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COMPARATIVE STUDIES ON MANUAL, ANIMAL DRAWN, TWO WHEEL TRACTOR AND FOUR WHEEL TRACTOR OPERATED TILLAGE OPERATION IN SWAZILAND

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ABSTRACT

Agriculture in Swaziland is the most important sector of the economy from the stand point of export earning, rural employment and dependency for family food. But, inspite of 65.5 percent of the household being busy in food production for family consumption in Swaziland, the import bill of food and live animals is rising from E119.7268 million in 1987/88 to E172.388 in 1988/89 and to E195.987 million in 1989/90 (An. St. Bul. 1989). A typical farm size, based on holding's growing crops, is only 1.93 ha which may prohibit owning a four wheel tractor for farm operations. The traditional hand tools are just not efficient and comfortable to operate in order to exploit full potential of the land. There are over 120,000 draught animals which have potential to be utilized in farming. The two wheel-tractor is another energy source which can be used for many farm-operations.

In this study comparative results based on the field operations (ploughing) have been presented to facilitate the farmer, farm manager and other interested agencies to decide the appropriate option of farming. Prevailing ploughing systems, namely-using hand tools only, using animal drawn equipment (different combinations), using two wheel tractor with matching equipment, and using four wheel tractor with equipment have been tested for their performance.

Key Words: Plough, Oxen, Tractor, Subsistance, Farmer, Field Capacity

INTRODUCTION

Although, Swaziland is a small country, the food production system is not much different than other developing countries. The farmers of Swaziland have been trying their best to increase the food and animal production for the consumption of the country's ever increasing population. Besides natural claimaties

like drought, the farmers lack the technical management-skill and the majority of them attach a great importance to the motorised farming for increased production and often ignore the potential outcome of good technical management over the economical management. The number of tractors in use in Swaziland have been consistently increasing from 1812 in 1972 to 3504 in 1989 (Central Sta. Office, 1975-89) but the production of food items could not result into reduction of food-import bills. The import bill of food and live animals have been increasing lately.

The nonavailability of spare parts and expertise to fix the tractors have been attributing towards the unusefulness of tractors and agricultural machines. In the meantime, one very basic aspect has been ignored. That is efficient utilization of animal power and/or use of small tractors in Swaziland's situation. The typical farm size, based on holding's growing, is only 1.93 ha in Swaziland (An. Surv. on SNL, 1990) which limits the individual farmer's income. On the other hand, a limited fund for investment always dictates a very low cost and most appropriate option. The most appropriate option can be decided only if researches are undertaken in a given socio-economic and agro-climatic condition. At present there are over 120,000 draught animals which have a great potential to be the source of power for farming in Swaziland. According to Peyton Johnson, (1973) in Cockrill's word it is said that in too many countries people, even professionals, often forget that 3/4th of the world's farmlands are still tilled by humans helped only by domestic animals.

An old style animal-drawn plough is in use in Swaziland often employing 4 to 6 animals. The efficiency and economics of a given equipment depends on its design and have a definite link with the size of the farm in order to be productive. In order to increase the effectiveness of the animal-power, a plough has been developed in the department of Land Use and Mechanization, Faculty of Agriculture, University of Swaziland and evaluated along with other prevailing modes of ploughing. It has been found that the two wheel tractor is just not as efficient as the animal drawn plough for ploughing and manual digging is the costliest mode of cultivating the land.

REVIEW OF LITERATURES

Human power and subsistance farming

Human labour is a prominent source of energy for cultivation at a subsistance level for the larger part of the Sourthern African

Region. Out of 30 farmers, visited at random, in Swaziland it was found that an average of 5.3 hand-hoes are being used by each farmer, (Personal visits and interviews by the author). A typical farm size based on holding's growing crops, is only 1.93 ha, which may prohibit owning a four wheel tractor for farm operations. Inspite of a continuous increase in the number of farming households and tractors in Swaziland agriculture, the import bill of food and live animals is increasing. Fig. 1 and 2 show these facts and it may be noted that merely the increase in the tractor number is not helping in increasing the production. Hand tools are still in common use although they are not efficient.

Musa (1979), reported that the time required for the use of manual tillage tools could be as high as 200 man-hr., to cover a hectare of land and it is emphasized that the limited man's power output and drudgery are the main reasons for it.

A case study was conducted by Panin (1992), to observe the labour economy in using hand-hoe technology, (HHT) and the animal-traction technology, (ATT) in primary tillage operation in Ghana. Panin observed that ATT, as currently in use, has no significant impact on the farm labour economy. He, however, recommends that ATT should cover secondary tillage operations as well.

