group the negilu is used all the time. This group includes small farms with small and weak draught animals, often cows.

The negilu is always used on wet-land (irrigated) both because the soil has a high content of clay, and because the field is usually more or less waterlogged. Many farmers in Namma-uru had irrigated fields in wet-land near some neighbour villages. The irrigated area lies often just below the corresponding water reservoir (tank). The fields which are irrigated from the big water reservoirs are put under water early in the year and will be tilled early, either before the dry-land or at the same time. The fields which are irrigated from the small tanks however will be inundated later, because the tanks are not filled so quickly, and here the tilling was usually done just after the sowing was finished on dry land.

Measurements made in relation to the tilling process

The measuring programme was arranged as follows in the summer 1973:

1) The measurement of traction-power was made with a self-writing dynamometer (manufactured by Schäffer & Budenberg).

2) Continuous measurements relating to tilling depth, walking speed of the animals, breadth of the furrows, length and frequency of rest-periods inbetween the actual tilling work.

3) For a limited number of farmers there was made a daily record concerning size of tilled area, type of plough and animals used.

The dynamometer was placed on an ordinary plough, the animals were hitched to it and then tested. Some days a negilu, some days a gunte was used, dependent upon what the majority of farmers would use.

The dynamometer was placed on the rear of the beam and the backside of it was supported by the plough-head itself. The dynamometer was connected to the yoke with a pair of steel-wires, and the yoke to the beam through a special slider arrangement with ball-wearings. In this manner the yoke could follow the swinging movement of the animals. The angle (v) between the dynamometer wire and the horizontal level could be calculated from measurements of tilling depth, height of the yoke above the soil surface, when the animals were in normal walking position. The actual pull in the horizontal direction could be calculated by adjustment as to cos v.

For practical reasons it was only possible to use one plough for the tests conducted the same day, therefore there were several cases where either the type of plough, or the adjustment of the height of the beam, or the breadth of the plough-head did not correspond to the plough the farmer used himself. The difference in the pull, if any, between the farmers own plough and the test-plough was estimated, partly from questions put to the farmer.

The animals were often clearly excited or frightened by the test instrument. Even when the animals did not show any outward signs of excitement, they would often walk at a greater speed during the test than normally. They even did so in many cases where the test-plough was more heavy to pull than their own plough.

The dynamometer curve itself, as it appears on the dynamometer tape, is an irregular zig-zag line where the upturned points represent the hard clashes when the plough is breaking the soil, while the downturned points corresponds to the slacking when the soil is broken and the plough is still only moving in loose soil before it reaches the next obstacle. The yielded effect in kgm/sec (power × walking speed), can be determined by combining the readings from the dynamometer curve, where the power is given in relation to time, with simultaneous measurements of walking speed. The dynamometer used in this study was driven by a clock-work, other types are driven by transmission of the rotating movement from a wheel running at the side of the plough. In this last type the power, or pull, is recorded in relation to distance walked, and the yielded work can then be measured directly (power × way = work, kgm).

The average pull is here defined as the average of all the breaking points of the dynamometer curve, both upturned and downturned. It is presumed that the average

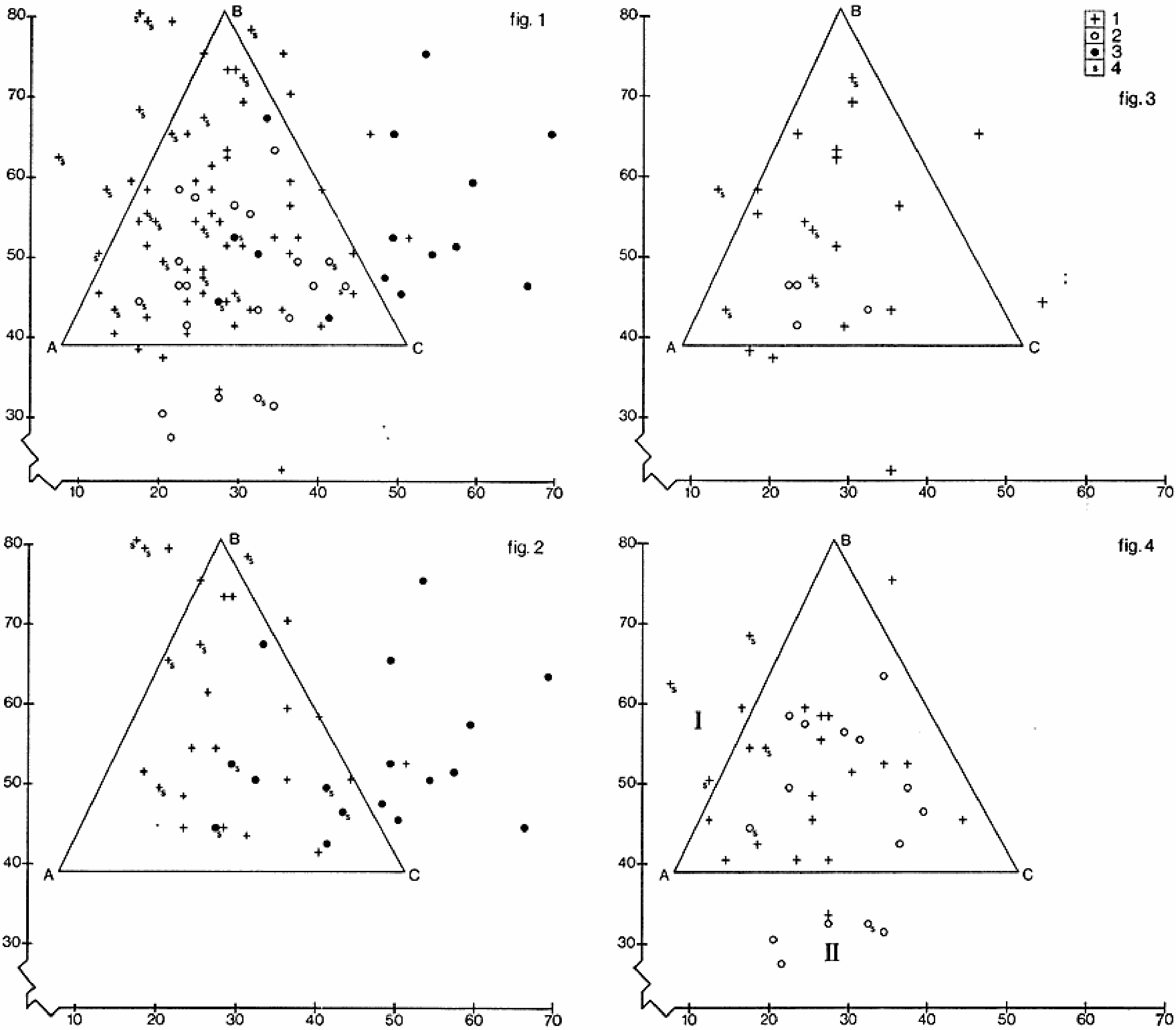


Fig. 1. All tillings. *Fig. 1. Samtlige pløjninger.*
Fig. 2. First tilling. *Fig. 2. Første pløjning.*

Fig. 3. Second tilling. *Fig. 3. Anden pløjning.*
Fig. 4. Third and fourth tilling. *Fig. 4. Tredie og fjerde pløjning.*

Figs. 1–4. X-axis = average oscillation (kg) or twice the amplitude. Y-axis = effect (kgm/sec.). 1, test made with a gunte; 2, test made with a negilu; 3, negilu, first tilling; 4, test made in very sandy soil (sand A, cf. figs. 5–9).
Fig. 1–4. X-akse = middeludsving (kg). Y-akse = effekt (kgm/sek.). 1) prøve udført med gunte. 2) prøve med negilu. 3) negilu ved førstegangs pløjning. 4) prøve i meget sandet jord (sand A, jfr. fig. 5–9).

length in time for one oscillation is independent upon the size (in kgs) of the oscillation. It is also presumed that the upturned points on the curve have the same shape as the downturned points, i.e. that the tops and downs of the curve are supposed to be symmetrical. In fact the impinges were in some tests of a shorter duration than the corresponding slack-periods. This could be seen from the curve, as some of the upturned points were narrower that the downturned points.

