сенажа тщательно контролировать влажность сенажной массы и четко соблюдать технологию приготовления корма.

Для снижения затрат дизельного топлива тракторами Т-150, выполняющими работу по утилизации жидкого навоза, необходимо укоротить плечо перевозок путем перекачивания навоза фекальными насосами в полевые навозохранилища, а также уменьшить количество жидких стоков за счет реконструкции системы навоза-удаления.

Наибольший удельный вес энергии, овеществленной в машинах, приходится на оборудование для кормораздачи - 14%, на кормоприготовление — 20%, отопление — 19% и навозоудаление — 39 %. В связи с этим предприятия сельскохозяйственного и тракторного машиностроения должны снизить энергоемкость выпускаемых машин и оборудования.

Основным направлением в снижении затрат энергии живого труда должна стать автоматизация технологических процессов.

Таким образом, полный анализ энергоемкости производства говядины на комплексе коллективного предприятия «Прогресс» свидетельствует о том, что суммарные энергозатраты зависят от затрат энергии на отдельные технологические операции. На величину этих затрат оказывают влияние самые различные факторы, которые следует учитывать при разработке мероприятий по снижению энергозатрат на производство продукции.

RESULTS OF SOIL BIN EXAMINATIONS OF OSCILLATING PENETRATING SHARES FOR AFRICAN SANDY SOIL ROOT CROP HARVESTING IMPLEMENT TO A SUSTAINABLE SOIL MANAGEMENT

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Abstract

Harvesting research in developed countries has progressed with equipment development. In Africa, the limited range of small root crops harvesting research and the neglect of small scale tool development has an adverse effect on food production, since the bulk of the food is produced by small scale farmers. The situation is complicated by complex factors such as increased population and food demand, exodus of youths from rural areas and the aging farming population. It is increasingly difficult for these farmers to cope with the drudgery of work using small unimproved tools (FAO, 1993).

Introduction

The oscillating shares, have been designed, fabricated and tested in soil bin. The share efficiency evaluation will be based on two criterias namely: soil/share performance and agroecological factors. Soil/share performance will be based on some defined engineering characteristics used in harvesting machinery design. These will include energy type/requirement, forces exercising on share by soil, soil resistance, harvesting depth, working speed, efficiency, etc.

Agroecological factors will be based on crop yield, plant needs, required soil condition, soil and water conservation after harvesting with respect to sustainability of agricultural land, etc.

These evaluations will permit to establish a model of shares for sandy soil. Naturally, they will involve shares modification to fit site specific conditions. Proposals for further development, modification, adaptation and use of the cutting organs will be made. The research will also strive to define the appropriate use of a small root crops harvester for conservation farming in Niger conditions, in order to achieve optimal tool efficiency and productivity, at the same time meeting the prerequisite of sustainability of agricultural land.

Research objectives

Among all harvesting components penetrating is the one, which carry more stress. This is done, due to their great role in the process. First to undercut soil and then to lift soil and roots to a band for partial separation of tubers from soil and paulm. The forces acting on cutting share depend on soil characteristics, which logically influence the energy need and the resistance of the machine to work. The prototype of cutting organs was constructed and tested at the Institute of Agricultural Engineering in the Tropics and Subtropics of university of Hohenheim, where research have been carried out.

The main research objectives cover the following items:

Soil characteristics measurement; measurement of forces acting on shares; calculation of soil traction resistance; comparison of theoretical results with practical; define criteria of development and working of oscillating penetrating shares.

The carried out study at soil bin results on relationships between soil and shares which will permit to develop a small tractor powered harvester of small root crops for small holders in Africa. The machine could be alternatively developed for animal draught power.

Materials and methods

At the workshop of the University of Hohenheim the designed shares were fabricated. The soil bin of the Institute of Agricultural Engineering in the Tropics and Subtropics was used to carry out the test measurements of main forces acting on the shares. The main technical parameters are draft force requirement, working time, depth control, working speed, amplitude of oscillation and soil resistance. They have been recorded at the bin.