In raising ground nut, it was reported that it takes 480 man-hr. to cultivate one hectare crop entirely using human power, 311 man-hr. and 53 hr. (with a pair of oxen), using animal drawn equipment, and 30 man-hr. and 11.5 tractor-hr. using tractor powered equipment, (FAO, 1972).

Animal power and animal-drawn implements

As the motorised agriculture with big co-operatives and market controls has met with resistance and technical failure in some areas and farming with hand tools alone did not produce food surpluses; the farmers and the governments in many developing countries have increased their interest in animal traction, (Watson, 1981). According to Kline etal, (1969), a human being is rated at about 1/10th of a horse power (hp) and the minimum power requirement for an effective agriculture has to be 1/2 hp per hectare. Even at this rate there is always an energy gap for optimum production.

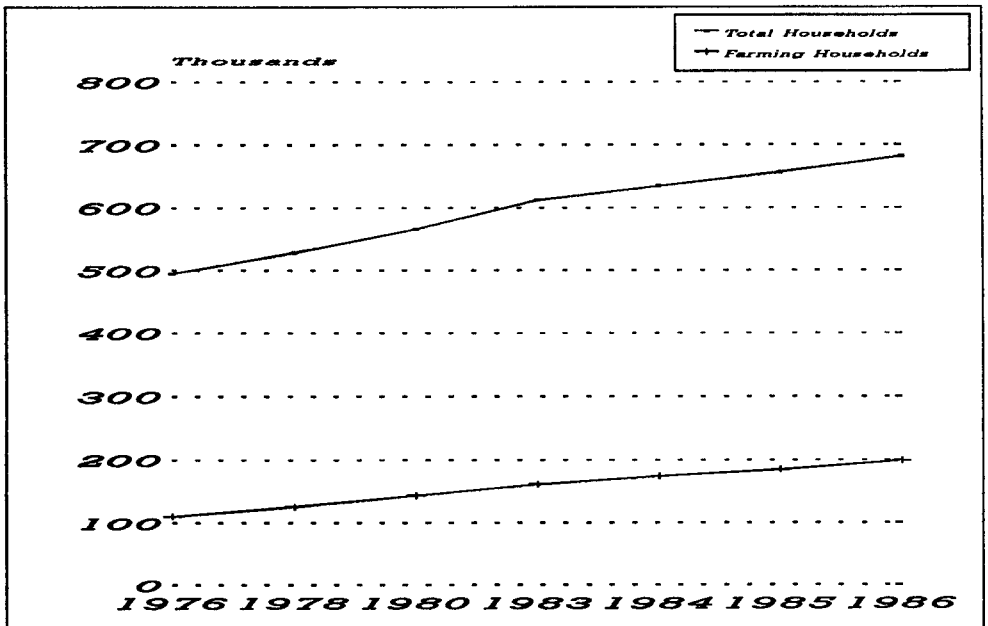

Fig 1. Total households versus farming households in Swaziland

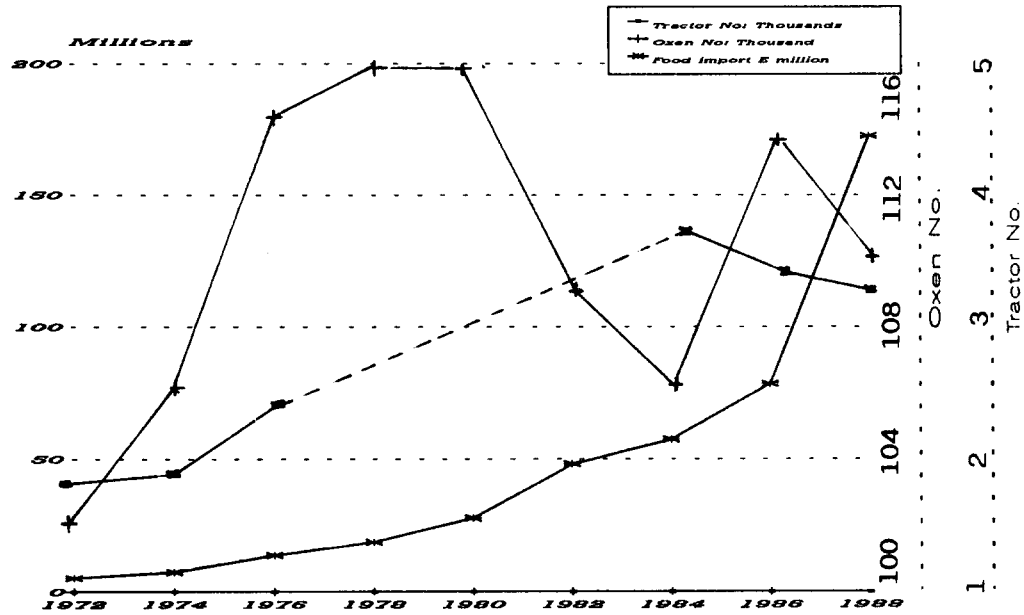

Fig 2. Trend of no. of tractors oxen and food import in Swaziland

According to Swaziland's agricultural census (1983/84), a 59.17 percent of ploughing operation seems to be done using oxen as the source of traction, yet only 2.37 ox-drawn ploughs are available in each homestead in Swaziland. However, Agric. Sta. Bulletin, (1988/89), reported in 1991 gives a different view. It shows that less than 50 percent of the homesteads own an ox-plough in most of the RDA's. It clearly shows, perhaps farmers may be using the services of other machine owners on a custom-hiring basis.

Astatake, (1986) reported that oxen in good condition are able to perform very well as singles for at least 23 weeks, even if they were poorly fed. The oxen restricted on diets and control, both, lost weight during the working period indicating that they used their body reserves for the work.

Engoru-Ebinu (1989) tested harnessing yokes for oxen in Swaziland and compared the performance of the traditional yoke to that of the improved one. According to him the working speed of a pair of the oxen seems to increase using improved yokes but thorough testing was not done to establish this fact.

Jere, (1991) reported that after launching the animal power project in 1986, there has been a 10% increase in the number of draught oxen employed in Malawi. This increase in the number of draught animals resulted in an increase in draught-animal worked area by 40% in 1989 in the Liwonde agricultural development division alone.

Mohanty etal, (1991) tested a modified version of a plough in which rollers were employed on the slotted portion of the mouldboard and found a reduction in the draft and increase in the field capacity at a soil moisture of 10.6%. Bansal etal, (1992) claim that all the animals showed a high speed of work for the first 20 min. and thereafter slowed down while ploughing in test-trials in Morocco. It was also reported that a team of a horse and a mule produced almost same power as produced by a single horse pulling a mouldboard plough. In one of the projects on the feeding strategies of draught animals undertaken in Ethiopia, it was reported that supplementing work-oxen during the dry season increased their body weight but had little effect on their capacity of work, ILCA report, (1989). In the south part of Vietnam, an adult, castrated buffalo can plough 0.25 to 0.33 hectares of irrigated rice-field in an eight to ten hour work day