The average oscillation (twice the amplitude) corresponding to the shake can be defined as the average distance (measured in kgs) between two succeeding breaking points. Another good characteristic of the curve is its stability. (If the curve at one moment oscillates around high values, the next moment around low values it is unstable, but if it is all the time oscillating around the same average value it is stable). It is possible to get an estimate of the stability of the curve partly from a visual judgement, partly from diagrams of the same type as those in figs 12–17, where the connection between average pull and average oscillation is indicated for small intervals of time, each dot representing 2 seconds.

The values given in table 1 are determined by macroscopic measurement of the dynamometer curves. The values in table 3 are determined by microscopical measurement of the dynamometer curve.

It appears that the effect can be calculated fairly well (± 2 kgm/sec.) by the macroscopic method, while the average oscillation is difficult to determine macroscopically. The values in table 3 are calculated as the average of measurements in 8–10 small intervals (4 seconds each) selected at random on the dynamometer curve.

Table 1 gives the effect (kgm/sec.), the table also gives the average oscillation in brackets (kgs). The diagrams for first to fourth tilling (fig.: 1–4) are constructed from the figures in this table. Table 2 which gives the average consumption of effect for the two plough types, gunte and negilu, and with different types of draught animals is also calculated from table 1.

The diagram (fig. 1) gives a general survey of the connection between the yielded effect and the average oscillation (shake) for all the tillings. Most of the points in this diagram fall within a triangle ABC.

The line AB shows that to some extent the average oscillation is dependent upon the effect, so that the shake cannot exceed a certain minimum, when the pull is increased. The line AB does not form a very distinct limit, as the oscillation is also very much dependent upon the soil conditions (hardness). Most of the points to the left of the line AB represent tests conducted in a very sandy soil, where the plough goes smoothly without any shake of importance, even if the pull is great.

The line BC indicates that the effect yielded by the draught animals is a variable which in some cases is dependent upon the average oscillation. When the oscillations become too big, then the effect or the average value of the breaking points drops because to some degree the maximum values (inpinge values) have a fixed upper limit. The points in fig. 1 represent tests with draught animals of very different strength and size, and the stress-level (see later) is also variable. Due to this, the line BC does not form a clearly marked limit. Many of the points (in fig. 1 and 2) which represent the first tilling, fall to the right of the line BC. This is due to the many low slack-values, which are common in connection with the first tilling, (see later).

The line AC in fig. 1 mirrors the fact that the farmer either does not want to, or cannot go below a certain minimum effect. E.g. there must always be yielded a certain minimum pull to make the plough move at all.

Characteristics for first, second, third and fourth tilling respectively

The following describes the most important features of the different tillings, partly by means of the diagrams fig. 2–4, partly by observations made during the tilling itself supported by the farmers own explanations.

The diagram for the first tilling (fig. 2) shows a marked difference between the negilu and the gunte. When the effect is constant there is in general much greater oscillations with a negilu than with a gunte. Unfortunately it cannot be decided, whether this difference in the diagramme is due to a real difference between the two implements, (an ordinary negilu, and especially the negilu used for the test, is more difficult to adjust with respect to the height of the beam, as mentioned). The reason may also be that the tests with the gunte were made some days later, when the soil was more soft because of rain. Most of the farmers try to start the first tilling as early as possible after the first rain in order to assure a heigh infiltration rate of the next shower. This will facilitate the next tillings, or at least make them more efficient, because the plough can go deeper and more weeds be brought to an early germination. It is easy to destroy the seedlings by the next tillings, when the weeds have first germinated.

When possible, the first tilling will be made with a gunte, because the farmer wants to get as big an area as possible tilled before the next rain. Nevertheless most of the farmers have to use a negilu the first time due to some other factors, maybe the soil is still too hard, or the draught animals too weak.

When tilling the first time the farmer does not always press the plough so deep into the soil as actually possible. He avoids to press it because this would only lessen the walking speed of the animals and thus delay the tilling. Even if the tilling should not be so deep the first time it will be redressed at the next tilling, where the soil might be moistened to a greater depth and where there may be time enough to do the work with a slower implement. Sometimes an iron plough or a negilu is used for the second tilling, just because the farmer wants to achieve a greater tilling depth.

Many farmers till a comparatively big area per day during the first tilling. In general the first tilling is also most energy demanding (see table 2).

If it is not absolutely necessary to start working on a remote field, the field lying nearest to the village will usually be tilled as the first of the year. This so because it is not considered auspicious for religious reasons to bring food out to the field on the first day.

Otherwise the first tilling will normally start on the sandy plots, if the first showers have been comparatively small. In this case the farmer hopes that there will soon come more rain so that the soils which need more water for softening can be tilled later. If on the contrary, the first rain has been heavy, the farmer hurries to have the difficult soils tilled (dark red soil, soils with a high content of clay), because they will otherwise dry out and become hard very quickly. The fields where the first tilling was started will often also be the first to be tilled the second and the third time, but evidently the sequence may vary from one year to another.

In 1973 several farmers started the tilling too late on the difficult soil; for which the first tilling was delayed even up to one month, as there did not come any showers before big enough to soften the soil. If the farmers had tilled these fields quickly after the first rain, it might have been possible to do the entire tilling on them quite as well as on the others even if the first tilling had been of less depth.

It is a general rule also by second and third tilling that the dark red coloured soils (drift soils) and the heavy clay soils, where the moisture quickly disappears, are tilled as soon as possible after a heavy rainfall, whereas the sandy fields can wait, because they are always possible to till, both just after the rain, but also later. As mentioned they keep the moisture longer, because the tendency to form clods is not so marked as for the other soils. Moreover the sandy soils can still be tilled, even after they have become comparatively dry.

The heavy clay soils and black soils ("antmonnu" = sticky soil) can very well be tilled first time just after the rain, but for the next tillings it is necessary to wait 2–3 days after a heavy rain, partly because these soils are sticky and difficult to work with the implements, partly because there might be some risk of trampling the soil and thus cause formation of clods; this might give troubles at the next tilling.

The second tilling
Several farmers stated that if the first tilling was late, i.e. after much of the rain had already fallen, then it was very urgent to do the second tilling soonest possible because the soil was comparatively dry due to less infiltration and would quickly dry out more and thus make the second tilling impossible or useless. If the second tilling was further delayed because the farmer had to await the next rain, the entire tilling was in danger of being done too late or at too short intervals before sowing time. Some farmers said, most often in connection with the second tilling, that if even a little rain came just after the tilling, the soil would form a crust (one or two cm thick) on the surface. This crust would prevent evaporation to some extent, so that the next tilling could wait quite a long time without risking a dry and hard soil. But if there came no rain after the tilling, the tilling would form a more open soil layer which the air could easily penetrate and dry out; for that reason it might be necessary to do the next tilling only short time afterwards.