Workshop

Steel 350Ч150Ч4 was used to fabricate the dumping share. The sloping digging share is made of steel 260Ч250Ч5. The two shares are fixed on a tube of 30mm of diameter. The tubes were welded to I section 200Ч40Ч10 and 300Ч40xЧ10 to facilitate the depth control through holes diameter of 18mm. Another I section 565Ч100Ч10 was fabricated to transmit from oscillating mechanism to the shares a translation or oscillating movement. The oscillating mechanism is a steel shaft • 30Ч500mm welded at both ends with a steel • 80Ч80. One side was fixed to I section and the second one to a V-shaped spear through a small shaft • 35mm. The V-shaped spear is fixed to an oval spear, which has 6 holes • 2mm. The oval mass was fixed to a reducing gear unit PTO transmission with ratio 1:2. A flexible shaft was used to connect the gearbox and the gantry. Figure 1 shows the full design of the fabricated implement (Fig. 3).

Soil bin

The soil bin of University of Hohenheim is one of the latest modern constructions and was installed in 1994. The hall has the overall dimensions of 46 m_x 11 m_x 4m and the soil bin 46 m_x 5 m_x 1,2m. The gantry is 6m width with 2,5m of road driving width. The gantry is powered of 75 kW. The soil bin texture is showed in table 1.

Table 1.

Soil Texture in the bin

Sand (%)	72,6
Silt (%)	16,1
Clay (%)	11,3

Soil bin experiment procedure

A program of experiments was elaborated to facilitate the procedure. Thus, two driving and rotation speeds for three depths were selected. The intensity of the oscillation was regulated through four amplitudes or radius of oscillation. To measure the forces acting, with each amplitude test was made at different combination of driving speed, n (rpm) and depths. The shares are fixed vertically with working angle α=15...18°.

The first experiments have been carried in light soil. The speed of 2 km/h and 350 rpm from the gantry was fixed. The dumping share was settled at 4cm as working depth and the digging share at 11,5cm from the soil top or 8,5cm deeper. The depth control was achieved with a supplementary triangular frame on U-shaped fixed behind the main frame. The U-shaped material permits a free movement of translation by two bearings. The bearings assume the front and back movements of the implement into the U-shaped. In 10 seconds, 200 measurements have been recorded for light soil and 100 in 5 seconds for compacted soil. Each experiment with fixed parameters was repeated 3 times in the both soils.

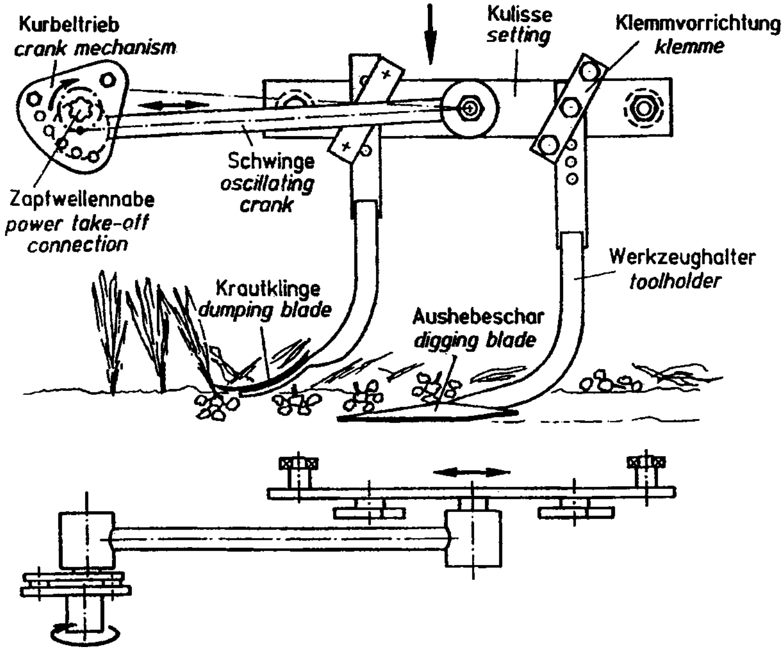

Fig. 1. Dumping and digging oscillating shares for powered small root crops implement

Soil bin measurement equipment and devices

The gantry was the power source for the experiments and was equipped with a tool mounting frame and draft captor. Then the tool was linked to the adapted main frame available in the bin. A roller and a tine-power harrow have been used for soil preparation. Soil strength was recorded with a cone penetrometer. The cone used was of ASAE standard with a 30°-cone angle and ∅20,27 mm. The three force components were measured with a draft captor, amplifier and a PC. The PC was run on MGC-panel program to record the axial forces on XYZ and the driving speed during the experiments. The radar sensor was used to capture the working speed, which will be recorded by the PC through a digital signal converter box (Fig. 2).