with five rest breaks. In general a strong buffalo is able to meet all the draft power requirement for a farm of 2.5 to 3 ha for one cropping season, according to Dam, (1993).

Taylor, (1992) gave his opinion that tractors are two expensive and hand-hoes too slow, so ox-ploughing offers a good and affordable compromise in Tanzania. He particularly emphasized that the youth's disinterest towards working with draught animals can be overcome as they see the oxen work and an extra special value attached to these animals as a bride price.

Tractor-power and its suitability

Friederich and Van Gilst, (1971) agree that a small four wheel tractor is economical for a 20 ha farm. Duff and Orcino, (1971) reported that a small tractor is more economical than draught animals for a farm size above 4 ha. Wadhwa, (1969) claims that operating the two wheel tractor is almost same as that of a pair of bullocks but it becomes more expensive than manual power below 1.4 ha. However, FAO, (1970) advocates 2 to 4 ha, under intensive cultivation, to be a reasonable size of a farm to justify for a two wheel tractor.

In a study of the production of tomato under no tillage, manual tillage and tractor tillage system, it was reported by Adeoti and Olarewaju, (1990) that the tomato in the tilled plots matured earlier than the untilled plot and even earlier in the tractor tillage system. Accordingly the yield was highest in the tractor tillage system and the yield in the manual tillage system was higher compared to no tillage system. On the other hand Kaul, and Musa, (1979) claim that although, a four wheel tractor-drawn tools are more advantageous in terms of output, soil compaction is becoming a problem in the developing countries due to excessive machinery traffic.

A two wheel tractor is considered economical for small and fragmented land holdings as claimed by Ullah and Kofoed, (1987). They investigated and reported the performance of a four wheel tractor compared to a two wheel tractor, (Ullah etal, (1989). It was said that the four wheel tractor consumes more energy in small plots compared to the two wheel tractors, when translated to unit area basis. Calilung area basis. Calilung and Stickney (1989) studied the performance of walking tractor (10 h.p. gasolene type) using mouldboard plough, disc plough, spiral-plough harrow, and

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RDAs = Rural Development Areas; SNL = Swazi Nation Land

floating tiller. They found that the mouldboard plough can cover an area of 0.108 ha/hr covering a depth of 10.1 cm and they claim that the spiral plough yields in better field capacity though the floating tiller is the most economical alternative.