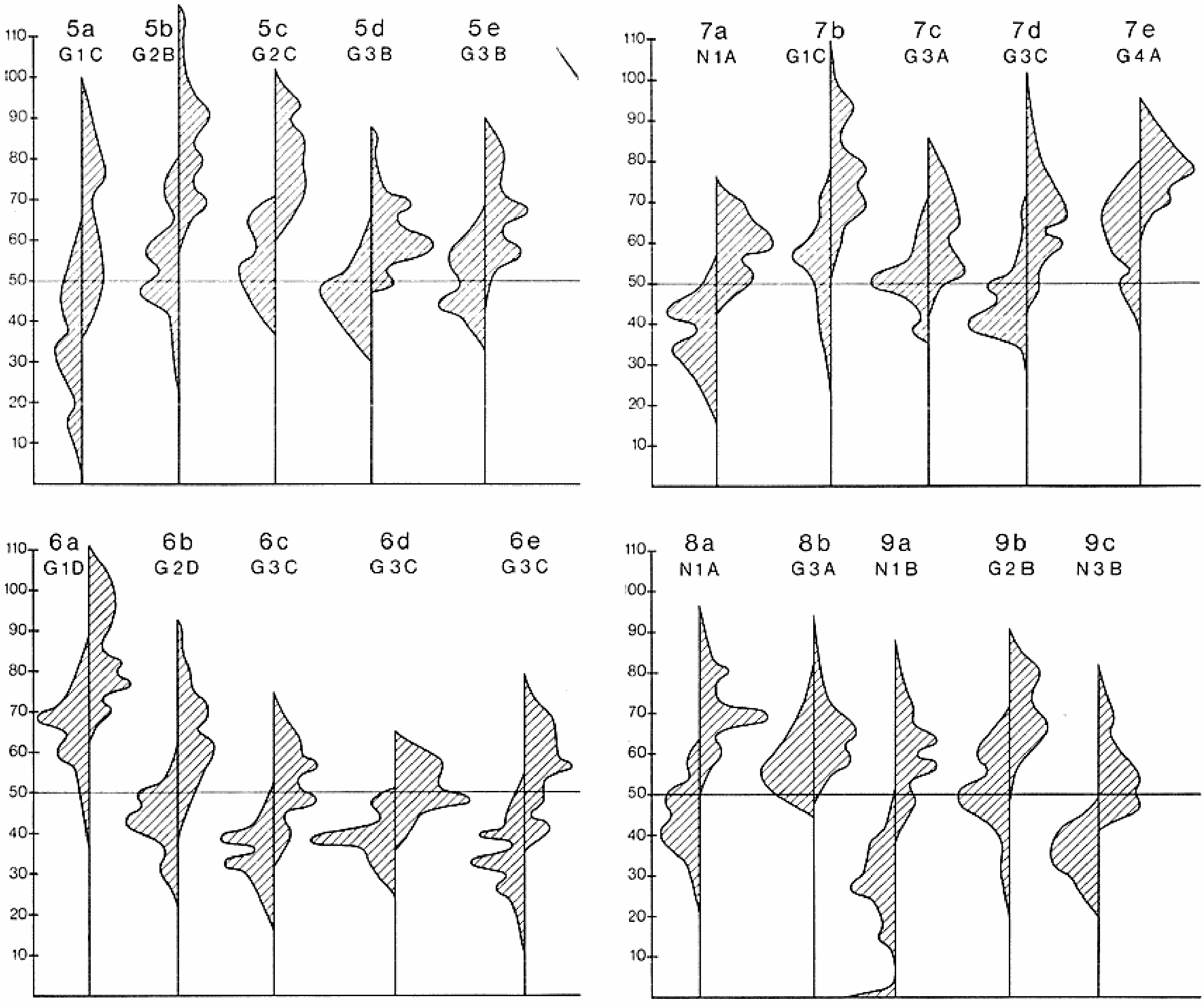
Many farmers think that three tillings are sufficient, the manure is therefore often spread just before the second tilling in order to get it well mixed with soil by second and third tilling. Moreover the hard spots after the manure heaps will be better removed. If they are tilled only once before the sowing, as will be the case because the farmer avoid the manure heaps the first times, the spots can easily give trouble for the light sowing machine later on.

Third and fourth tilling
The diagram for these tillings (fig. 4) shows the same general pattern as he diagrams for the previous tillings. There are only a few special features to mention, for example group I, very sandy soils, where the points lie to the left of the line AB due to the small oscillation, and group II downside the line AC. This last group has an especially low effect because the tests were made with a negilu which can slide very smoothly through already tilled soil.

Some farmers said that if first and second tilling was done in a proper way (it means if it reached a proper depth) the third tilling might be done at any convenient time. No matter how much the work was delayed, the soil could never be so dry and hard again that the third tilling could not be done. Accordingly some farmers mentioned that the purpose of first and second tilling was to loosen the soil down to a certain depth, whereas the main purpose of following tillings was to remove the weeds, to break the last clods, to dry the soil and to mix the manure further. Many farmers also said that they did not want rain before or just after the third tilling, because the weeds would not wither so easily then.

From this information it might have been concluded that the consumption of energy (effect) by third (and fourth) tilling would have been less than by second tilling, because the plough should not break deeper down into the soil, but should only go in the already loosened soil layer. Apparently however, the average consumption of energy was only slightly different from second to third tilling. Thus the effect with bullocks by the second tilling was 44 kgm/sec. with negilu, and 52 kgm/sec. with gunte, while the effect by the third tilling was 39 and 51 kgm/sec. respectively (table 2). (A simple visual evaluation of the dynamometer curves shows that there is a general change from the second tilling to the third and fourth. The curves are more stable by the later tillings).

There are however certain circumstances which might explain why the use of energy do not seem to be less by third tilling than by the previous tilling. In 1973 there came some showers (14/6: 7 mm, 1/7: 30 mm, 5/7: 14 mm). In many cases did these showers come just in between the second and the third tilling. It is possible that the showers softened the soil beneath the previous tilled and loosened layer so much that the plough would go deeper than by the earlier tillings. If the soil had remained dry the plough would only have just slided over the surface of the hard untilled layer beneath the loose, tilled layer. Some of the more clayey soils have an inclination for clod formation or hardening in the entire tilled



Figs. 5–9 are frequency curves for impinge and slack values. Y-axis = effect (kgm/sec.) during small intervals, each containing either one impact-value or one slack-value. X-axis = frequency of small intervals with the given maximum or minimum effect. Impinge values are indicated to the right of the Y-axis, slack-values to the left. A number of tests have been conducted with the same bullocks (e.g. 5A, 5B etc.). The symbols of each diagram indicates: 1) test number (cf. tables 3 and 4, and figs. 11 and 18), 2) implement used at the test (N = negilu, G = gunte), 3) tilling number, 4) estimated content of sand in the tilled soil-layer (A = highest content of sand, D = lowest content of sand).

Fig. 5–9 er fordelingsdiagrammer for stød og aflastningsværdier. Y-akse = effekten (kgm/sek.) i småintervaller, der hver svarer til et stød eller en aflastning. Y-akse = hyppighed af småintervaller med den givne maksimale eller minimale effekt. Stødværdier er angivet til højre for y-aksen, aflastningsværdier til venstre for y-aksen. Med samme stude er udført forskellige prøver, f.eks. 5A, 5B etc. Symbolerne ved hver kurve angiver følgende: 1) prøvens løbenummer (jfr. tabel 3 og 4 samt fig. 11 og 18), 2) redskab anvendt ved prøven (N = negilu, G = gunte), 3) pløjningens nummer (1–4), 4) det skønnede indhold af sand i pløjelaget (A = mest sandet, D = mindst sandet).

layer if they are tilled in wet condition. This hardening might cause a higher consumption of energy by the following tilling, in this case third and fourth tilling.