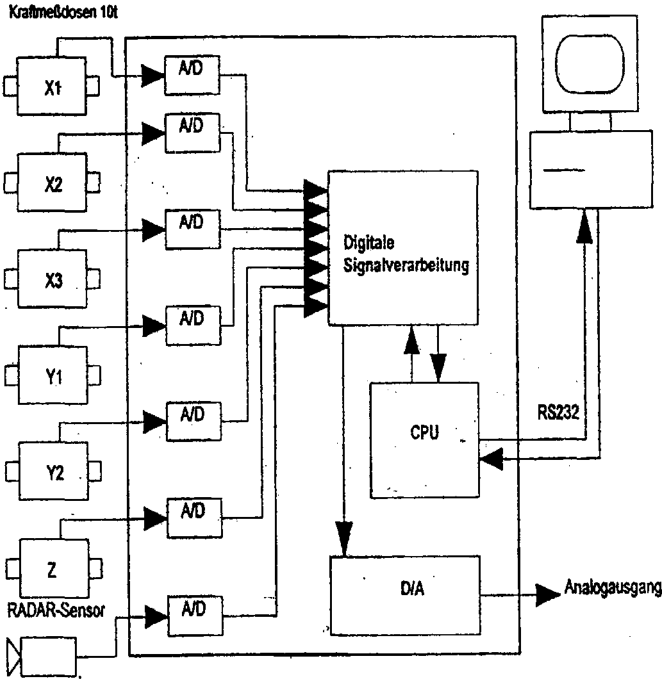

Fig. 2. Diagram of devices for measurements in the bin

Soil bin preparation for light soil experiments

It was necessary to establish a consistent method of preparing the soil in the bin that could be used for all the experimental tests. The criterion for selecting a method was to obtain the least possible density variation with the depth.

Experiments have been carried out on two different soils: light and compacted.

Tine-power harrow KE-153, width of 1,6m was used after watering the soil in order to obtain a uniform light soil. The soil strength was measured before each experiment measurements.

Compacted soil was obtained with a cylindrical roller ∅ 0,95m and length 1,3m in one run. The roller weight is 1245kg. Thus, a pressure of 0,172N/mm^2 was run to the soil. A high soil uniformity was obtained.

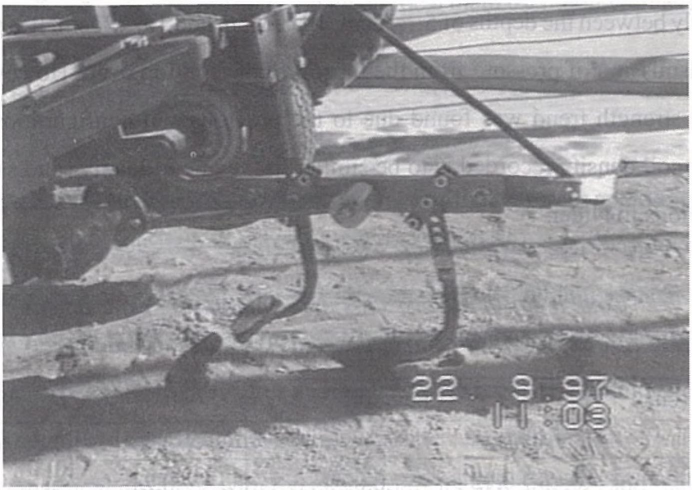

Fig. 3. Linkage of dumping, digging shares to the oscillating mechanism in soil bin

Results and discussions

Soil strength measurement

Three cone index measurements have been done and registered before each test at three different points in the bin. The soil strength was determined for the following depths:

5, 10, 15 and 20 cm. Cone index values were obtained by taking penetrometer readings over the implement working depths (table 2).

Soil strength regressions 0,07, 0,034 and 0,029 were obtained between the following depths: 5…10cm, 10…15cm and 15…20cm in the light soil. The low soil strength at 5cm depth is due to a second superficial passage of the tine-power harrow. The strength slightly varied in 15cm depth, but increased after 15cm. It seems that, the tine-power harrow had made the soil more light in 15 cm depth. In general the soil strength is not higher than soil strength in Niger sandy soils. Hence the experiments response completely to the soil on which tiger nut is planted.