Boyer (1978) advocated the intermediate motorization for small-holder farm-operation in tropical countries. According to him the power unit should be simple, robust, and contain the maximum standardised components. This will enable even an unskilled person to operate it and maintenance shall be simple. In the tropical country of Papua New Guinea, it was observed that the power tiller (8.5 h.p.) is 5 times more efficient in ploughing, 20 times in rotary tilling and 15 times in ridge making compared to manual operations to do the same job, (Nath, 1990). Nath, (1993) also observed that more than two numbers of oxen employed to run the conventional plough ensures prolonged operation without fatigue but is not cost effective.

MATERIALS AND METHODS

The Soil

The site where several methods of ploughing hereafter called as modes of ploughing were undertaken is primarily sandy clay loam. The slope was maximum up to 3% and the soil was covered with natural weeds and vegetation. This helped in restricting the soil erosion. The moisture content of the soil observed was in the range of 18 to 21% (db). The distribution of clay, silt and sand was 22.63, 22.96 and 48.92% respectively with the bulk density of 1.58 g/cm^3.

Different modes of ploughing

The following modes of ploughing were undertaken in order to compare their performance in the best interest of the farmers at subsistance level. A plough which is widely used by the farmer, called as a conventional plough, has two handles attached with braces and is supported by the depth wheel in the front. It can be drawn by 2, 4 and 6 oxen employing two or three labourers. In order to reduce the employment of many oxen, a new plough has been developed in the department of Land Use & Mechanization, Faculty of Agriculture, University of Swaziland and the same is referred to as new plough. Other modes of ploughing is with two

wheel tractor, four wheel tractor and manual digging. Hence, modes of ploughing are (i) New plough (2 oxen + 1 labour), (ii) 2 oxen + 2 labours, (iii) 4 oxen + 2 labours (iv) 6 oxen + 3 labours (v) A two wheel tractor (10 Kw, single cylinder, horizontal type water cooled, chinese make), (vi) A four wheel tractor (46 Kw John Deere, 4 cylinder diesel) and (vii) The manual digging.

The procedures

The test area was cultivated using each mode of ploughing. The working width, depth, speed, field efficiency, indicator of soil inversion, and field capacity were observed. The number of man-hrs. were carefully noted to estimate the operating cost in each case. The field efficiency and the capacity were estimated in the usual way covering a 0.2 ha land. The indicator of soil-inversion was estimated by comparing the number of weeds before and after ploughing/digging in one square meter area and expressed in percentage. In case of manual digging any time loss causing disruption/break in continuous work was noted for the calculation of field efficiency. The ploughing was undertaken from centre to the border of the field and the digging hoe was 17cm wide.

RESULTS AND DISCUSSION

The width and depth of ploughing using new plough was a bit lower compared to the conventional plough and therefore the field capacity of the new plough was only 0.21 ha/day compared to 0.315 ha/day using 6 oxen and 3 labours, (Fig.3). The field capacity of two wheel tractor was found to be even lower than the new plough. The field capacity using human power was only 0.00922 ha/day per labourer (7 hrs./day) although the percent soil inversion was highest with well levelled dug-surface. The soil inversion for other modes of ox-drawn ploughing under different conditions ranged from 92 to 95 percent with exception of the new plough which recorded the inversion factor of only 79%.

In order to compare the cost involved in different modes of ploughing fixed cost and variable costs were estimated on hourly basis and knowing the field capacity, cost per hectare were estimated. The cost of ploughing for a hectare of land was found to be only E351.43 with the new plough compared to E693.3 using the conventional plough with 6 oxen and 3 labourers (Fig.4). The ox-driven plough was used 6 hrs./day and it was observed that