In some cases especially the test plough might have gone deeper into the soil, because it was difficult to adjust it correctly. Some farmers mentioned explicitly that they would not press the plough so much down as possible, either because they only wanted to remove some small weeds, to mix the manure, to get the upper soil layer dried and so on.

Many farmers had completed the third tillings before and in many cases just a few days before the rain falling in Namma-uru on 1/7 and the following days. This rain came at a very unconvenient time, because many weeds which would otherwise have dried, recovered and resumed growth. Many farmers had planned to sow some time after the third tilling and had made great efforts to make a nice tilling, level out the "dongiris" and so on.

But the rain 1/7 and following days came too early to be of any use for the sowing. The farmers did not dare to sow because they know by experience that longer time might pass inbetween the showers so early in the month, and the seedlings might be damaged. Only the sandy soil (which has a clayey sublayer as mentioned) had so much moisture that it was safe to sow. The crop got a very good start on these fields, especially when the next rain came already 7/7. But on the other, unsown fields new weeds sprouted and old weeds recovered growth. Therefore many farmers were forced to till a fourth time as a "bittnesalu", and many had to do the work urgent, and use a gunte, even if a negilu would have given a nicer sow bed. Shortly after this fourth tilling the rains started again, and most of the farmers sowed after this rain. Thus many farmers were in 1973 forced to sow in a comparatively newly tilled soil "vosdu ukie". Some farmers were of the opinion that this is no good because the air easily penetrates and dries the loose soil and obstructs the germination of the seeds.

In 1973 there was a dry period after the sowing, and then a longer period with rain nearly every day. Due to this the crop got a poor start indeed, as the soil was first too dry and then too wet. Contrary to the crop, the weeds grew very well, and it was not possible to make the usual intercultivation, because the crop had not developed properly and could not stand such a treatment. For this reason the weeds had their chance. The mentioned intercultivation is made with a special implement "kunte" with five or six teeth.

Due to the necessary fourth tilling the tilled layer became a little deeper than the farmer had first planned. Some farmers did not want to get such a deeply tilled layer, because the soil "would then drink more water" as it was expressed, when the crop was on the field. This effect is due to the fact, that the loose and waterabsorbing layer can soak more water during a heavy shower before the water starts running away superficially.

The tilling in general

In the previous it is tried from information about effect and average oscillation etc. to describe which factors are of importance from the first to the last tilling. A more thorough description of the single tilling can be obtained by an analysis of the distribution of the impinge and slack values respectively.

It is only in rare cases that the impinge and the slack-values (respectively) are normally distributed. The frequency curves (figs. 5–9) for the impinge and the slack-values have often more than one maximum and one minimum in the distribution. Overlapping is also seen, some slack-values are higher than some impinge-values.

The frequency curves (figs. 5–9) do not indicate the

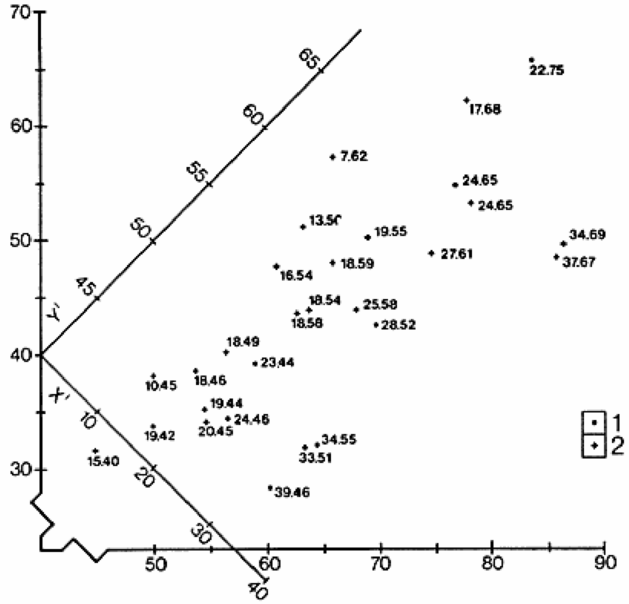


Fig. 10. X-axis: median for impact-values (kgm/sec.). Y-axis: median for slack-values (kgm/sec.). X¹-axis: average oscillation = x ÷ y (kgm/sec.). Y¹-axis: effect $= \frac{x+y}{2}$ (kgm/sec.). 1: first tilling, 2: other tillings. The pair of numbers near each point indicates average oscillation and effect calculated directly (first method, see text).

Fig. 10. X-akse: median for stødværdier (kgm/sek.). Y-akse: median for aflastningsværdier (kgm/sek.). X¹-akse: middeludsving = x ÷ y (kgm/sek.). Y¹-akse effekt $= \frac{x+y}{2}$ (kgm/sek.). 1: første pløjning, 2: øvrige pløjninger. Talsættet ved hvert punkt angiver middeludsving og effekten beregnet efter den direkte, første metode (se tekst).

pull itself, but all the values are multiplied by the average walking speed during the actual test, so that the frequency curves indicate either the maximum or the minimum effect (pull x speed = kgm/sec.) in microintervals, each containing one impinge or one slack-value.

The frequency curves look quite different from test to test. But it is a common feature for many of the tests from first time tillings, that they have a wider dispersion of both the slack and of the impinge-values, especially there are many low slack-values, many as low as zero (figs. 5A, 6A, 7A, 8A, 9A). It is difficult to explain the appearance of the frequency curve in each individual case and to explain exactly what factors have contributed to each maximum. However the diagrams give a good characteristic of each individual tilling; e.g. they indicate how the tilling was felt for the draught animals (high impinge-values may for example cause pain).

In many cases the different maxima on the frequency curves might be explained by the mosaic-like variation in the hardness of the soil over short distances. This variation might be caused by uneven distribution of moisture, as rain-water tends to collect in small depressions. At some test-tillings there was a very clear difference in the hardness of the soil; here should be mentioned an example where one furrow was tilled in a soft, moist soil near the edge of the field (fig. 6D), whereas the next was made on the field where the soil was more hard (fig. 6E). The frequency curve for the test as a whole (fig. 6C) is composed of the two widely different frequency curves for soft and hard soil respectively. In other cases a particular maximum on the frequency curve might have been caused by some characteristic situation which often occurs during the tilling. There might for instance be clods of a certain size and hardness or stones in the soil. The plough may hit these hard objects or other obstacles with a certain frequency. It might also happen that the plough now and then breaks into the hard layer below the loose, tilled layer.

Finally it should be remarked that the characteristics of the draught animals themselves (strength, height etc.) also have a great influence upon the appearance of the frequency curves. Fig. 7A might for example be compared with fig. 8A and fig. 7C with 8B, (7A and 7C are the same animals, just as 8A and 8B). 7A and 8A are quite different from each other, while there is some similarity between the two other tests because the soil conditions in their case were rather special (very sandy). Although the soil is quite homogeneous and might be expected to give a normal distribution of the impinge and slack-values, the effect of the draught animals uneven walk and interference between the two animals will cause different maxima on the frequency curves.