The roller showed a compaction regression of 0,122, 0,053 and 0,046N/mm² respectively between the depths of 5...10cm, 10...15cm and 15...20cm. It is probably due to the transmission of pressure from the topsoil to the soil top deep. However the traditional soil strength trend was found due to the previous soil configuration in all both cases. The soil density recorded is to be similar to the one of loamy sand soil where are planted onions in Niger.

Table 2

Cone index of the two soils in the bin during experiments

Cone index (N/mm²)				
Depth (cm)	Light soil		Compacted	
	Range	Average	Range	Average
5	0,035-0,154	0,071	0,21	0,210
10	0,056-0,227	0,141	0,28-0,385	0,332
15	0,077-0,267	0,175	0,35-0,42	0,385
20	0,126-0,28	0,204	0,385-0,49	0,431

Forces acting measurement

Three forces have been recorded. Those are horizontal, vertical and lateral. The real oscillating forces were obtained as the difference between the main soil oscillating forces i.e. to oscillating forces recorded at the working depth, amplitude and driving parameters; and the oscillating forces in air with the same parameters.

The draft forces were recorded with two gantry-driving speeds for three working depths.

Real horizontal oscillating force (F_{reh})

$$F_{reh} = \left[\sum (X_{1m} + X_{2m} + X_{3m})*(-1) - \sum (X_{1a} + X_{2a} + X_{3a})*(-1) \right]$$

Where X_{1m}, X_{2m}, X_{3m}, X_{1a}, X_{2a}, X_{3a} are respectively main horizontal forces and horizontal forces in the air in three components.

Real vertical oscillating force (F_{rev})

$$F_{rev} = \left[\sum (Y_{1m} + Y_{2m}) - \sum (Y_{1a} + Y_{2a}) \right];$$

Where Y_{1m}, Y_{2m}, Y_{1a}, Y_{2a} are respectively vertical main oscillating forces and oscillating forces in the air.

Real lateral oscillating force (F_{rel})

$$F_{rel} = \sum Z_{1m} \sum -Z_{1a}$$

Where Z_{1m}, Z_{1a} are respectively main lateral oscillating forces and oscillating forces in the air.

It was found, as expected, that at or just before each sliding surface appeared on the film, the horizontal tool force (F_x) was at its maximum value. Just after the sliding surface appeared on the film, the force F_x rapidly decreased to its minimum value. Then it increased gradually to the maximum again.

Data treatment was done with Excel version 7 for Windows 95 and statistical report was made for each measurement. A graphic comparison of horizontal, vertical and lateral forces was made in order to show the deviation between the three forces records. Relationship between the forces and speed was shown in accordance with different working depths and amplitudes (Fig. 4).

Both the maximum and minimum values of F_x , F_y , F_z increased as the speed increased for all tool depths and amplitudes. It was expected that the difference between the maximum and minimum values of F_x would disappear and approach a constant value with increasing speed; however the amplitudes were independent of speeds for all tool depths.

Data analysis showed, that in all experimental cases the means and standard deviation of main oscillating forces were less than those of real oscillating forces were. It proves that the soil had resisted to be penetrated during the experiments. However when the working depth increased, all amplitudes did not played great role in force increase. It was found the mean forces were approximately the same with 4cm and 16,5cm implement working depth. It was remarked that with 4cm and 11,5cm the high amplitude required less forces than the rest. The n (rpm) has slightly increased the force values from amplitude R_1 to R_4.

The amplitude variation demonstrated the expecting trend. Increase of main, real oscillating forces and soil resistance to penetration was found, when the amplitude was increased from R_1=12,8mm to R_4=51,2mm. With constant parameters i.e. *V= 2km/h, n = 350rpm (175)*, h_1 = 4cm, h_2 = 11,5cm and amplitude variation from R_1 to R_4; increase of means for real oscillating, main and draft forces was observed. The soil resistance to implement penetration has increased in accordance with the increase of the amplitude. Tables show the general trend of minimum and maximum amplitudes R_1 and R_4 for light and compacted soils.

In light soil, the soil resistance in XYZ was ranked respectively between 0,031...0,052, 0,081...0,091, (-0,064)...(-0,038) for R1 and 0,04...0,075, (-0,086)...0,053 and (-0,095)...0,938kN for R_4.

The high soil porosity and low soil cohesion could be a response to the soil resistance variation.