E = Lilangeni, the legal currency and 100 cents make 1 Lilangeni

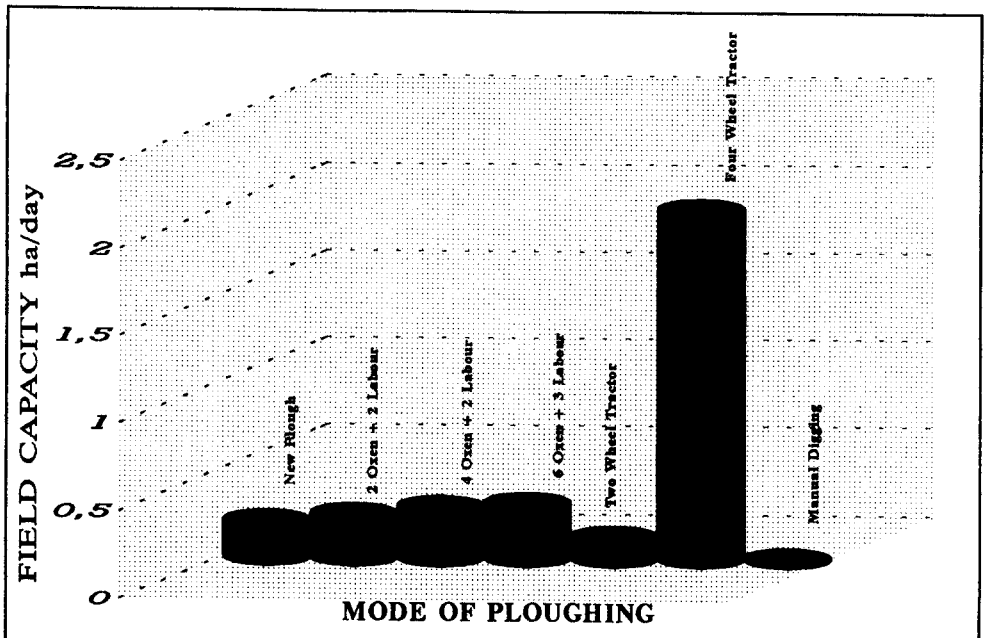

Fig 3. Field capacity in different mode of ploughing

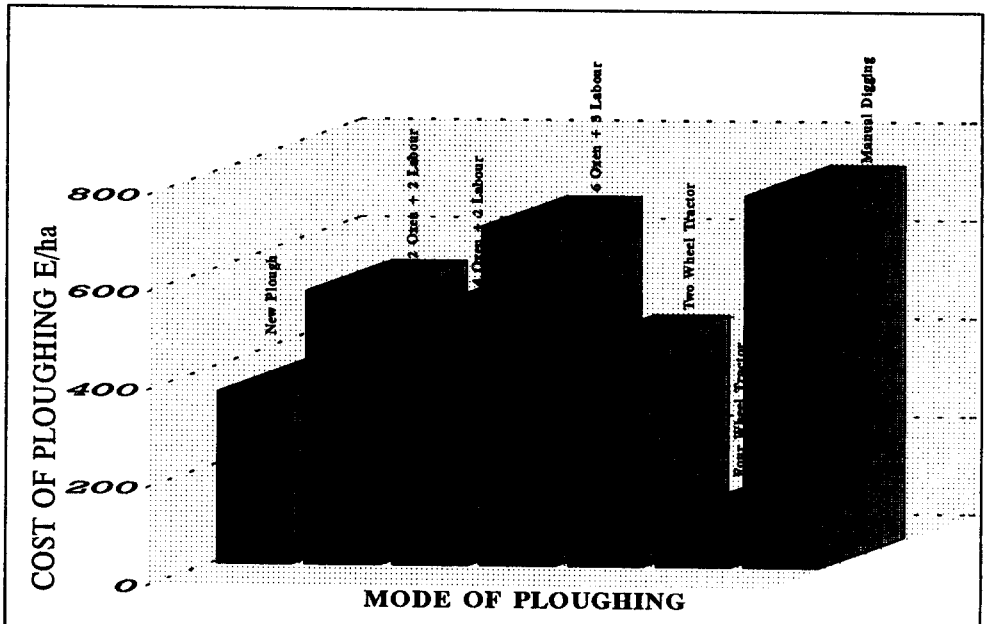

Fig 4. Comparative cost of ploughing

more number of oxen made it easier to continue work for a prolonged period of time. The increased cost of ploughing using 4 oxen and two labourers and 6 oxen and three labourers were primarily due to increase in the number of labourers. It may be emphasized here that the weights of first, second and third pair of oxen were 485 and 440 kg; 440 and 400 kg; and 420 and 395 kg respectively.

The speed of digging was quite fast in the first two hours in case of manual digging and then stablised by the end of the fourth hour and rest was needed. The two wheel tractor did not yield any better result compared to ox-drawn ploughing. The four wheel tractor (using 3 bottom plough) was the cheapest in terms of cost per hectare, though the initial cost is extremely high.

CONCLUSIONS

i) The new plough has to be tested by the farmers themselves and necessary modifications be made accordingly. The new plough has a great potential as it employs only two oxen reducing the feeding cost from 6 to 2.

ii) The two wheel tractor is economical compared to manual digging and the cost of operation is almost comparable to the conventional plough with four oxen and two labourers.

iii) Further testing is to be done in order to make any concrete recommendation in order to adopt the mode of ploughing for a given farm-size.

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