Besides the already mentioned method of calculating the effect and average oscillation directly from the dynamometer curve, it is also possible to calculate these factors from the medians of the impinge-values and the slack-values respectively. These medians can be obtained from the frequency curves (fig. 5–9). The effect is calculated as the average of the two median values, whereas the average oscillation is calculated as the difference between these median values. Fig. 10 shows that there is a good correlation between the two methods. The directly calculated (1 method) values for effect and average oscillation are given as pair of numbers in fig. 10. In this pair of numbers the average oscillation (measured in kgs) is multiplied by the walking speed, so that the resulting figure indicates the variation in effect, not in pull.

The small deviation between the values for effect and average oscillation, calculated by the two different methods, are due to irregularities in the frequency curves; this implies that the median value is not necessarily in accordance with the average value.

The diagram fig. 10 shows that the median for the impinge values is only in rare cases more than 80 kgm/sec. This maximum value corresponds principally to the line BC in the diagram fig. 1.

The line AB in fig. 1 can be explained by assuming that there is an upper limit for the slack-values, (com-

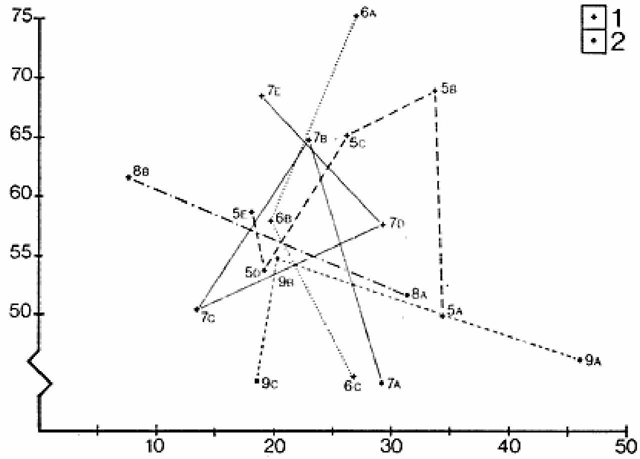


Fig. 11. X-axis: average oscillation (kg). Y-axis: effect (kgm/sec.). This figure represents the same tests as in fig. 5–9. Points representing the same pair of draught animals are connected by a line. 1: gunte used at the test, 2: negilu.

Fig. 11. X-akse: middeludsving (kg). Y-akse: effekt (kgm/sek.). Denne figur viser de samme prøver som fig. 5–9. Punkter fra prøver med samme trækdyr er forbundet med en linie. 1: gunte brugt ved prøven, 2: negilu.

pare again fig. 1 and fig. 10). This seems reasonable as there must be some upper limit to the resistance, when the plough is only moving in loose soil (slack-situation). If the impinge values are high, the average oscillation must also be great because the slack values can only reach a limited height. A limit corresponding to the line AB in fig. 1 is not found distinctly in fig. 10, perhaps because fig. 10 only represents a small sample. Fig. 10 shows that the high average oscillation for many of the first tillings can be explained by the low slack values.

When a big sample is considered (fig. 1), it appears as mentioned that, if the average oscillation becomes too great the effect is going down. This will most likely not be so evident in case of a small sample due to random variations, so it is difficult to show this relation between average oscillation and effect for the single pair of animals, with the restricted number of measurements available. In fig. 11 for instance, where measurements for some selected pairs of draught animals are indicated there is not found a distinct limit corresponding to the line BC in fig. 1. This means that the median for the impinge-values may vary from one test to another with the same animals. It is obvious that the animals work at varying stress-levels dependent upon the urgency of the work and the hardness of the soil. If the farmer wants to make the animals work at a higher stress-level, he must continously hiss and shout at them. It was often observed when considering only one test (or two tests with the same animals the same day) that there was a clear negative correlation between the effect yielded and the average oscillation for small intervals of time within the testing period. In these cases it must be concluded that