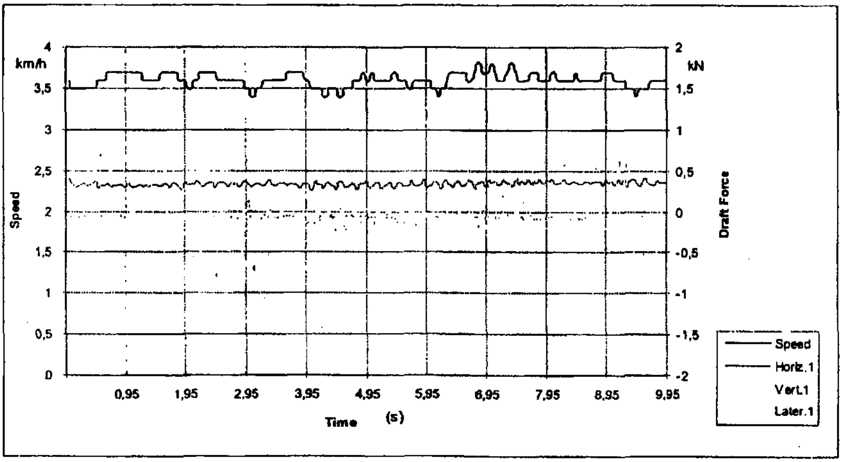

Fig. 4. Relationship between draught force, speed, depth and amplitude for following working parameters: n=400rpm, R_4= 51,2mm, v=3,6 km/h, h_1= 4cm *and* h_2= 16,5cm *in light soil*

A comparison was made in order to achieve on parameters, which showed work efficiency and required at the same time the lowest forces in horizontal, vertical and lateral axes. It was found that, in light soil the increase of the depth, speed and revolution per minute has not great influence on forces with all amplitude values.

However, the maximum amplitude R4 could be a function of the gantry and soil parameters:

$R_4 = f(V=3,6km/h,\ n=400rpm,\ h_1 = 4cm,\ h_2 = 11,5cm \text{ and } h_2 = 16,5cm)$.

This function was found as optimal condition for sandy soil working (Fig. 4). Its parameters required only more lateral forces, which are eliminated with construction as disturbance.

Conclusion and recommendations

R_4 was determined as optimal amplitude for two values *n=350* and *400rpm*, *V=3,6km/h*, dumping depth h_1 *=4cm*, and two digging depths h_2 *= 11,5cm* and h_2 *= 16,5cm*. It was found that, active shares with oscillating movement required less power such as their main forces were the lowest. The implement could be run in light soil with the amplitude of *51,2 mm*, *V=6,8km/h*, *n=400rpm* for the experimented depths. The tool should serve a model for oscillating harvesting shares in sandy and light soils of Niger where tiger nuts and onions are planted after that a test was carried out in field in Niger.

However it was found with interest that, the tool could be run with 6,8km/h, with R_4*=51,2 mm, n=400rpm,* h_1 *= 4cm,* h_2 *= 16,5cm* in light soil. Soil bin measurements showed a general mean value of draught force less than 1kN.

With regard to the future, the implement could be adapted to animal traction for at least tiger nut and onion lifting such as cattle could offer a draft force less than 1kN.

And finally the force measurement should permit to calculate the total energy requirement of a powered harvester for small root crops, through which soil control and management could be achieved.

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AN INTRODUCTION TO FOOD SECURITY IN AFRICA

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Food security and self-sufficiency in food production is a major objective of african countries. Within the next 40 years, agricultural productivity must double in order to feed a fast growing population, but without further deterioration of natural resources, especially soils. This objective can be assumed to be true regardless for every climate, but it is of a paramount importance for such sahelian-countries like niger. Therefore sustainable soil management, as postulated in agenda 21 during the 1992 unced conference in rio de janeiro, must be a fundamental component in the cropping systems of those countries. The protection of natural resources, food security and poverty alleviation has to become the principal objectives of national development policies. The german government was among the first countries that ratified agenda 21 illustrating that they attached priority to the issues.

An increase in food production can only be achieved through yield increases on lands already under cultivation. Using appropriate technologies and new agricultural implements such as cereal and root crops harvesting machines in site specific approach is a basic challenge. That is why, many organizations governmental and non-governmental are involved. In the case of rural areas of Niger, one of the main problems meet by small farmers is located within the harvesting of small root crops. Sparingly, of burning the