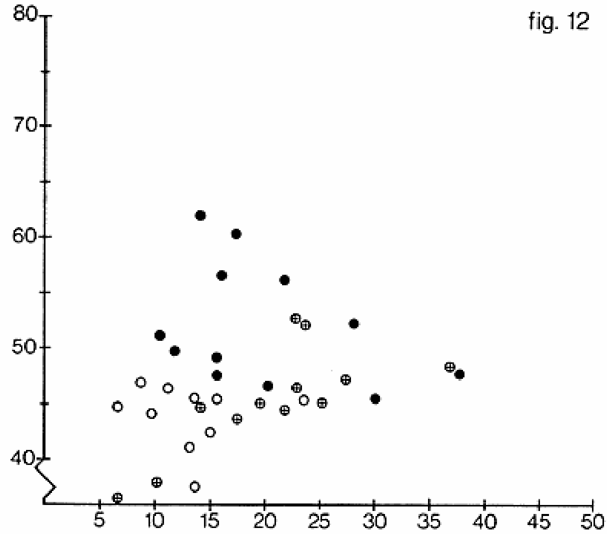


fig. 12

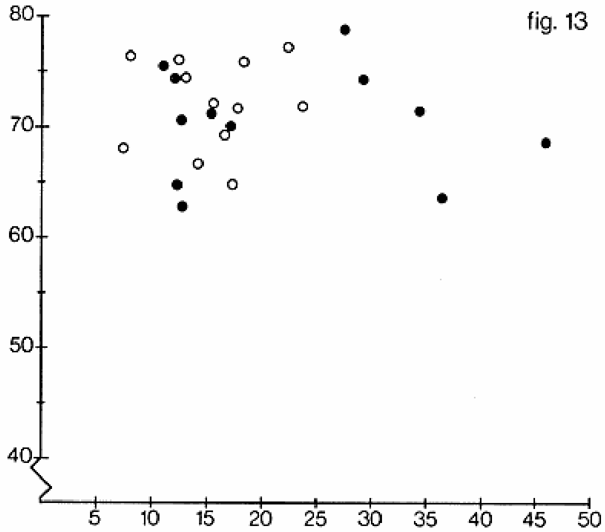


fig. 13

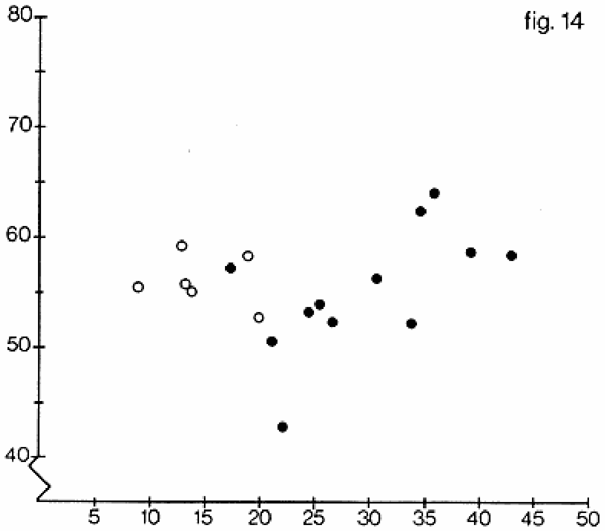


fig. 14

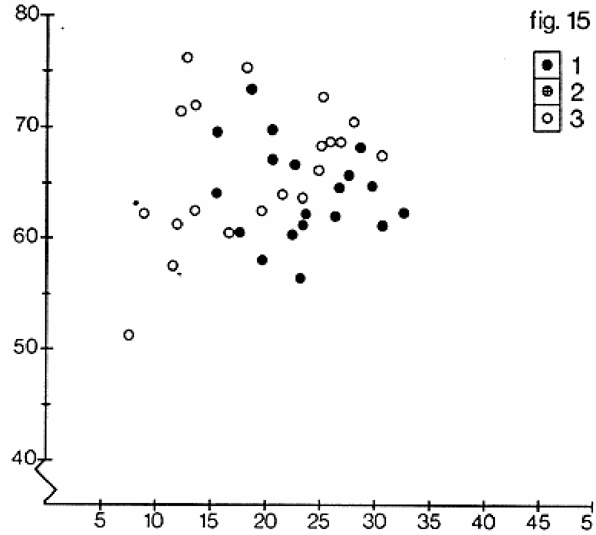


fig. 15

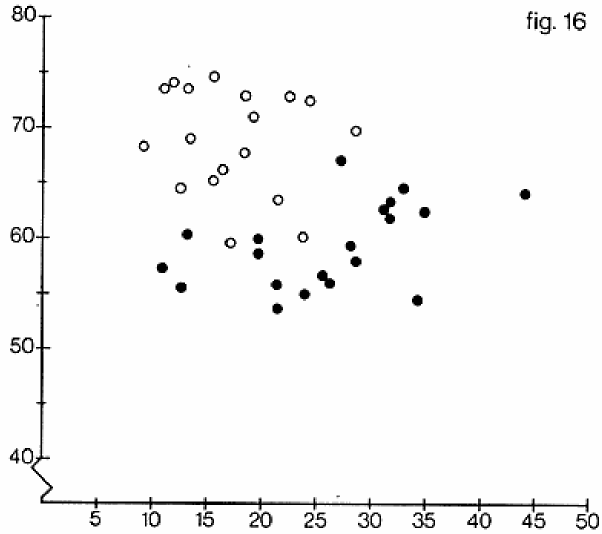


fig. 16

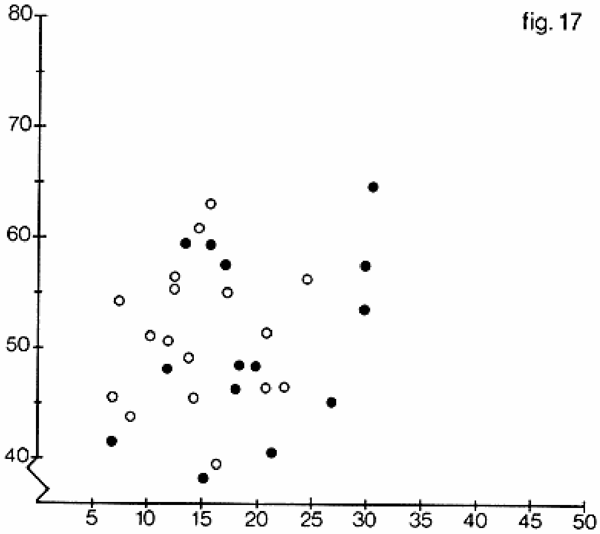


fig. 17

the stress-level has been kept constant, at least within the period of the test (or tests). To keep a constant stress-level the draught animals and the man driving the plough make adjustments in such a way that the pull goes down if the shake (average oscillation) becomes too great, and the opposite, if the shake is less, the pull should be increased. Whether this adjustment is actually made, depends upon the lenght of the interval, during which the shake is either too high or too low.

The diagram fig. 12 shows a test, where there was a change in the hardness of the soil within the same tilling line (length 46 m); here the pull was not lowered even when the shake was high at the one end of the field. This shows that the animals have got an energy reserve, which can be mobilised for shorter or longer periods. The existence of this reserve was further demonstrated by a few tests made after the routine measurements. The farmer was requested to press the plough very hard into the soil, so that the maximum pull of the animals could be measured; this pull was often 50–100 % higher than the average pull.

The diagrams fig. 13 and 14 from tests, where the plough ran in a line with soft and in a line with hard soil alternately, show that the pull is lowered when the oscillation becomes too great (fig. 13), or at least that a too great oscillation is tried to be avoided (fig. 14). If the periods with constant hardness of soil become of still longer duration, it will be even more evident that the pull goes down, if the average oscillation becomes too great. Fig. 15 shows this adjustment within the same test, where the tilling first was done 3 or 4 lines in soft soil, and after that in a comparatively hard soil.

Fig 16 and 17 show again the same thing. In this case a pair of draught animals were tested at an interval of a few hours on two different fields.

Likewise as the yielded effect may vary from one day to another for a given pair of draught animals, the size of the tilled area may also vary from day to day. Further, the yielded effect is high in many cases just those days, where the tilled area is great (fig. 18). In this manner the variation in the work yielded per day becomes even greater (for example farm No 5: 1.7 Kwh – 3.3 Kwh per day, see table 4). This is so partly due to the simple

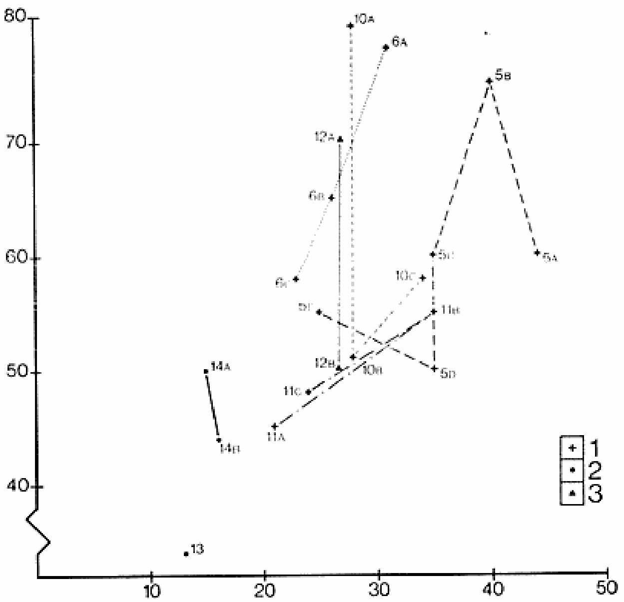


Fig. 18 (c.f. table 4). X-axis: tilled area per day in guntas (40 guntas = 1 acre). Y-axis: estimated effect used by drawing the farmers own plough. The farmer's own implement the day when the test was made: 1: gunte, 2: negilu, 3: iron plough.

Fig. 18 (jfr. tabel 4). X-akse: pløjet areal pr. dag i guntas (40 guntas = 1 acre). Y-akse: skønnet effekt ved brug af landmandens egen plov. Landmandens eget redskab den dag målingen blev foretaget: 1: gunte, 2: negilu, 3: jernplov el. svingplov.

fact that the effect will be high when the walking speed is high, even if the pull is the same. It is possible to reach a bigger area per day by making the animals walk fast, but also by dropping some of the usual rests, by starting earlier in the morning and so on. Often the farmer has to till a big area per day, for example when he wants to finish work before the rain comes, before a holy day, and before the sowing. Sometimes, especially during the first tilling a great hardness of the soil coincides with the necessity of doing the work fast, and the animals will get an extra hard work under these circumstances.

The general importance of the cattle in the farming

As will be clear from the previous, it will demand a lot of measurements to make a fair estimate of the working capacity of a given pair of draught animals. It is necessary to measure the pull many times, because the stress-level varies; it is necessary to investigate how a given stress-level influences the draught animals and the length of the period they can maintain this level without getting exhausted or ill. Sometimes the farmers mentioned that their animals were exhausted after hard work for some days. In some cases the animals had wounds from the yoke on their neck and shoulders. These wounds healed up, however, within a comparatively short time. The working capacity of the animals also have to be put in relation to their demand of fodder etc. The farmers them-

Fig. 12–17. X-axis: average oscillation (kg). Y-axis: pull (kg). These figures show correlation between average pull and average oscillation within the same test. Each dot represents a period of 2 seconds duration. (Fig. 16 shows the same tests as figs. 7D and 7E. Fig. 14 shows the same test as figs. 6C – 6E). 1: comparatively hard soil, 2: medium, 3: comparatively soft soil.

Fig. 12–17. X-akse: middeludsving (kg). Y-akse: træk (kg). Disse figurer viser korrelationen imellem træk og middeludsving inden for den samme prøve. Hvert punkt markerer en periode på 2 sekunder. (Fig. 16 er fra de samme prøver som fig. 7D og 7E. Fig. 14 er samme prøve som 6C – 6E). 1: forholdsvis hård jord, 2: middel, 3: forholdsvis blød jord.

Table 4.

1.Farm No.	3.			5.					19.			66.			69.		75.	89.	
2.Type of draught animal	Bullocks			Bullocks					Big cows			Bullocks			Bullocks		Small cows	Bullocks	
3.Test No.	10A	10B	10C	5A	5B	5C	5D	5E	11A	11B	11C	6A	6B	6C	12A	12B	13	14A	14B
4.Tilling No.	1	2	4	1	2	2	3	3	1	1	3	1	2	3	2	3	3	1	2
5.Tilled area per day (gunta)	28	27	34	44	40	35	35	25	21	35	24	31	26	23	27	27	13	15	16
6.Breadth of furrow (cm)	27	22	25	25	25	25	25	25	25	25	25	22	25	25	21	25	17	18	18
7.Effective working time calculated (hours/day)	3.0	3.8	4.5	4.9	4.5	3.9	4.6	3.2	2.9	4.5	3.1	4.8	3.2	3.5	4.5	3.5	2.6	2.1	2.5
8.Effect measured at the test (kgm/sec)	67	38	45	50	69	65	54	59	49	58	54	75	58	45	65	42	40	50	52
9.Estimate of effect with own plough (kgm/sec)	80	50	58	60	75	60	50	55	45	55	48	78	65	58	70	50	34	50	44
10.Work calculated from test (Kwh/day)	1.70	1.41	1.89	2.42	3.00	2.69	2.41	1.81	1.40	2.54	1.64	3.56	1.82	1.55	2.84	1.44	1.19	1.02	1.27
11.Work calculated from estimate on own plough (Kwh/day)	2.2	1.9	2.4	2.9	3.3	2.5	2.2	1.7	1.3	2.4	1.3	3.7	2.0	2.0	3.1	1.7	1.0	1.0	1.1
12.Type of farmer's own implement	G	K	G	G	G	G	G	G	G	G	G	G	G	G	K	G	N	N	N
13.Type of implement used at test	N	G	G	N	G	G	G	G	G	G	G	G	G	G	G	N	G	N	G

Ad 5. 1 gunta = 101 square meters.
Ad 12 and 13. N = negilu, G = gunte, K = iron plough.

Tabel 4. 1: brug nr., 2: type af dyr, 3: prøve nr., 4: pløjning nr., 5: pløjet areal pr. dag (guntas, 1 gunta = 101 kvadratmeter), 6: furebredde (cm), 7: beregnet effektiv arbejdstid (timer/dag), 8: effekt målt ved prøven (kgm/sek.), 9: skønnet effekt ved eget redskab (kgm/sek.), 10: arbejde pr. dag beregnet ud fra måling (kwt/dag), 11: skønnet arbejde med eget redskab (kwt/dag), 12: landmandens eget redskab, 13: redskab anvendt ved prøven, G = gunte, N = negilu, K = jernplov.

selves evaluate the animals primarily according to their endurance. A high endurance means that the animal can work steadily under a comparatively high stress-level without demanding much rest. The intelligence of the animals is also of great importance, it is necessary that they walk well with the plough, that they obey the calls, that they are easy to turn at the end of the furrow, that they can themselves find their way home when they come from the field or the grazing areas. The evaluation is also dependent upon the appearance of the animals, for example the curvature of the horns, and the details of the hairs. As the bullocks are mostly sold in pairs it is also important that the pair has nearly the same coloration.

Most of the animals traded on the cattle fairs are bullocks. As a rule the farmer keeps the cows born on his farm as long as they live. If he himself rears bullocks, he keeps them until they have reached approximately half their living age (it means 6–8 years). The best draught animals are the young bullocks. The elder ones are usually sold on the fair. When one pair of bullocks are sold another pair will be purchased soon thereafter. Many farmers are passionate cattle traders. Only in few cases a pair of elder bullocks remain longer than one or two years on the same farm. These elder bullocks are bigger than the young ones and eat more fodder, but their working capacity is less.

The quality and price of draught animals are very variable, (700–2200 Rs for one pair). In some respects the farmers bullocks are a sort of insurance besides being an investment. If he gets into economic troubles, he might sell the bullocks and get new ones at a lower price and still have the means for tilling. Besides the

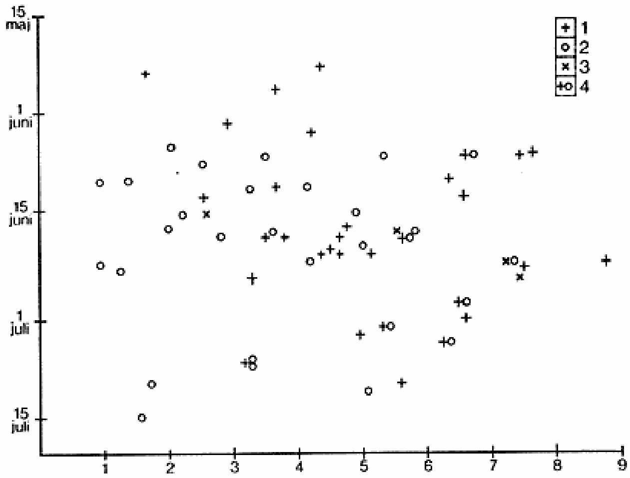


Fig. 19. X-axis: acres of dry-land per pair of draught animals. Y-axis: median date for all the days when either second or third tilling was performed. Each point represents a farm. (This figure shows data collected 1970). Draught animals used: 1: one pair of bullocks on the particular farm, 2: one pair of cows, 3: two pairs of bullocks, 4: one pair of bullocks + one pair of cows.
Fig. 19. X-akse: areal af regnvandet jord pr. par trækdyr (acres). Y-akse: median dato for alle de dage, hvor enten anden eller tredie pløjning blev udført. Hvert punkt repræsenterer et brug. (Denne figur viser data indsamlet 1970). Trækdyr anvendt: 1: et par stude i det pågældende brug, 2: et par køer, 3: to par stude, 4: et par køer + et par stude.

pure hallikars there are many other more or less mixed varieties on the market, e.g. crosses with red sindhi and several dwarf varieties. The latter often have a very remarkable working capacity considering their small size. Nowadays some crossbreedings with European cattle (Bos taurus) are also seen on the market.

In Namma-uru there were several farmers who only used purchased bullocks, because they could not keep cows and calves themselves, as they did not have the necessary female labour force to take care of these animals.

The fodder consumption for one head of cattle in Namma-uru is approximately 15–20 lbs of dry matter per day. The yield of dry matter on one acre of dry land is approximately 6200 lbs per year, out of which 800 lbs can be used for human consumption, and accordingly the necessary area for supplying fodder for one head of cattle will be approximately one acre. In fact, the stock of cattle (cows, calves, bullocks) on most of the farms in Namma-uru is in accordance with the size of the farm, so that there is one head of cattle per acre. In some cases there is more, because there are good opportunities in this village of getting fodder from uncultivated areas. Some landless households have a single cow or so because they can always find some grazing here and there.

The farmer prefers to rear his young bullocks himself if there is any possibility at all. It is necessary to have a number of cows to keep the stock of cattle at a certain level. So there will always be both cows and bullocks on a standard farm. But the small farms have not got fodder enough for both, and therefore the bullock calves are sold or given away, when they are still small.

From fig. 19 it appears that the small farms (less than approximately 2 acres) use cows as draught animals. The average farms (approx. 3–6 acres per pair of draught animals) use bullocks. The farmers who have an even greater area per pair of draught animals often use the cows also, because they do not want to invest in an extra pair of bullocks. This so because an extra pair of bullocks will naturally be of no use in breeding, and the farmer has already one pair for cart driving. On these comparatively big farms it is often seen that one or two ploughs are pulled by bullocks while the third is pulled by cows.

Fig. 19 shows that the farms that have a small area per pair of draught animals perform the tilling work comparatively earlier in the year. This implies a better chance of doing a perfect tilling, as these farmers can better find the time to do the work just at the optimal moments, (provided that the animals are not too weak and skinny).

It appears that only about 5 % of the farmers changed their type of draught animal from 1970 to 1973 (here changes due to farm division by heritage are omitted). But only in a few cases did the same animal work on the same farm both in 1970 and in 1973. Most of the animals were exhanged by new ones. So, in spite of the eager trade with draught animals it seems that there is a marked stability regarding the type of animals used for the tilling work on each farmstead.

RESUME

Denne artikel behandler forhold vedrørende udnyttelsen af det lokale kvæg (Hallikar racen) ved pløjningen i et sydindisk monsunlandbrug på uvandet jord (dry-land). Undersøgelserne er foretaget i en landsby i SE-delen af staten Karnataka nær Bangalore.

Specielt måltes studenes og køernes trækkraft ved hjælp af selvskrivende dynamometer. Den udskrevne dynamometerkurves knækpunkter markerer henholdsvis stødværdierne og aflastningsværdierne. (Stødværdierne repræsenterer den kraft, der skal til for at bryde en knold eller lignende løs). Den ydede effekt (kgm/sek.) er i første omgang beregnet direkte ud fra dynamometerkurven ved at anvende middelværdien af knækpunkterne. Det gennemsnitlige udsving (angivet i kg) er ligeledes beregnet direkte ud fra dynamometerkurverne som middelafstanden imellem knækpunkterne. Effekt og middeludsving er angivet i tabel 1 og i fig. 1–4.

Selve fordelingen af stød – og aflastningsværdierne er for nogle udvalgte pløjninger angivet i fig. 5–9. Fordelingen af disse værdier er afhængig dels af jordbunden, dels af trækdyrene. Det er vanskeligt konkret at forklare de forskellige maxima og minima på disse fordelingsdiagrammer, men de giver et overblik over pløjningens karakter og over, hvorledes pløjningen kan have indvirket på trækdyrene selv. (Fx kan kraftige stød gøre direkte ondt på dyrene eller udmatte dem mere).

Ved hjælp af et fordelingsdiagram kan man bestemme medianværdierne for henholdsvis stødene og aflastningerne. Middel af disse to medianværdier svarer til effekten, medens differensen imellem disse to svarer til middeludsvinget. Effekten og middeludsvinget kan dels beregnes direkte ud fra dynamometerkurverne som nævnt, dels beregnes ud fra fordelingsdiagrammernes medianværdier. Der er god overensstemmelse imellem disse to metoder til bestemmelse af effekt og middeludsving (fig. 10).

Landmændene anvender flere plovtyper dels »negilu«-ploven (en krog-plov), dels »gunte«-ploven (hvor plovhovedet har to jerntænder, således at redskabet fungerer som en kultivator), og nu også i stigende omfang jernplove (svingplov). Der pløjes gerne 3–4 gange på kryds og tværs før såningen.

Negilu anvendes fortrinsvis i leret jord, ved første pløjning eller hvis trækdyrene er små og svage, modsat anvendes gunte fortrinsvis i sandet jord eller i jord, der allerede er pløjet en gang, samt når man har stærke trækdyr. Hvis man skal skynde sig bruges også gunte, hvis det er muligt.

Fig. 1–4 angiver sammenhængen imellem effekt og middeludsving for henholdsvis første, anden, tredie og fjerde pløjning. Første pløjning adskiller sig fra de øvrige dels ved det store middeludsving (fig. 2) og som regel ved en høj effekt (tabel 2, det store middeludsving skyldes i flere tilfælde de lave aflastningsværdier (fig. 10). Tabel 2 (sidste del) angiver gennemsnitstal for den målte effekt ved samtlige prøver. Det fremgår heraf, at effektforbruget med gunte er ca. 20 %

højere end negilu. Jernploven svarer stort set til en gunte. Det fremgår ligeledes af tabel 2, at de store køer kan yde det samme arbejde som en middelgod stud.

Det viser sig, at der for det samme par af trækdyr er en stor variation i den ydede effekt fra prøve til prøve (fig. 18). Ligeledes er der stor variation i størrelsen af det pløjede areal fra dag til dag (fig. 18). Det viser sig ofte, at der på den samme dag for et givet par af trækdyr er en vis balance imellem effekten og middeludsvinget (rystelserne), således at trækket sættes ned, hvis rystelserne bliver for kraftige (fig. 12–17), man kan sige, at der holdes et konstant stressniveau inden for den sammen dag. (Af linien BC i fig. 1 fremgår det ligeledes, at effekten falder, når middeludsvinget bliver stort, dette skyldes at maximalværdien af stødene er en nogenlunde fast begrænsning, ca. 80 kg/sek., jfr. fig. 10). Det ville ikke være noget større teknisk problem at montere simple støddæmpere på plovene, sandsynligvis ville dette forøge den ydede effekt, og man ville også undgå at okserne fik slidsår af åget.

Stressniveauet og dermed også effekten er som regel højt netop de dage, hvor der pløjes et stort areal (fig. 18), dette skyldes, at pløjearbejdet kan være særligt presserende, fordi man skal skynde sig (fx medens jorden endnu er blød efter regn, eller fordi man skal så). Når dyrene skal gå hurtigere bliver effekten alene af den grund større. Undertiden kan jorden også være særlig hård netop de dage, hvor man skal skynde sig, dette gælder fx ofte ved den første pløjning.

I den undersøgte landsby kan 1 acre dry-land foruden human føde (ca. 800 lb) producere 5400 lb plantemateriale, denne mængde svarer stort set til det årlige foderforbrug af et stykke kvæg. Den aktuelle kvægbestand (kalve+køer+stude) er da også ca. 1 stk. pr. acre.

De helt små brug (under 2 acre) er nødt til at bruge køer som trækkraft, idet der ikke er foder nok til også at have stude (fig. 19). De større brug (3–6 acre pr. par af trækdyr) anvender som regel stude ved pløjningen (fig. 19). De brug, der har et stort areal pr. par af trækdyr tager også køerne til hjælp ved arbejdet i stedet for at anskaffe et ekstra par stude. Det viser sig generelt, at de brug ,der har et lille areal pr. par af trækdyr gerne får pløjet tidligst (fig. 19) og derved også har chancen for at få pløjet bedre.

LITERATURE

Axel Steensberg (1971) Drill-sowing and Treshing in Southern India compared with Sowing Practises in other parts of Asia. In Tools and Tillage Vol 1, 4, p. 241–256. (This article contains among other things fotos of ploughs (gunte) and sowing machine of exactly the same types as used in Namma-uru).

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